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Institute for Regulatory Policy Studies Conference

Department of Economics at Illinois State University

April 26, 2012

Crowne Plaza Hotel, Springfield, Illinois

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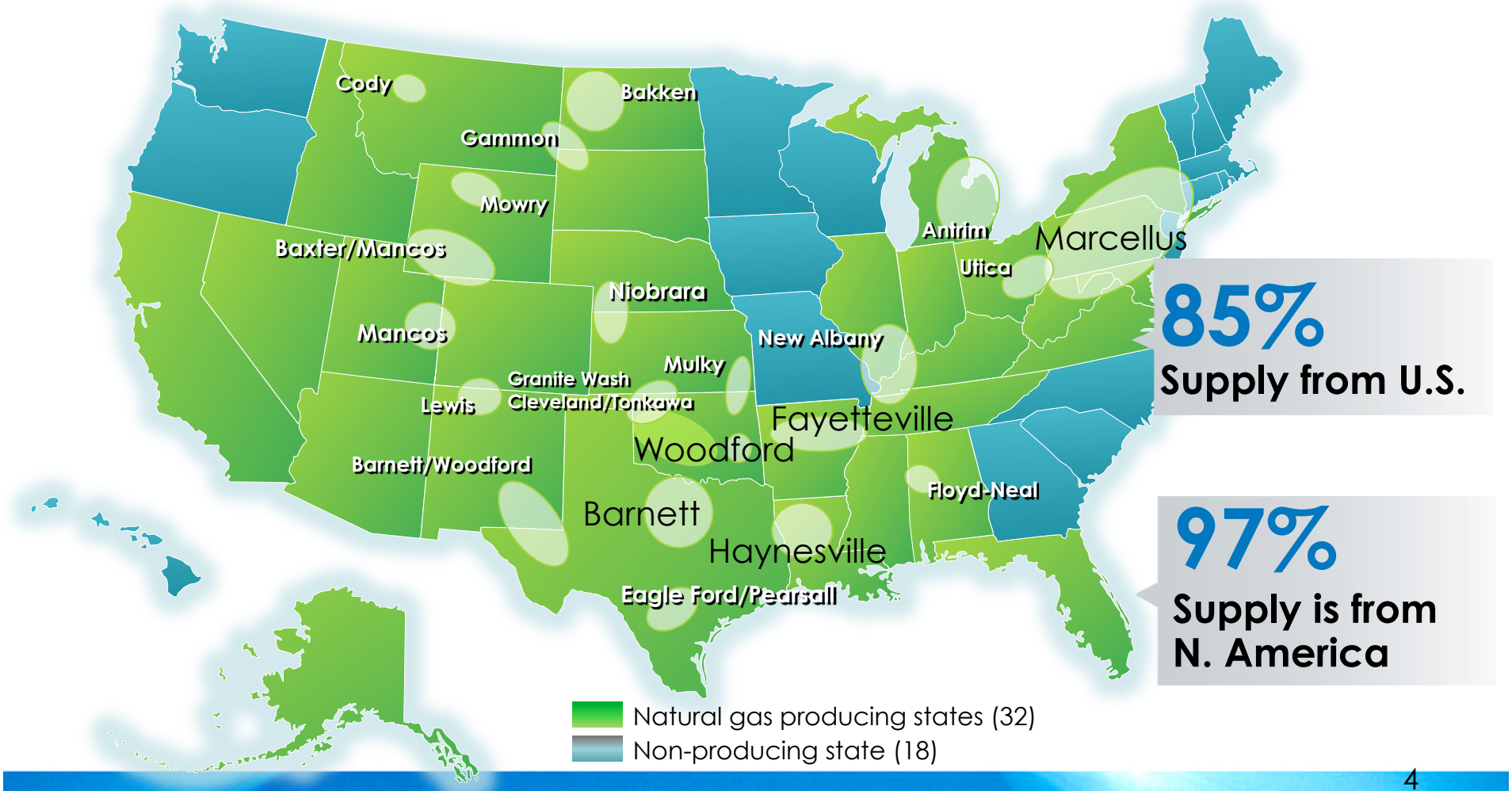
Hydrofracturing: Innovation in Regulation

Jim Roth
Chair, Alternative Energy Practice Group
PHILLIPS MURRAH, P.C.

Shale Deposits Located in 32 U.S. States Creates Increasing Fuel Supply Certainty and Economic Growth



85%
Supply from U.S.

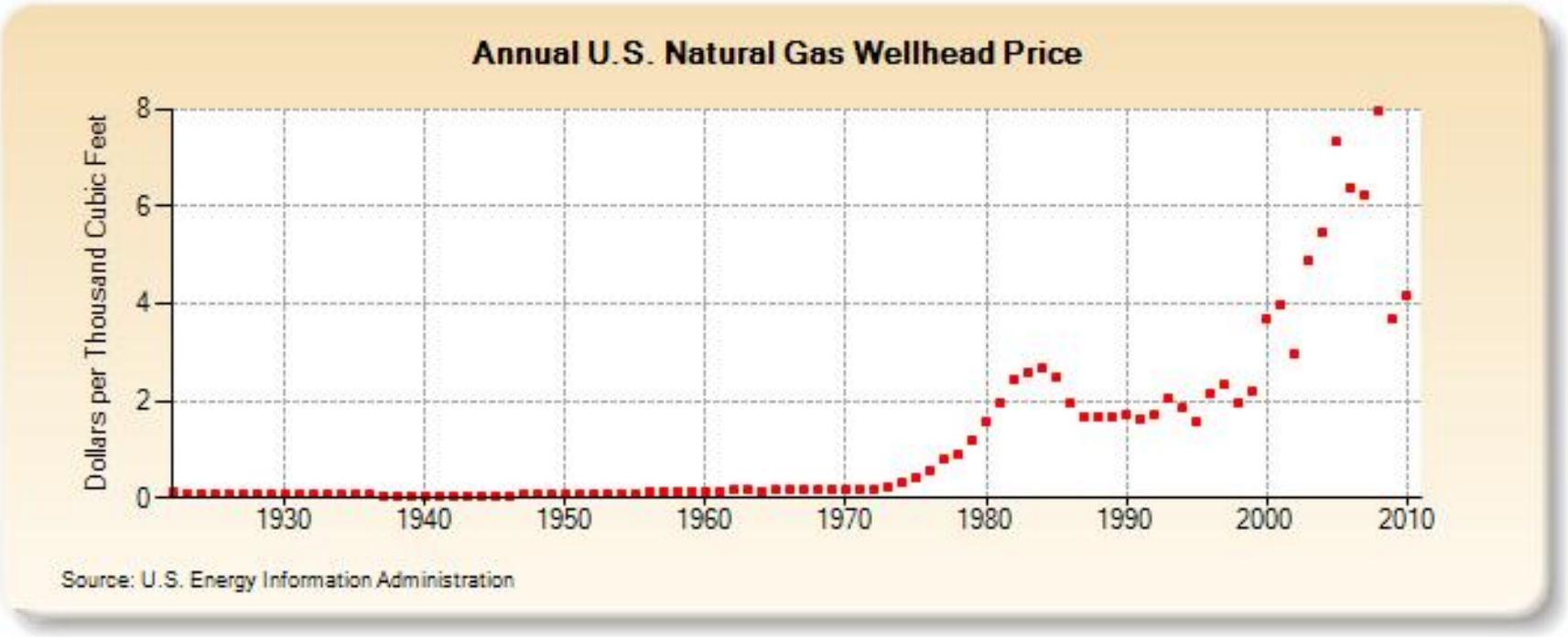
97%
Supply is from N. America

Natural Gas is now a hallmark of Oklahoma and United States energy production.

Today, Oklahoma is the nation's *3rd largest* natural gas producing state (behind Texas and Wyoming), and typically accounts for about *one-tenth* of U.S. production. In 2010, Oklahoma produced more than 1.8 trillion cubic feet, accounting for 80 % of the state's overall energy production

More than a dozen of the *100* largest natural gas fields in the country are found in Oklahoma.

Historic natural gas price volatility



Technological game changers

Without horizontal drilling and hydraulic fracturing, shale gas production would not be economically feasible because the natural gas would not flow from the formation at high enough rates to justify the cost of drilling.

Discoveries in unconventional shale gas enhanced recovery techniques are *drastically* changing the American and global energy economy.

What is different about shale gas?

Shale gas resources form within the organic-rich shale source rock (formations with low permeability).

Hydrofracturing: General Overview

Hydraulic Fracturing Simply Stated

Hydraulic fracturing is a process used in nine out of 10 natural gas wells in the United States, where millions of gallons of water, sand and chemicals are pumped underground to break apart the rock and release the gas.

Source: National Geographic

Source: Chesapeake Energy

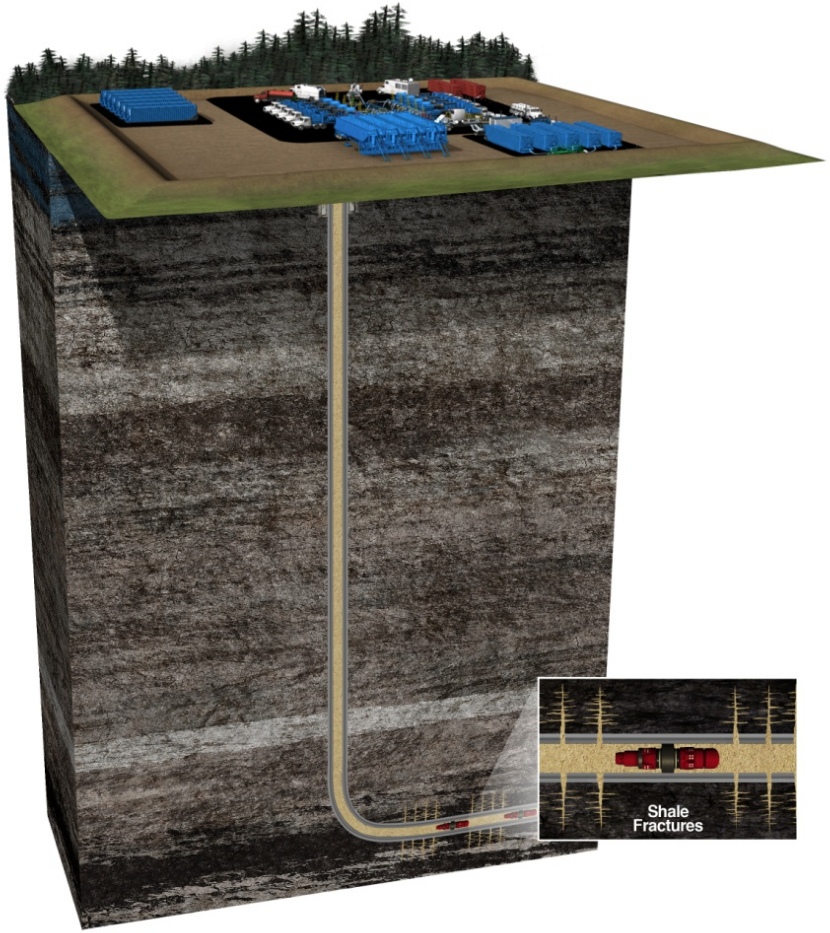
The Process Explained

Hydraulic fracturing produces fractures in the rock formation that stimulate the flow of natural gas or oil, increasing the volumes that can be recovered. Wells may be drilled vertically hundreds to thousands of feet below the land surface and may include horizontal or directional sections extending thousands of feet.

Once the drilling rig leaves, hydraulic fracturing begins

Hydraulic fracturing is an advanced technology that allows the safe and economic removal of natural gas and oil from the deep shale formations

Fracking has been used by the natural gas and oil industry since the 1940s

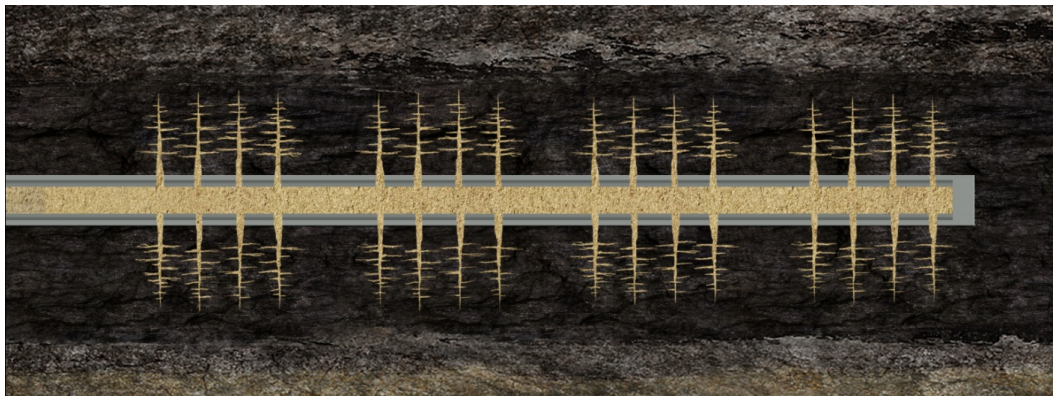


The Process Explained

Fractures are created by pumping large quantities of fluids at high pressure down a wellbore and into the target rock formation. Hydraulic fracturing fluid commonly consists of water, proppant and chemical additives that open and enlarge fractures within the rock formation. These fractures can extend several hundred feet away from the wellbore. The proppants - sand, ceramic pellets or other small incompressible particles - hold open the newly created fractures.

Hydraulic Fracturing Process

- It is the process of "stimulating" natural gas from the impermeable shale by creating small fractures
- Water mixed with sand and additives is pumped into the reservoir at high pressures
- Fractures are "propped" open by the sand to allow the natural gas and oil to flow
- The hydraulic fracturing process is completed in a matter of days



The Process Explained

Once the injection process is completed, the internal pressure of the rock formation causes fluid to return to the surface through the wellbore. This fluid is known as both "flowback" and "produced water" and may contain the injected chemicals plus naturally occurring materials such as brines, metals, radionuclides, and hydrocarbons. The flowback and produced water is typically stored on site in tanks or pits before treatment, disposal or recycling. In many cases, it is injected underground for disposal. In areas where that is not an option, it may be treated and reused or processed by a wastewater treatment facility and then discharged to surface water.

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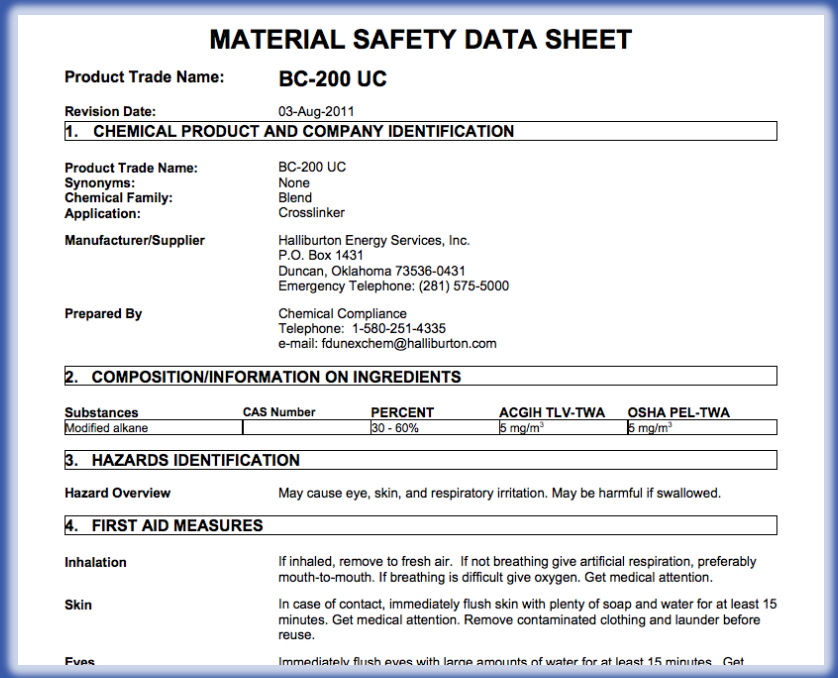
What's in the fluid?

An Industry & Oklahoma Example: Halliburton Oil



MATERIAL SAFETY DATA SHEET

Product Trade Name: **BC-200 UC**

Revision Date: 03-Aug-2011

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: BC-200 UC
Synonyms: None
Chemical Family: Blend
Application: Crosslinker

Manufacturer/Supplier Halliburton Energy Services, Inc.
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substances	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Modified alkane		30 - 60%	5 mg/m^3	5 mg/m^3

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye, skin, and respiratory irritation. May be harmful if swallowed.

4. FIRST AID MEASURES

Inhalation If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult give oxygen. Get medical attention.

Skin In case of contact, immediately flush skin with plenty of soap and water for at least 15 minutes. Get medical attention. Remove contaminated clothing and launder before reuse.

Eyes Immediately flush eyes with large amounts of water for at least 15 minutes. Get

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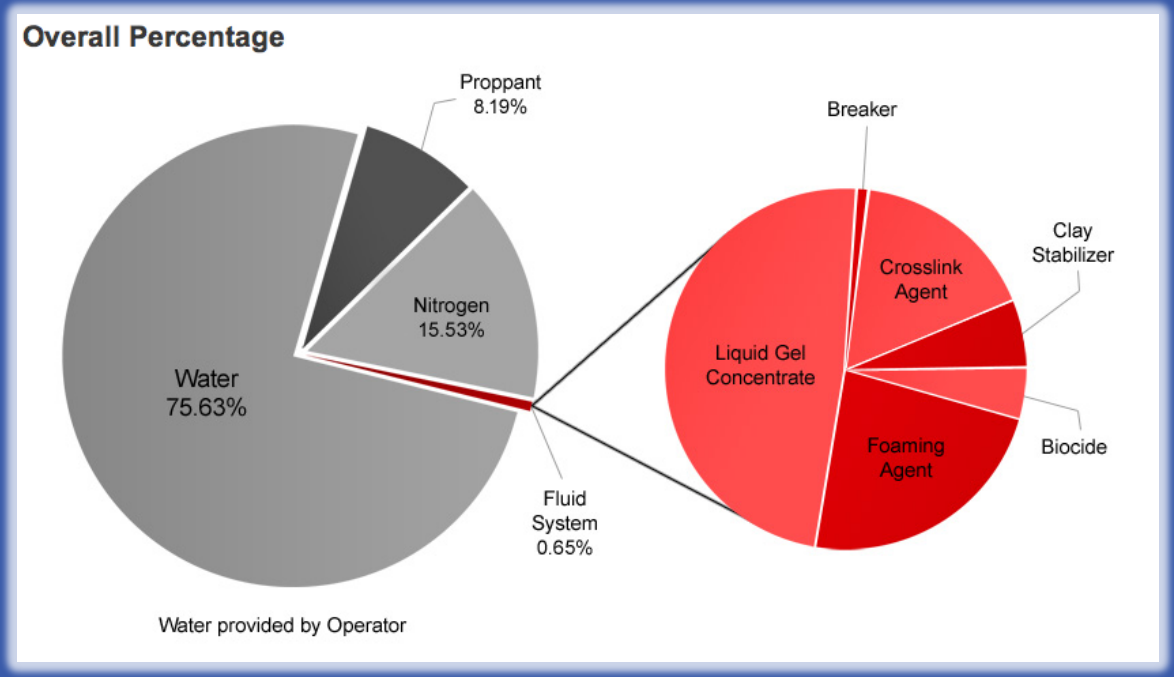
What's in the fluid?

Tonkawa Foam Frac Formulation



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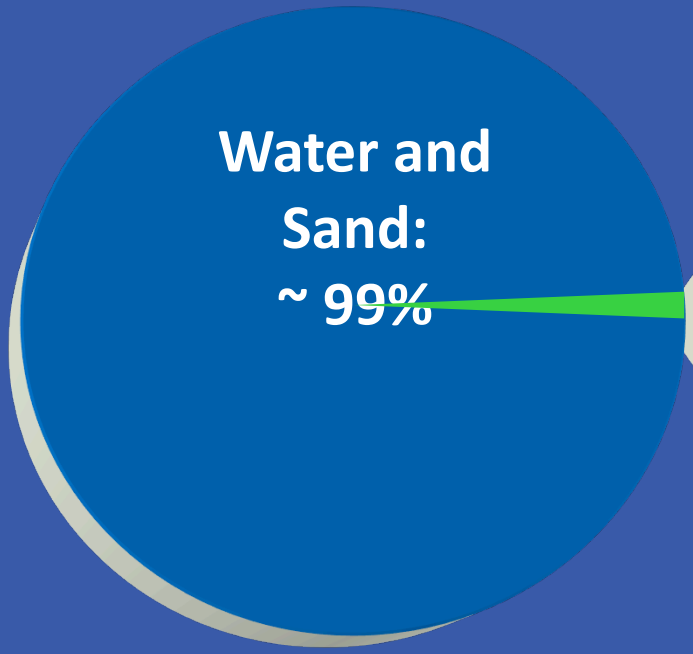
Typical Barnett Deep Shale Fracturing Products



Other: ~ 1%

- Acid
- Anti-bacterial Agent
- Breaker
- Clay Stabilizer
- Corrosion Inhibitor
- Iron Control
- Friction Reducer
- Gelling Agent
- Scale Inhibitor

For more information, visit HydraulicFracturing.com and FracFocus.org or see our fact sheet on Hydraulic Fracturing

What Chemicals Are Generally Used?

The number of chemical additives used in a typical fracture treatment depends on the conditions of the specific well being fractured. A typical fracture treatment will use very low concentrations of between 3 and 12 additive chemicals, depending on the characteristics of the water and the shale formation being fractured.

FracFocus.org

Each component serves a specific, engineered purpose. For example, the predominant fluids currently being used for fracture treatments in the gas shale plays are water-based fracturing fluids mixed with friction-reducing additives (called slickwater).

FracFocus.org

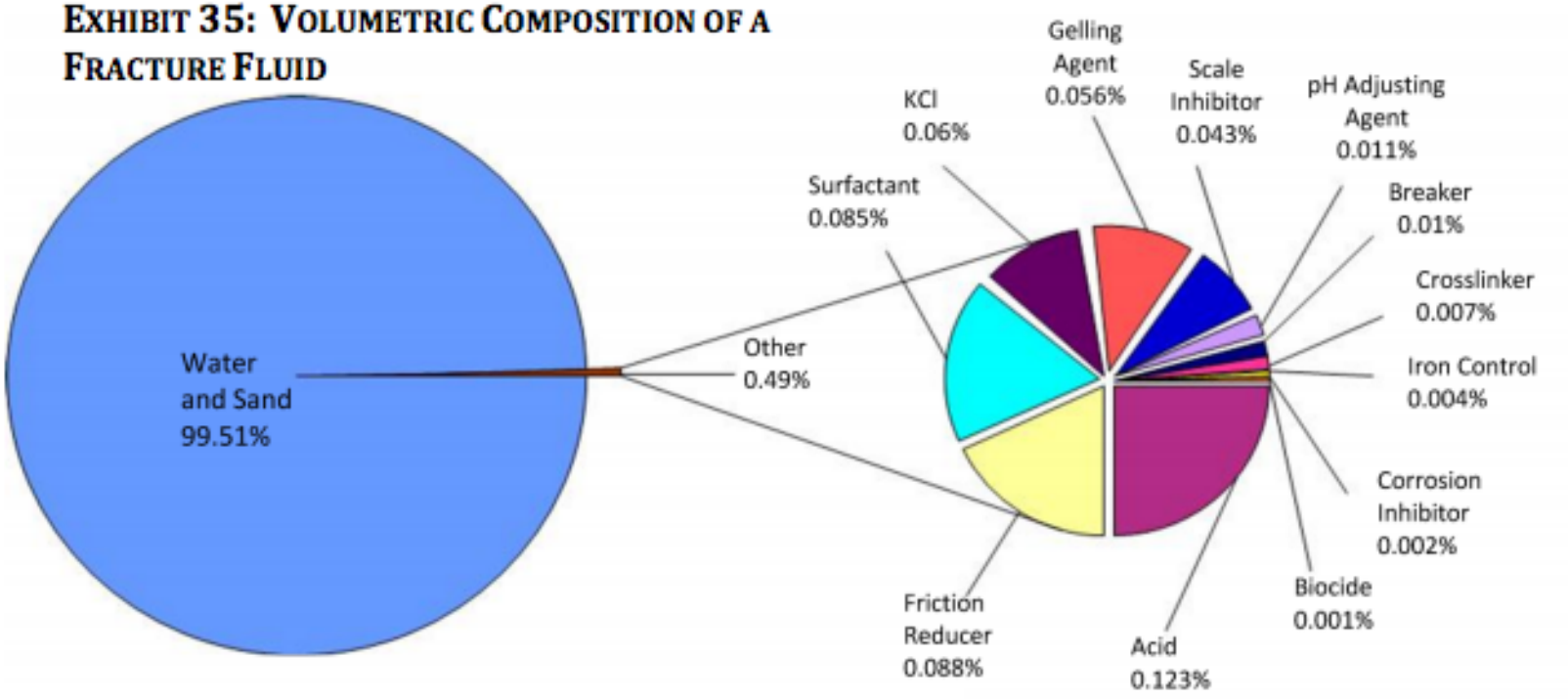
The addition of friction reducers allows fracturing fluids and sand, or other solid materials called proppants, to be pumped to the target zone at a higher rate and reduced pressure than if water alone were used. In addition to friction reducers, other additives include: biocides to prevent microorganism growth and to reduce biofouling of the fractures; oxygen scavengers and other stabilizers to prevent corrosion of metal pipes; and acids that are used to remove drilling mud damage within the near-wellbore area.

FracFocus.org

The chart on the next slide is taken from Modern Shale Gas Development in the **United States: A Primer** demonstrates the volumetric percentages of additives that were used for a nine-state hydraulic fracturing treatment of a Fayetteville Shale horizontal well.

MODERN SHALE GAS DEVELOPMENT IN THE UNITED STATES: A PRIMER

EXHIBIT 35: VOLUMETRIC COMPOSITION OF A FRACTURE FLUID



Source: ALL Consulting based on data from a fracture operation in the Fayetteville Shale, 2008

What Chemicals Are Generally Used?

Hydrochloric acid (HCl) is the single largest liquid component used in a fracturing fluid aside from water; while the concentration of the acid may vary, a 15% HCl mix is a typical concentration.

A 15% HCl mix is composed of 85% water and 15% acid, therefore, the volume of acid is diluted by 85% with water in its s tock solution before it is pumped into the formation during a fra cturing treatment.

Once the entire stage of fracturing fluid has been injected, the total volume of acid in an example fracturing fluid from the Fayetteville shale was 0.123%, which indicates the fluid had be en diluted by a factor of 122 times before it is pumped into the formation.

The concentration of this acid will only continue to be diluted a s it is further dispersed in additional volumes of water that may be present in the subsurface.

Plus, if this acid comes into contact with carbonate minerals in the subsurface, it would be neutralized by chemical reaction with the carbonate minerals producing water and carbon dioxide as a byproduct of the reaction.

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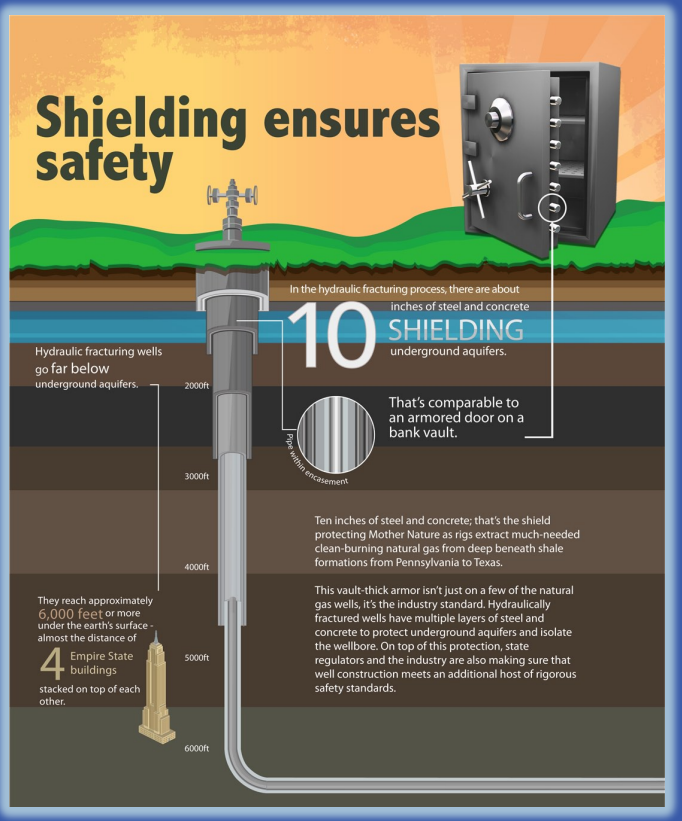
What about groundwater protection?



What about groundwater protection?

Studies by the Ground Water Protection Council (GWPC), an association of state regulators, and the Environmental Protection Agency (EPA) have clearly demonstrated the effectiveness of current state regulations in protecting water resources.

What about groundwater protection?

The ultimate goal of the well design is to ensure environmentally sound and safe production by containing the hydrocarbons inside the well, protecting groundwater resources, and insolating the productive formations.

What about groundwater protection?

The primary method used for protecting groundwater during drilling operations consists of drilling the wellbore through the groundwater aquifers, immediately installing a steel pipe (called casing), and cementing this steel pipe into place.

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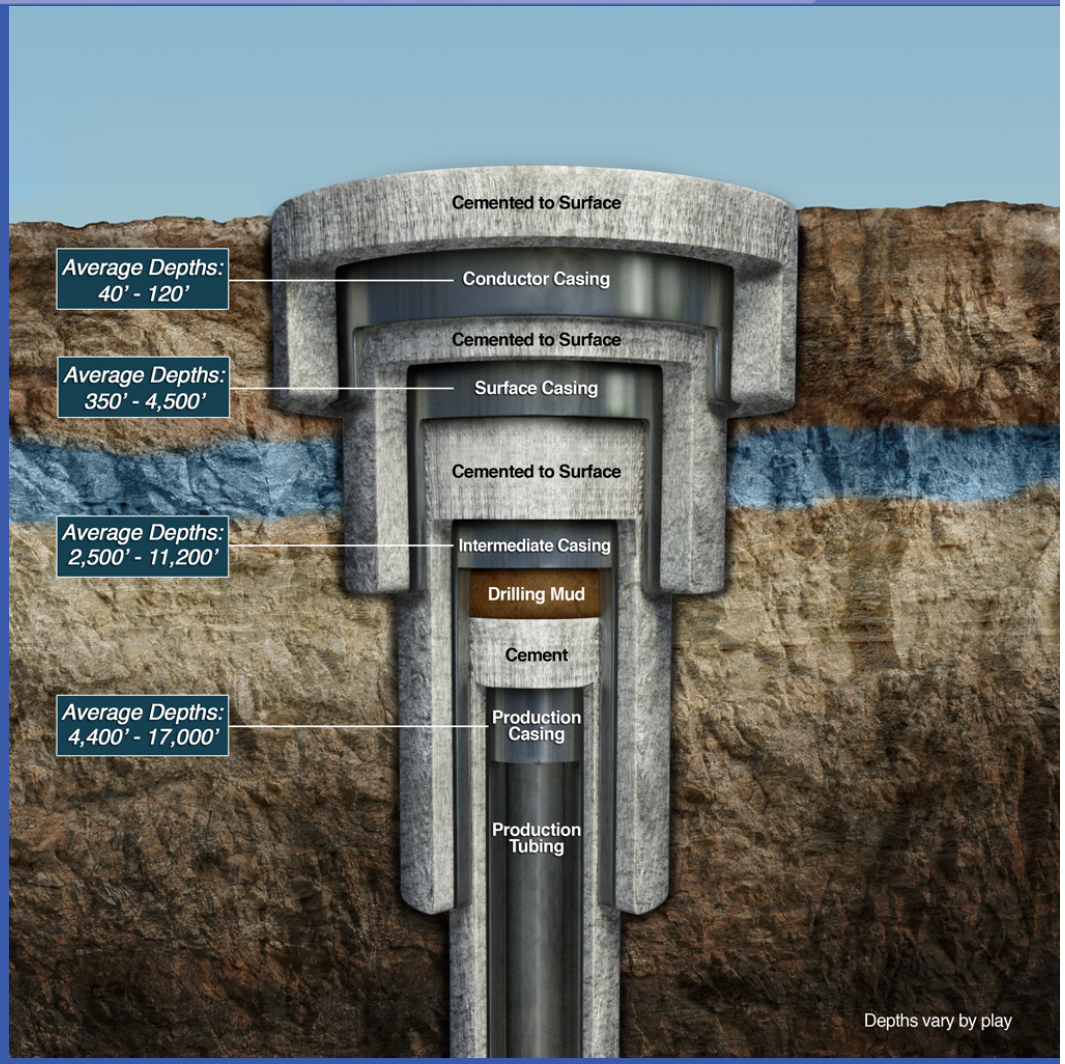
Multiple Layers of Protection

- Knowing where fresh water is located
  - Established by state water protection agencies
- Protective well design
  - Consist of multiple layers of steel casing



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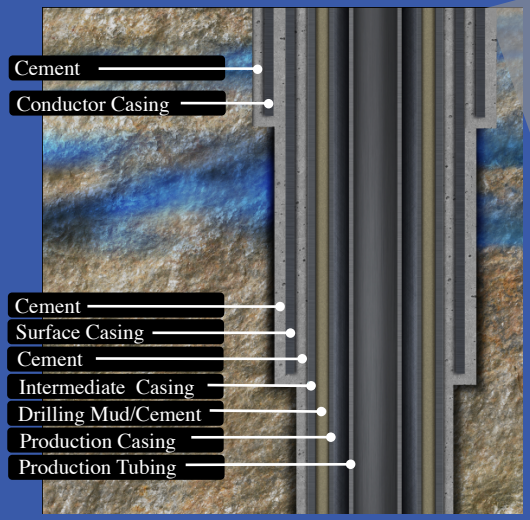
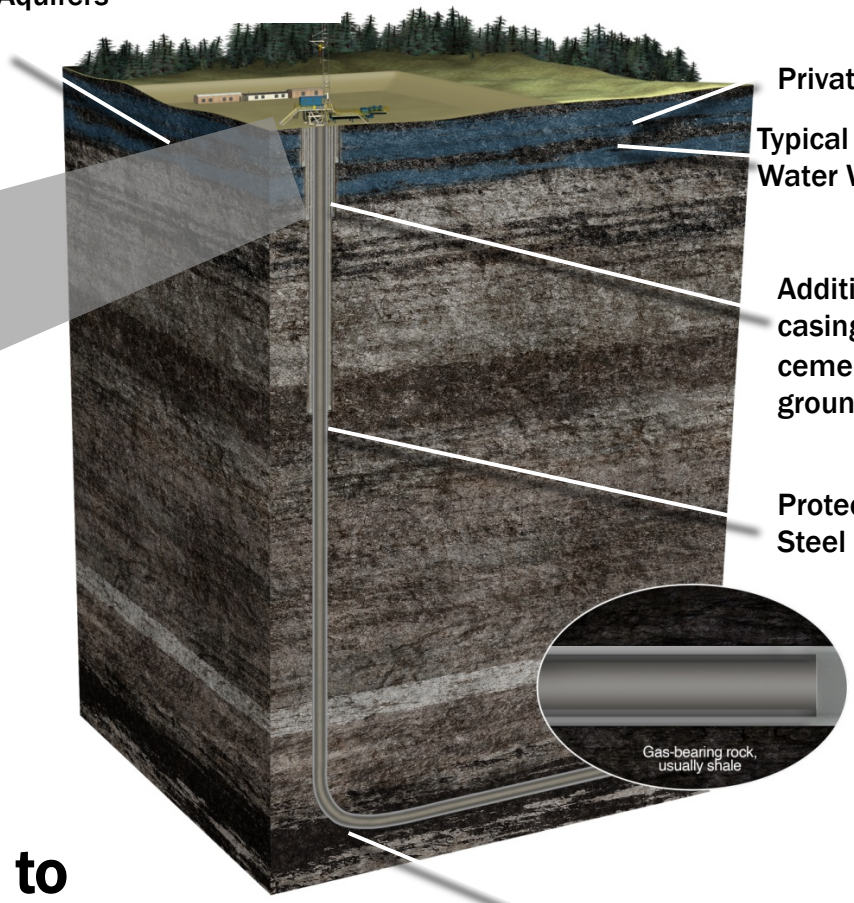
Groundwater Protection



Treatable Groundwater Aquifers



Private Well

Typical Municipal Water Well: < 1,000 ft.

Additional steel casing and cement to protect groundwater

Protective Steel Casing

*not to scale

Average distance from surface: 7,700 ft

What about groundwater protection?

All state drilling regulations specifically address groundwater protection, including requirements for the surface casing to be set below the lowest groundwater aquifer.

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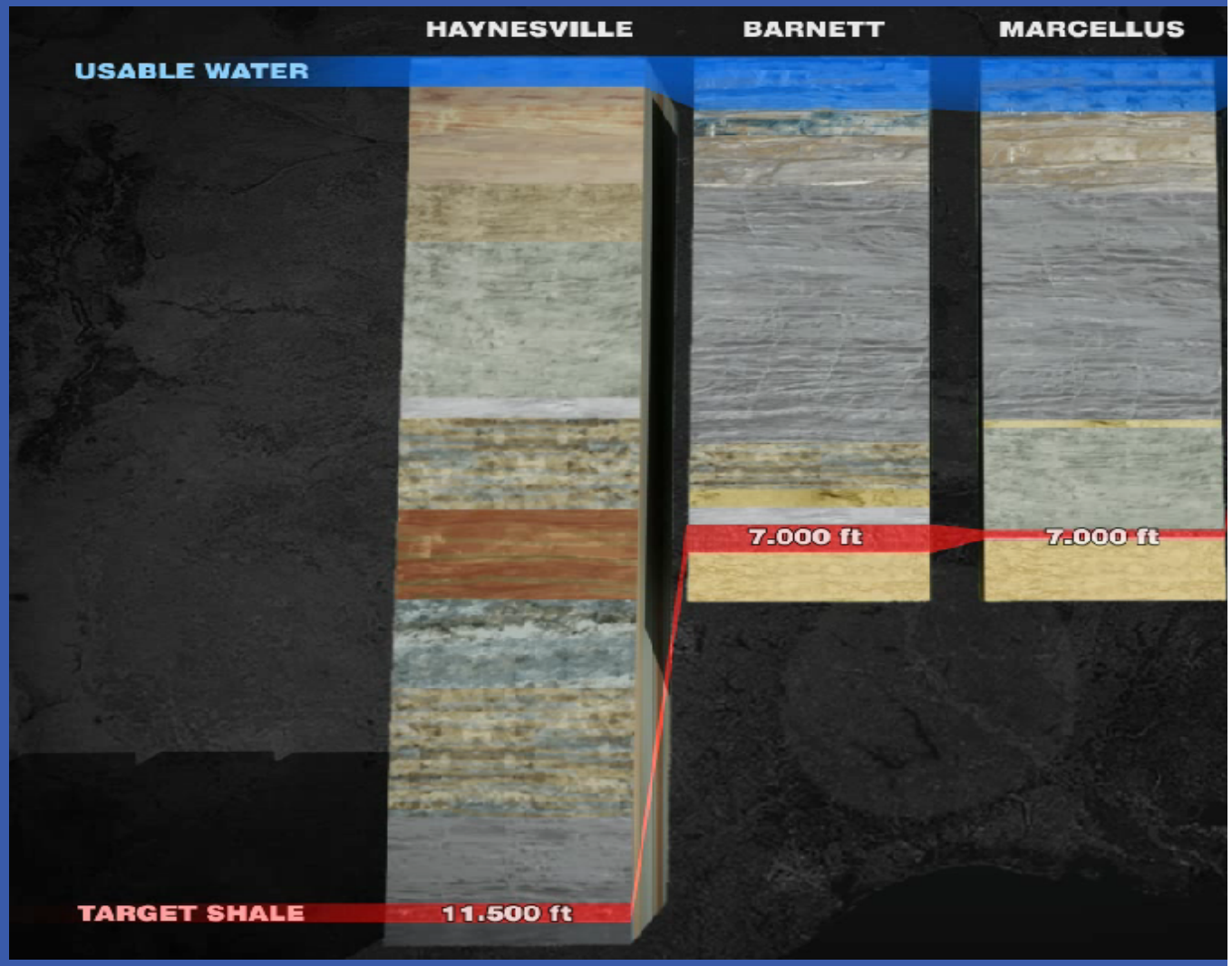
Usable Water vs. Target Depth

State water agencies determine the usable water level
that drives the surface casing programs



What about groundwater protection?

This casing in combination with other steel casing and cement sheaths that are subsequently installed protects the groundwater with multiple layers of protection for the life of the well.

New rules approved by Oklahoma Corporation Commission will require disclosure of hydraulic fracturing chemicals in state

Oklahoma energy companies will have to disclose the chemicals they use in hydraulic fracturing at FracFocus.org or at the state Corporation Commission, if the Oklahoma Legislature gives final approval to new rules.

By Paul Monies | Published: March 21, 2012 1

Oklahoma energy companies will have to disclose the chemicals they use in hydraulic fracturing under new rules approved by the state Corporation Commission.

MORE INFO

We think it's a great step forward and a great first step. We look forward to expanding on the rule later."

David Ocamb

Director of the Oklahoma chapter of the Sierra Club

The rules give companies the option of reporting at a website called FracFocus.org or to the Corporation Commission. The rules now go to the Legislature for its approval.

Oklahoma would join six other states in requiring disclosure of the chemicals.

Hydraulic fracturing, or "fracking," involves injecting water, sand and chemicals at high pressure to break apart

BY PAUL MONIES
ENERGY REPORTER
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Paul Monies is an energy reporter for The Oklahoman. He has worked at newspapers in Texas and Missouri and most recently was a data journalist for...
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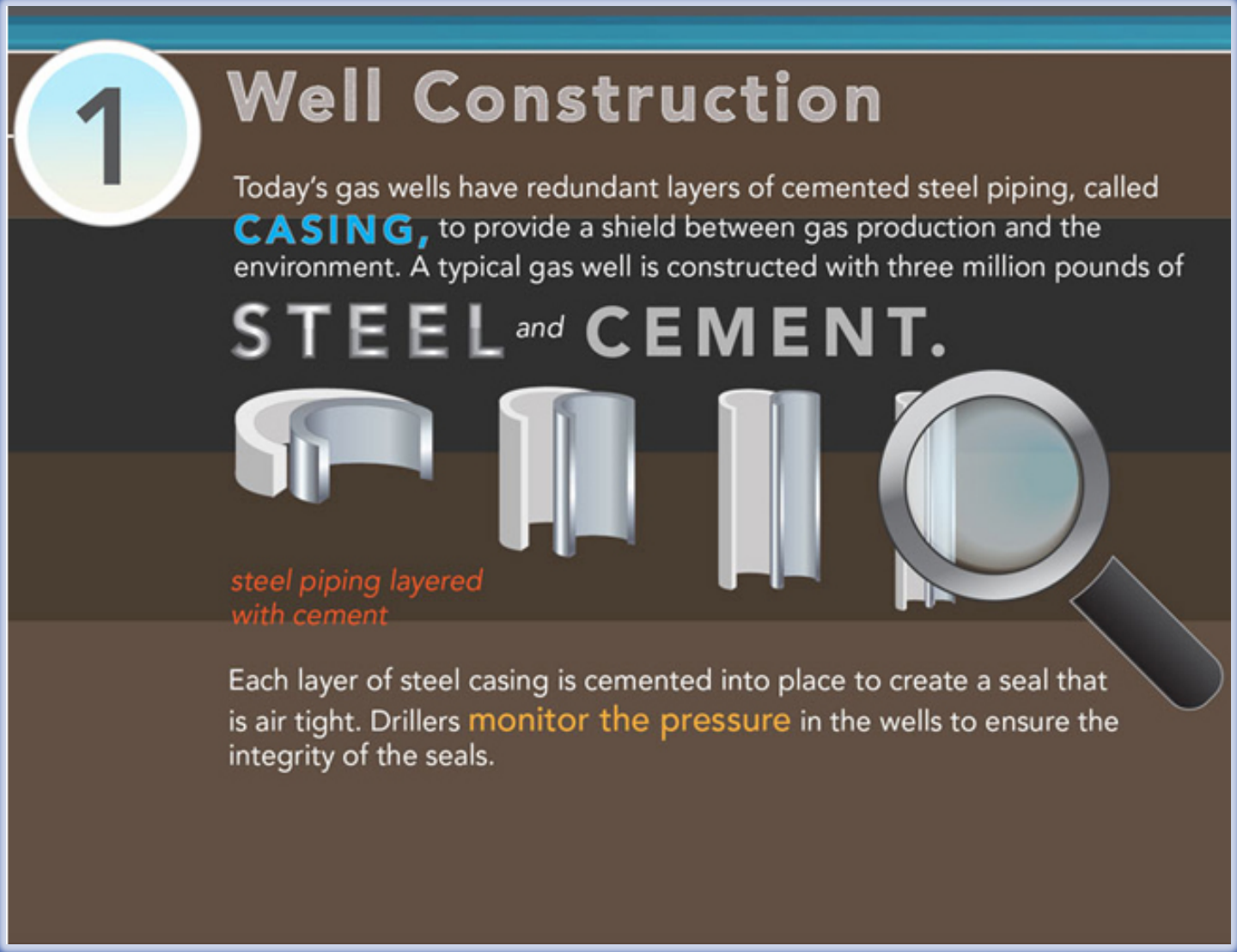
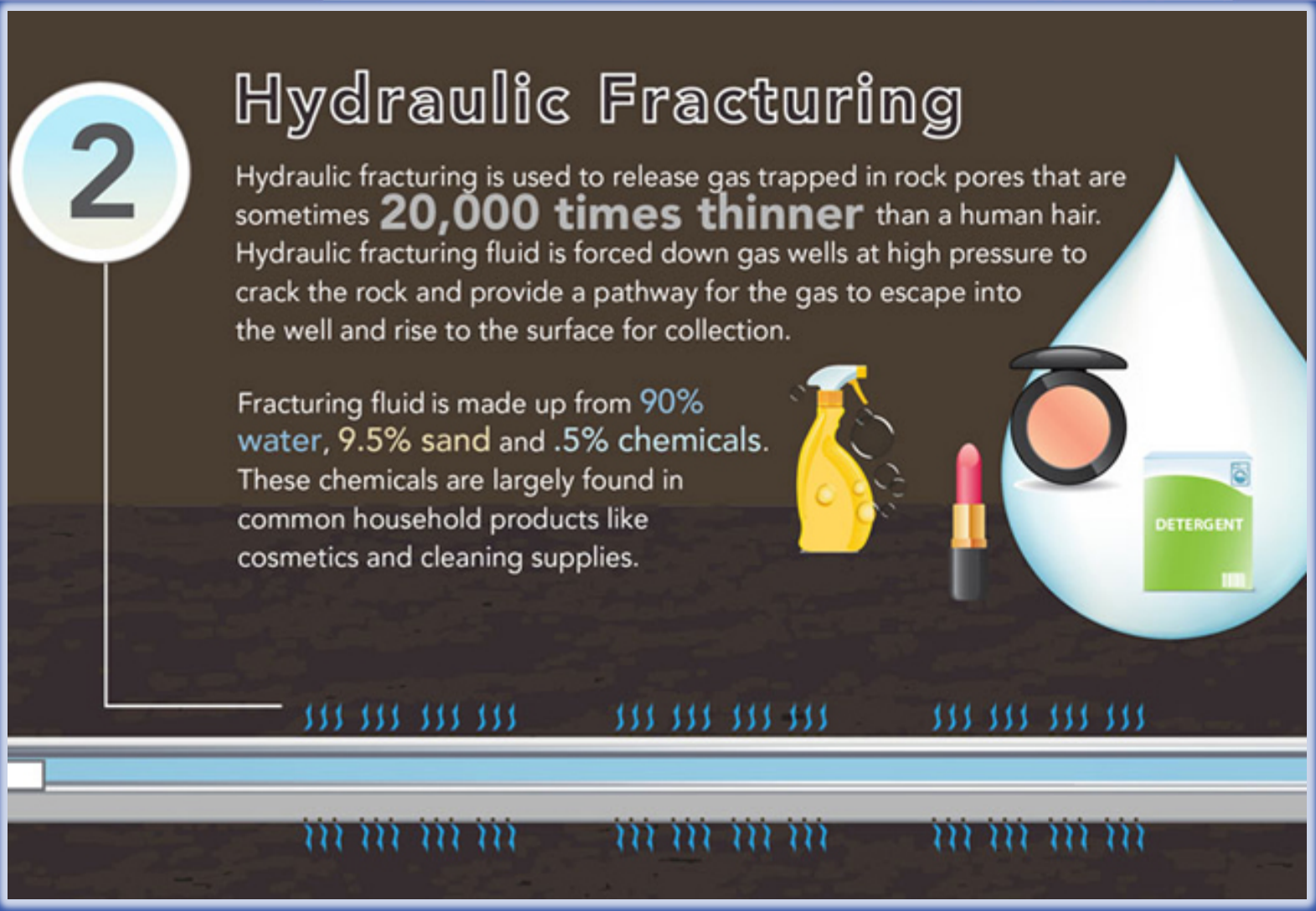


Source: Groundwater Protection Council



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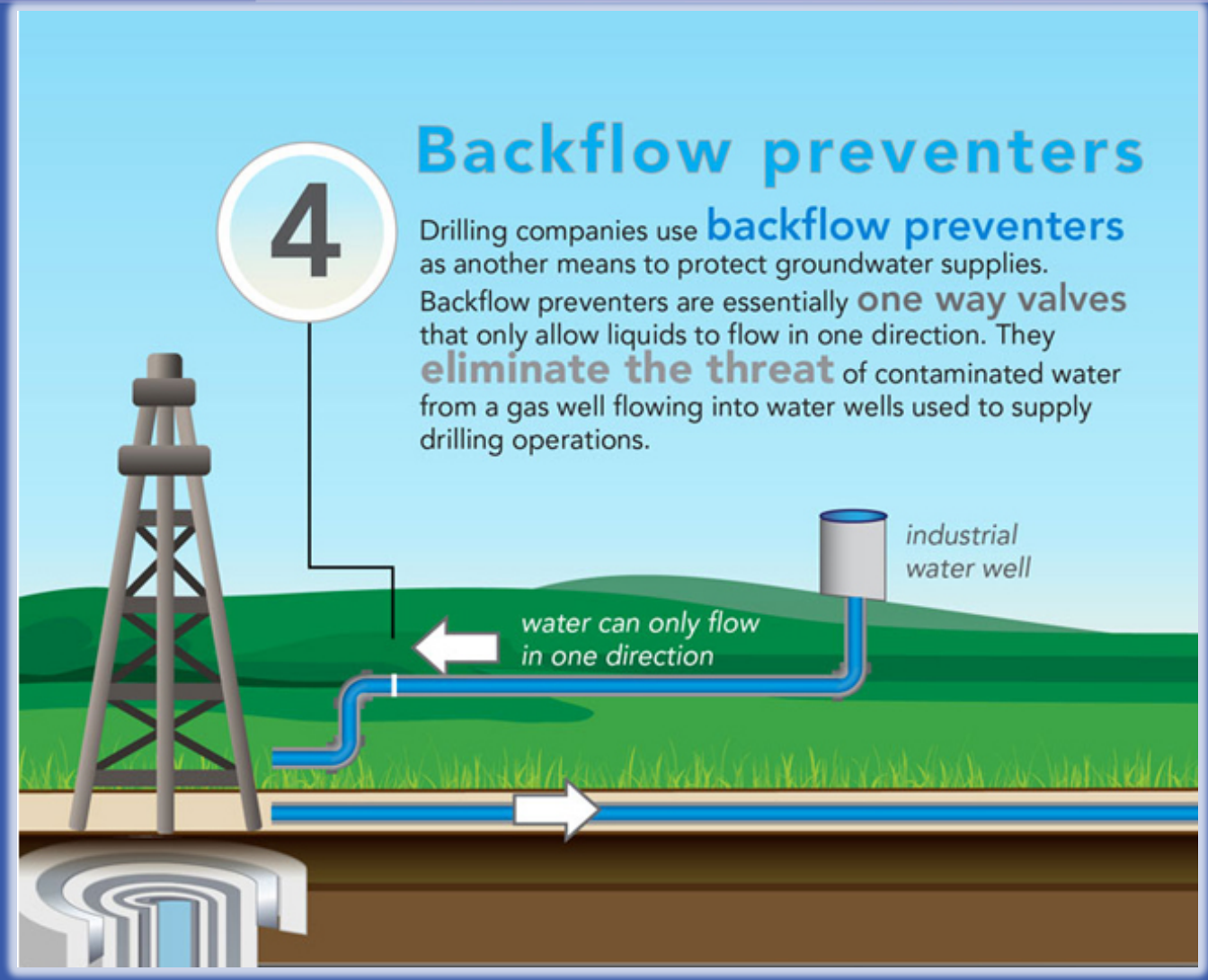

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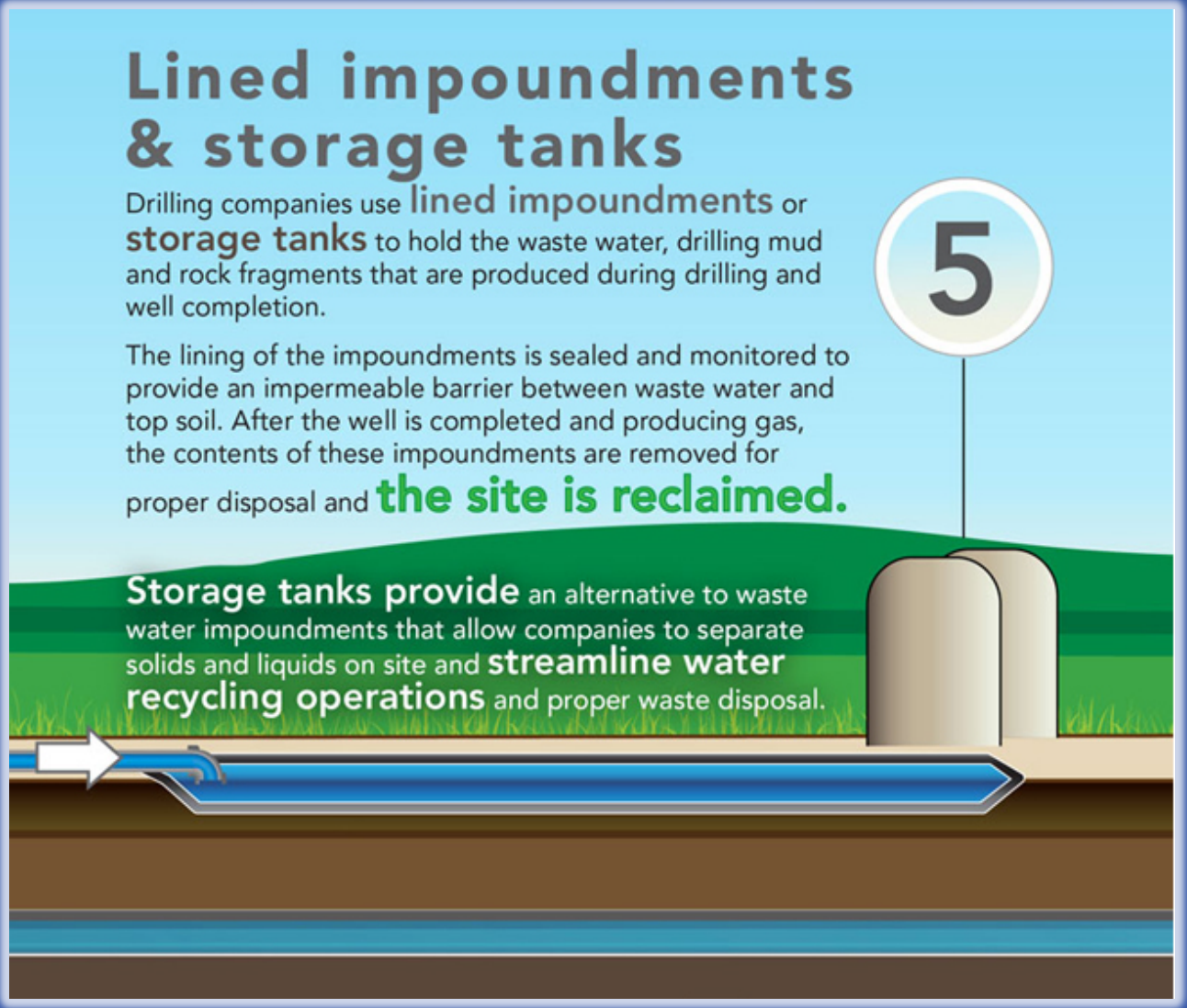

Source: Groundwater Protection Council

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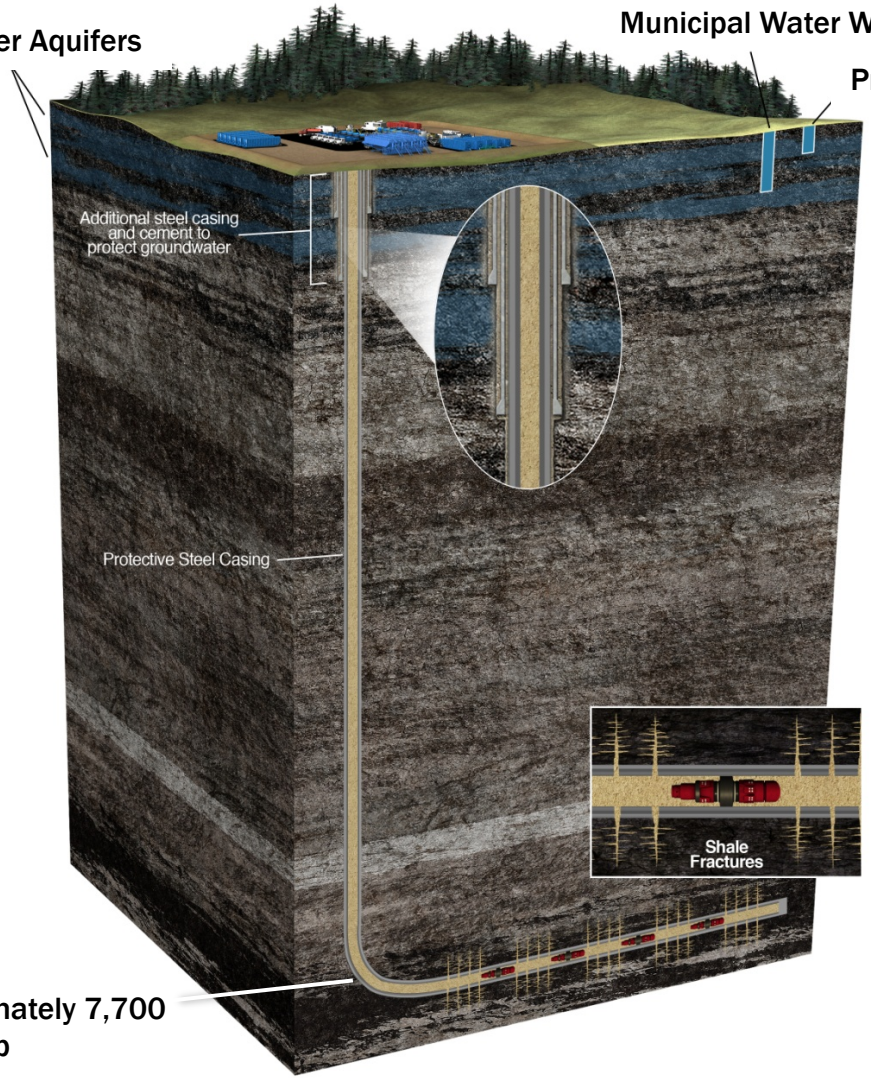
Separation of Hydraulic Fracturing from Freshwater Aquifer



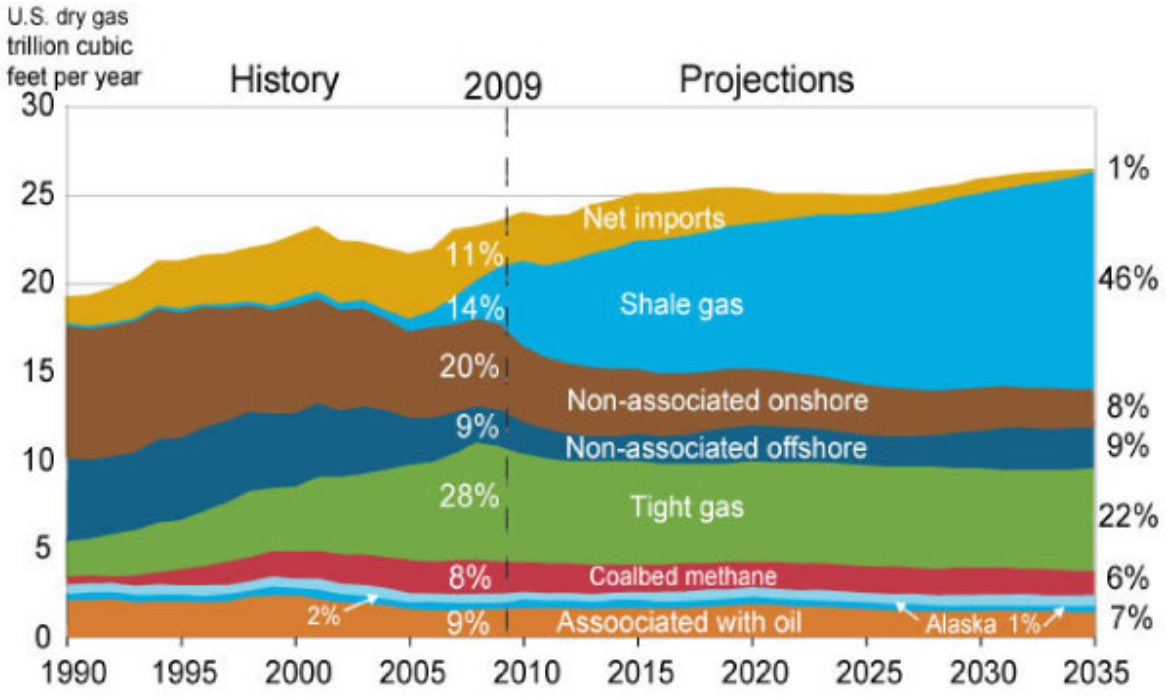
Source: Groundwater Protection Council

Hydraulic fracturing does not introduce new or unique environmental risks to exploration and production operations.

But concerns have been raised due to the potential scale of operations where this technology is applied. Many of these concerns are genuine and the oil and natural gas industry recognizes that there needs to be a bigger conversation about the development process and the steps being taken to ensure safe operations.

Access to Shale Gas has forever changed the U.S. Natural Gas outlook.

U.S. Natural Gas Supply, 1990-2035



Source: EIA, *Annual Energy Outlook 2011*

Shale Gas is expected to account for 46% of U.S. supply in 2035 (up from 14% in 2009).

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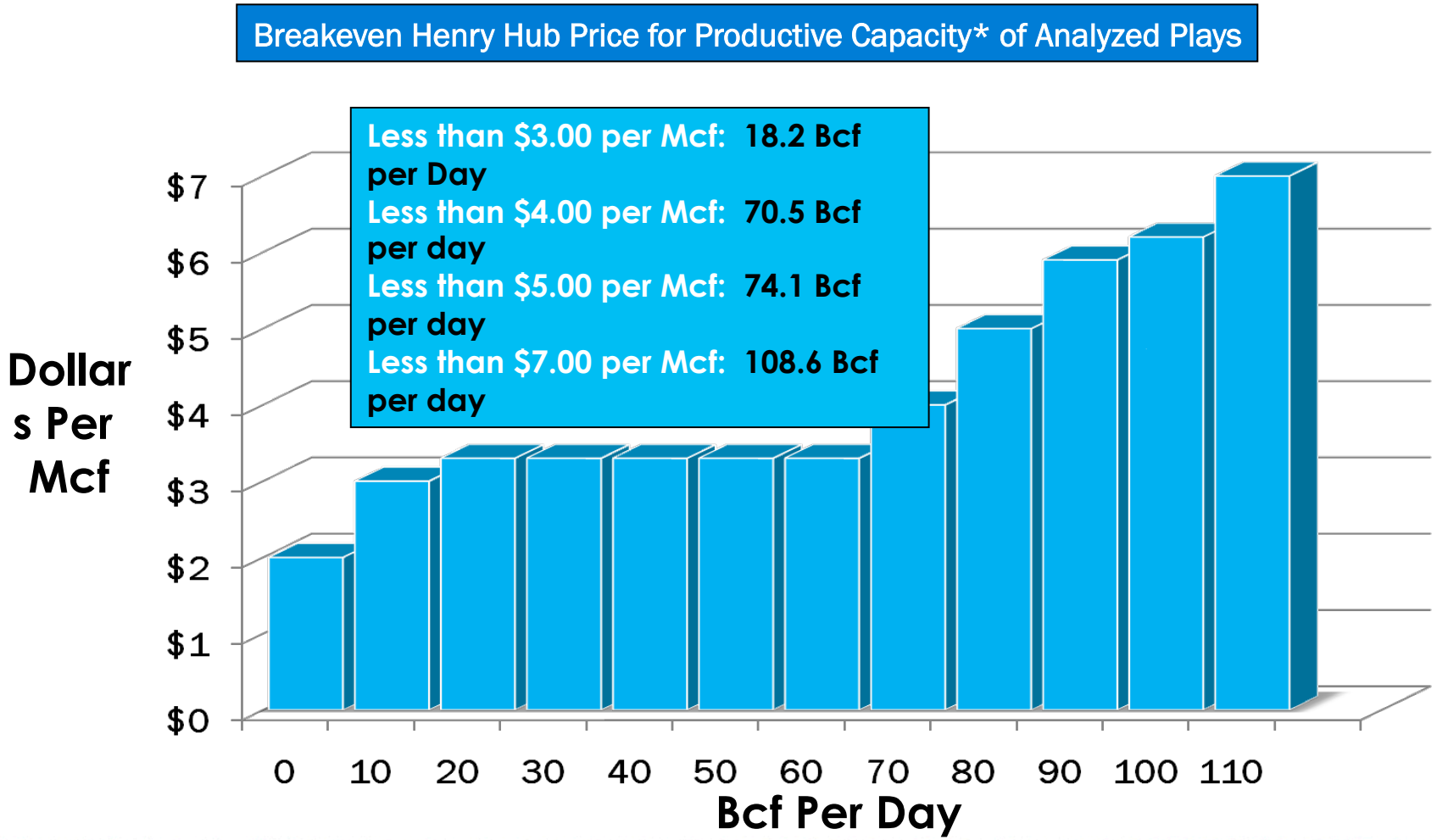
Shale Production Economics Provide Substantial Cost Benefit to Broad Range of Consumers



Source: IHS CERA 2010
* Forty years of plateau proved, possible, and potential productive capacity

"The environmental impacts of shale development are challenging but manageable."

MIT Study on the Future of Natural Gas

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Thank You

Jim Roth

Chair, Alternative Energy Practice Group

PHILLIPS MURRAH, P.C.

jaroth@phillipsmurrah.com
(405) 235-4100

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