Frequently Asked Questions About Hydraulic Fracturing:

What is hydraulic fracturing?

Hydraulic fracturing, commonly referred to as fracing, is the process of creating small cracks, or fractures, in underground geological formations to allow oil or natural gas to flow into the wellbore and thereby increase production. Prior to initiating hydraulic fracturing, engineers and geoscientists study and model the physical characteristics of the hydrocarbon bearing rock formation, including its permeability, porosity and thickness. Using this information, they design the process to keep the resulting fractures within the target formation. In Colorado, the target formation is often more than 7,000 feet below the ground surface and more than 5,000 feet below any drinking water aquifers.

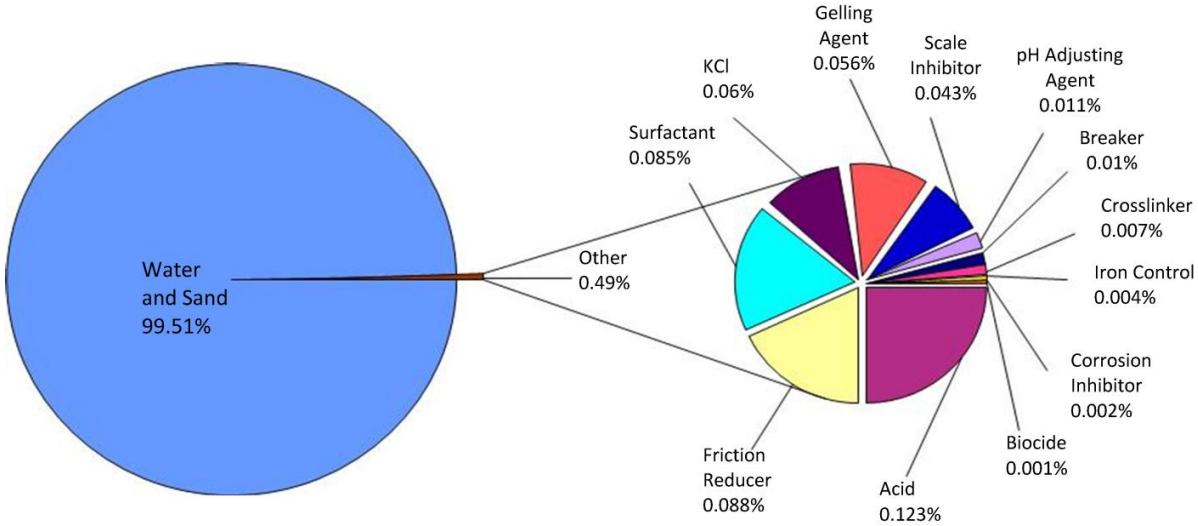
To fracture the formation, special fracturing fluids are injected down the well bore and into the formation. These fluids typically consist of water, sand, and chemical additives. The pressure created by injecting the fluid opens the fractures. Sand is carried into the fractures by the fluid and keeps the fractures open to increase the flow of oil or natural gas to the well bore. The chemicals serve a variety of purposes, including increasing viscosity, reducing friction, controlling bacteria, and decreasing corrosion. Following the treatment, much of the fracturing fluid flows back up the well bore and is collected at the surface in tanks or lined pits.

Why is hydraulic fracturing necessary in Colorado?

Most of the hydrocarbon bearing formations in Colorado have low porosity and permeability. These formations would not produce economic quantities of hydrocarbons without hydraulic fracturing. Fracture treatment of oil and gas wells in Colorado began in the 1970s and has evolved since then. Recent technological advances combine multi-stage fracture treatment with horizontal drilling.

What chemicals are used in fracing?

Approximately 99.5% of the fracing fluid volume is water and sand. Other typical ingredients include friction reducers, gelling agents and biocides. In Colorado, potassium chloride (KCl) is a common additive and can constitute 2% to 4% of the fracing fluid. A generalized fracturing mixture and list of additives are provided below:



Source: US DOE, Modern Shale Gas Development in the United State, Exhibit 35: Volumetric composition of a fracture fluid.

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Fracturing Ingredients			
Product Category	**Main Ingredient**	**Purpose**	**Other Common Uses**
Water	~98%	Expand fracture and deliver sand	Landscaping and manufacturing
Sand	water & sand	Allows the fractures to remain open so the gas can escape	Drinking water filtration, play sand, concrete and brick mortar
Acid	Hydrochloric acid or muriatic acid	Helps dissolve minerals and initiate cracks in the rock	Swimming pool chemical and cleaner
Biocide	Glutaraldehyde	Eliminates bacteria in the water that produces corrosive by-products	Disinfectant; Sterilizer for medical and dental equipment
Breaker	Ammonium persulfate	Allows a delayed break down of the gel	Used in hair coloring, as a disinfectant, and in the manufacture of common household plastics
Corrosion inhibitor	n,n-dimethyl formamide	Prevents the corrosion of the pipe	Used in pharmaceuticals, acrylic fibers and plastics
Crosslinker	Borate salts	Maintains fluid viscosity as temperature increases	Used in laundry detergents, hand soaps and cosmetics
Friction reducer	Petroleum distillate	"Slicks" the water to minimize friction	Used in cosmetics including hair, make-up, nail and skin products
Gel	Guar gum or hydroxyethyl cellulose	Thickens the water in order to suspend the sand	Thickener used in cosmetics, baked goods, ice cream, toothpaste, sauces and salad dressings
Iron control	Citric acid	Prevents precipitation of metal oxides	Food additive; food and beverages; lemon juice ~7% citric acid
Clay stabilizer	Potassium chloride	Creates a brine carrier fluid	Used in low-sodium table salt substitute, medicines and IV fluids
pH adjusting agent	Sodium or potassium carbonate	Maintains the effectiveness of other components, such as crosslinkers	Used in laundry detergents, soap, water softener and dishwasher detergents
Scale inhibitor	Ethylene glycol	Prevents scale deposits in the pipe	Used in household cleansers, de-icer, paints and caulk
Surfactant	Isopropanol	Used to increase the viscosity of the fracture fluid	Used in glass cleaner, multi-surface cleansers, antiperspirant, deodorants and hair color

Source: US DOE, Modern Shale Gas Development in the United State, Exhibit T 36: Fracturing fluid additives, mani compounds, and common uses.

Are fracing chemicals dangerous?

Fracing chemicals are similar to other industrial or household chemicals which must be handled properly. For certain chemicals, safe work practices, proper site preparation, and attentive handling are required to ensure that employees, the public, and the environment are protected. The COGCC requires an operator to maintain an inventory of the chemical products used downhole or stored at a well site for use downhole, including fracing fluids. Such chemicals must also have Material Safety Data Sheets (MSDSs), which are readily available at a central location for all personnel on the job site. The MSDSs outline the hazards associated with the chemicals and the appropriate steps to protect the user and the environment.

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Does hydraulic fracturing greatly increase the pressures on a gas well, including the well casing and cementing?

Hydraulic fracturing involves injection pressures that exceed those of the geologic formation. In practice, however, the well casing and cementing are designed to manage these pressures. In Colorado, the COGCC requires that the well components be designed to manage the site and reservoir specific pressures. Rule 317.d mandates that well casings be "planned and maintained" to "prevent the migration of oil, gas or water from one (1) horizon to another." Rules 317.g and 317.h set forth specific cementing requirements. And Rule 317.j requires production casing to be "adequately pressure tested for conditions anticipated to be encountered during completion and production operations."

In addition, Rule 341 requires operators to monitor the well's bradenhead pressure during hydraulic fracturing and to report promptly to the COGCC any significant pressure increase. Monitoring these pressures helps to indicate if hydraulic fracturing fluids have escaped the target formation.

Does hydraulic fracturing greatly increase the volumes of liquids which must be managed?

Oil and gas development typically involves large volumes of liquids, which may include liquid hydrocarbons, produced water, and fracturing fluids. The COGCC estimates that fracturing fluids constitute about 9% of the total liquids generated by or used for oil and gas development. To ensure that all such liquids are properly managed, the COGCC has adopted a variety of regulations, including Rules 206 (compliance checklists), 209 (protection of water-bearing formations), 317 (general drilling operations), 317A (special drilling operations), 317B (public water system protection), 324A (pollution prevention), 604 (oil and gas facilities), 608 (coalbed methane wells), 902 (general and special pits), 903 (pit permitting), 904 (pit lining), 905 (pit closure), 907 (waste management), 908 (centralized waste management), 1002 (stormwater management), and 1003 (interim reclamation). These regulations were comprehensively updated in 2008. Under these updated regulations, Colorado operators are improving their water management. For example, the percentage of well pads utilizing closed loop or pitless drilling systems has increased from 31% in January 2010 to 79% in March 2011.

How is groundwater protected?

The COGCC requires all wells to be constructed with cemented surface and production casing to isolate fresh water aquifers from the hydrocarbon zone. The steel casing and surrounding layers of cement protect the drinking water aquifers that the wellbore penetrates. Surface casing is required to extend 50 feet below the base of the freshwater aquifer to seal it off from any possible migration of fluids associated with oil and gas development. The production casing cement is required to be verified by a specialized well survey (cement bond log) on all wells.

After it is determined that the well is capable of producing oil or natural gas, a tubing string is set to provide an added layer of separation between the oil or natural gas stream and freshwater aquifer. The multiple layers of steel and cement used to construct an oil or natural gas well, when properly installed, provide several layers of protection to prevent the contamination of freshwater zones.

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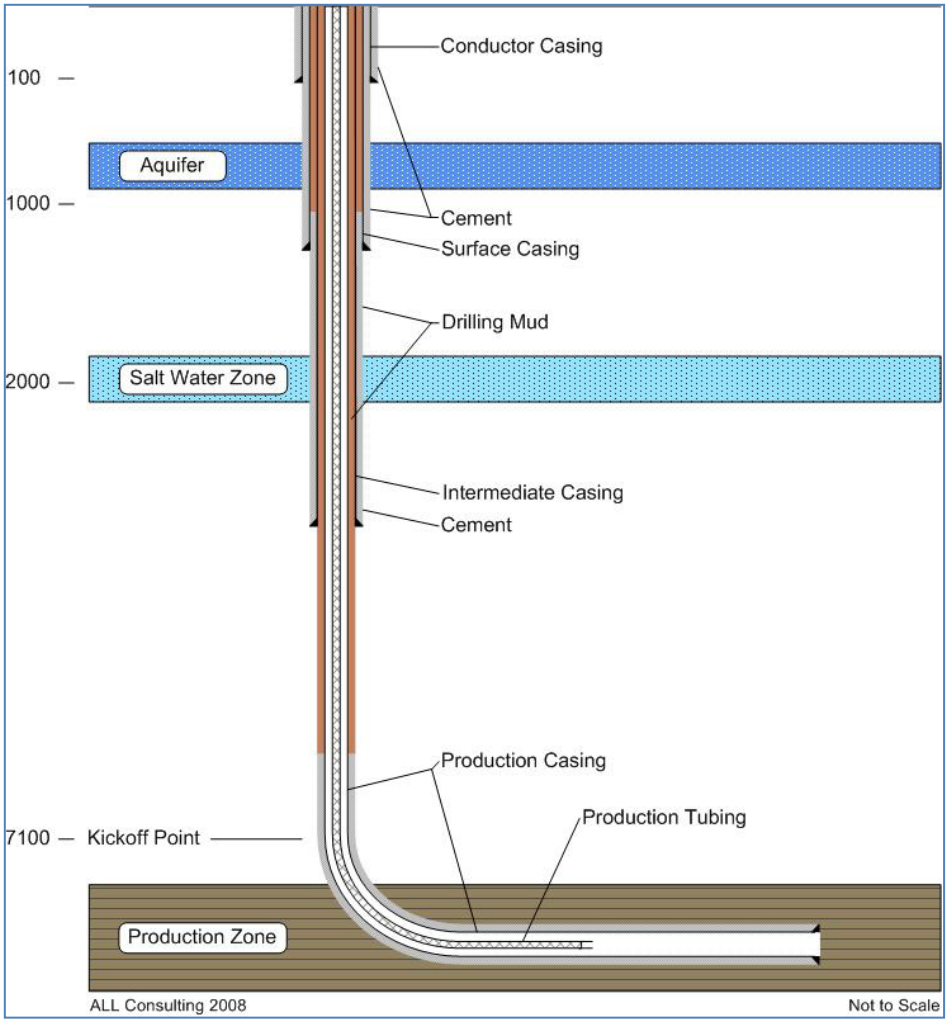

Source: US DOE, Modern Shale Gas Development in the United State, Exhibit 30: Casing zones and cement programs.

How much water is used to frac a well?

Water is the primary component of most fracing fluids. The amount of water needed to frac a well in Colorado depends on the geologic basin, the formation, and the well. For example, approximately 50,000 to 300,000 gallons may be used to frac a shallow coalbed methane well in the Raton Basin, while approximately 800,000 to 2 million gallons may be used to frac a deeper tight sand gas well in the Piceance Basin. In the DJ Basin, approximately 250,000 gallons may be used to frac a vertical well, while up to 5 million gallons may be used to frac a horizontal well.

How much is one million gallons of water?

One million gallons is the amount of water consumed by:

- A 1,000 megawatt coal-fired power plant in 2.5 hours
- A golf course in 5 days
- 1.5 acres of corn in a season

While these represent continuing consumption, the water used for fracing is a one-time use, and the flowback water can often be reused or recycled.

Has the Colorado Oil and Gas Conservation Commission undertaken any studies relating to the potential for seismic activity as a result of drilling?

Colorado is very familiar with "induced seismicity" related to human activity tied to a variety of processes, including the deep underground injection of waste. The Colorado Geological Survey and the Colorado School of Mines, as well as the University of Colorado, have a wealth of data on these matters and the COGCC can and does turn to these institutions for assistance. Tens of thousands of oil and gas wells in Colorado have been hydraulically fractured without notable geological impacts.

Please describe Colorado's process for permitting oil and gas wells?

Anyone seeking to drill a natural gas or oil well in Colorado must submit a Form 2, Application for Permit to Drill ("APD"), under COGCC Rule 303.a. The APD includes information on the well location, formations and spacing, and drilling plans and procedures, including the casing, cementing, and blowout preventer. This information is reviewed by engineers and permit technicians at the COGCC, and additional conditions are imposed where necessary to protect public health and the environment.

Applicants must also submit a Form 2A, Oil and Gas Location Assessment, for the well pad and certain related facilities under Rule 303.b. The Location Assessment contains information about the location, including information about the equipment to be used, nearby improvements, surface and ground water, access roads, current and future land uses, and soils. This information is reviewed by environmental professionals at the COGCC, and conditions of approval can be imposed where necessary to protect public health and the environment.

All Location Assessments and associated APDs are subject to public notice and at least 20 days of public comment under Rule 305. Special notice is provided to the local government, the surface owner, and, across most of the state, the owners of surface property within 500 feet.

Operators are also required to consult with the surface owner and the local government in locating certain facilities under Rule 306. If a proposed well pad is located in important wildlife habitat, then the COGCC will consult with the Colorado Division of Wildlife. If the operator seeks a variance from certain environmental regulations or the local government requests, then the COGCC will consult with the Colorado Department of Public Health and Environment.

Following staff review and any consultation and public comment, Location Assessments and APDs are approved by the COGCC Director. The COGCC may attach technically feasible and economically practicable conditions of approval under Rule 305, and, as noted above, the COGCC often does so to protect public health and the environment. In addition, applicants must provide financial assurance to the State under Rule 304 and the 700 Series of Rules. Following the drilling and completion of the well, additional reporting requirements apply under Rules 308A, 308B, and 309.

How does the COGCC confirm that operators are complying with its regulations?

The COGCC actively monitors and inspects oil and gas drilling and production operations. Operators are required to have approved permits and provide as-constructed completion

reports under Rules 308A and 308B, which are verified by inspections. The COGCC preformed more than 17,000 inspections during 2010, most of which were unannounced.

What type of agency reporting is required?

Under Rules 308A and 308B, an operator is required to submit to the COGCC completion reports providing information on the cemented surface casing which isolates the freshwater aquifer. The operator must also provide information on the cemented production casing, which isolates the hydrocarbon producing zone. This information includes the size and amount of casing used in the well, in addition to the amount of cement used to seal off the casing from the surrounding earth. The report will detail the locations where the fracing occurred. It will also note any additional operational equipment installed in the wellbore.

What is the likelihood of a spill at the wellhead during the fracing process?

Spills at the wellhead during fracing activities are relatively rare. The piping and fracing equipment used to transport fluids to the wellhead are inspected and pressure tested prior to the start of each fracture treatment. The equipment is pressure rated and continuous monitoring occurs during operations to ensure that pressures remain below the safety-rated pressure levels. Raw chemicals are maintained inside lined secondary containment areas to catch any releases before they can migrate off the site. Likewise, the sites are specifically constructed to contain any releases on the wellsite.