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Shale Play Hydraulic Fracturing: Water Quality and Supply Issues

Texas Rural Water Association
Technical Conference
July 14, 2011
Galveston, Texas

Range Resources
EPA Emergency Order

- EPA Emergency Unilateral Order – Dec. 7, 2010; Parker County (Barnett Shale); Effective Immediately -- Issued w/o Hearing
- "Concerns with water quality, indoor air quality, and potential explosivity."
- "The contaminants identified…may present an imminent and substantial endangerment to the health of persons . . . are potentially explosive or flammable, and benzene if ingested or inhaled could cause cancer . . ."
- "EPA has determined that appropriate state and local authorities have not taken sufficient action to address the endangerment…and do not intend to take such action at this time…."

Source: *In the Matter of Range Resources Corporation and Range Production Company*, Environmental Protection Agency, Emergency Administrative Order, SDWA-06-2011-1208.

THE TEXAS TRIBUNE

Even in Texas, Concerns Grow About Gas Drilling

Enlarge

photo by: Stuart Palley

Demonstrators protest against natural gas drilling in downtown Fort Worth, Wednesday April 20th, 2011. The day marked the one year anniversary of BP's Deepwater Horizon rig explosion in the Gulf of Mexico.

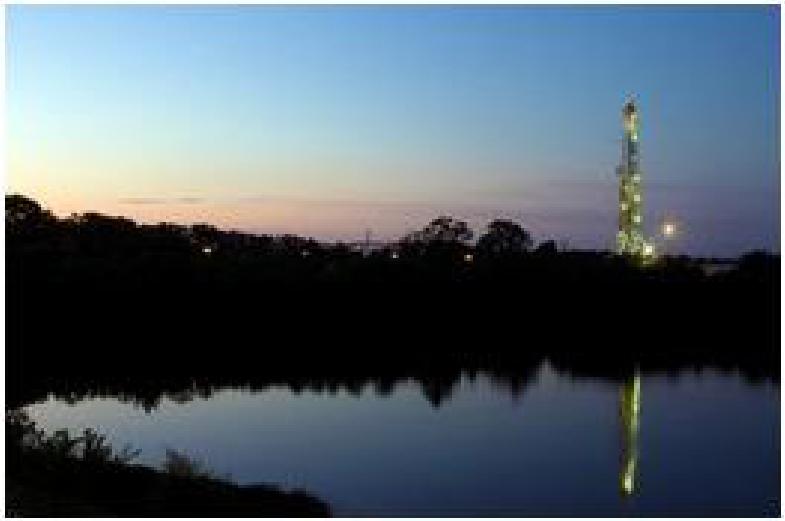
by Kate Galbraith | April 25, 2011 | 35 Comments

Texans pride themselves on being the heart of the nation's oil and gas business. But even here, public concern about the environmental consequences of natural gas drilling is growing. FULL STORY

Media's Take on Fracing

THE TEXAS TRIBUNE

Does Gas Drilling Put Radiation in Texas Water?



Enlarge photo by: Creative Commons/Daniel Foster

by Kate Galbraith | March 11, 2011 | 2 Comments

With drilling on the rise, the Texas Railroad Commission and the Texas Commission on Environmental Quality answer questions about whether Texans need to worry about radioactivity in their water. FULL STORY

Presentation Outline

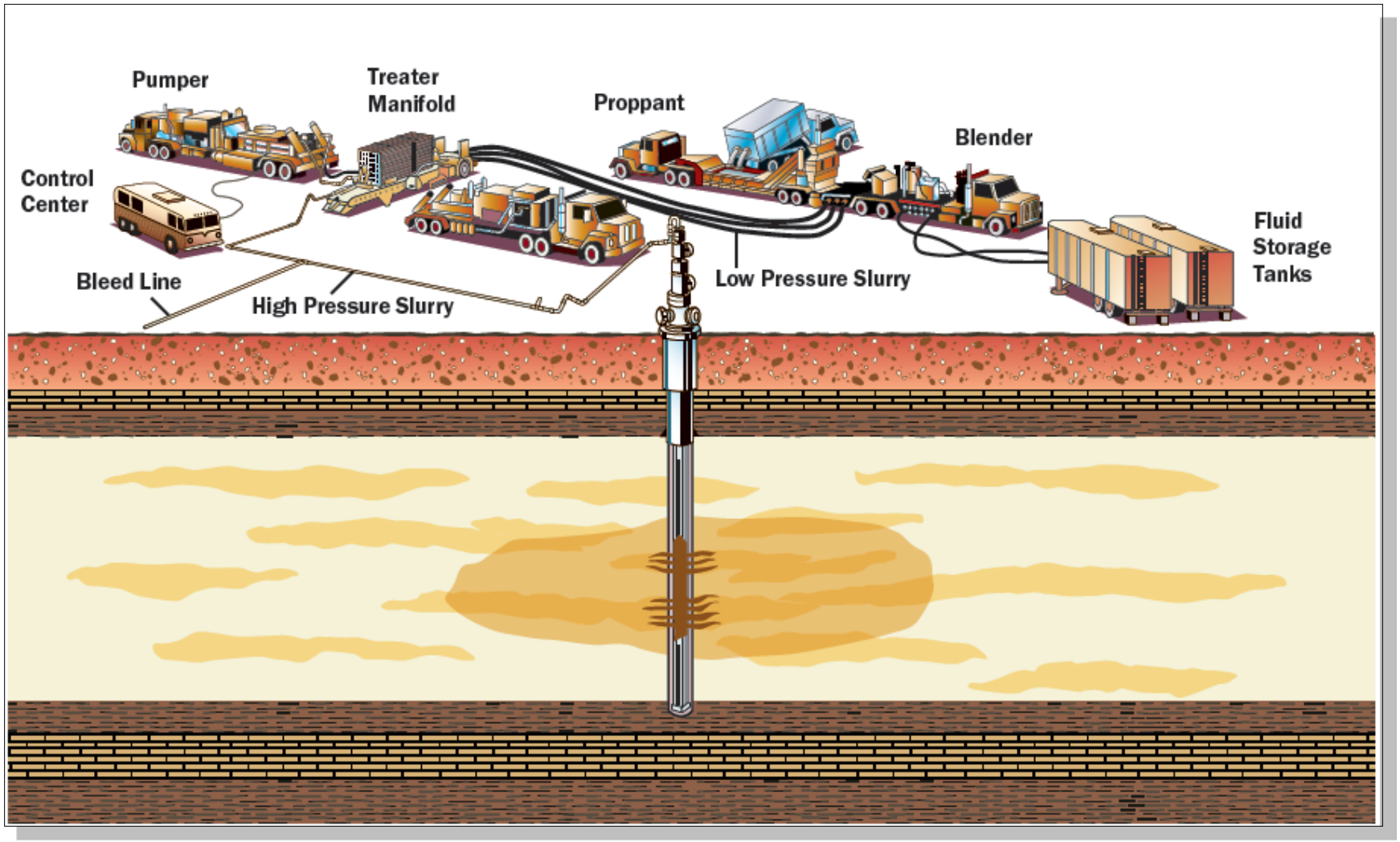
- Unconventional Shale Development in Texas
- Federal and State Regulatory Overview
- Water Needs, Supply Options, and Challenges
- Potential Risks to Groundwater and Surface Water
- Range Resources Case

Hydraulic Fracturing Basics

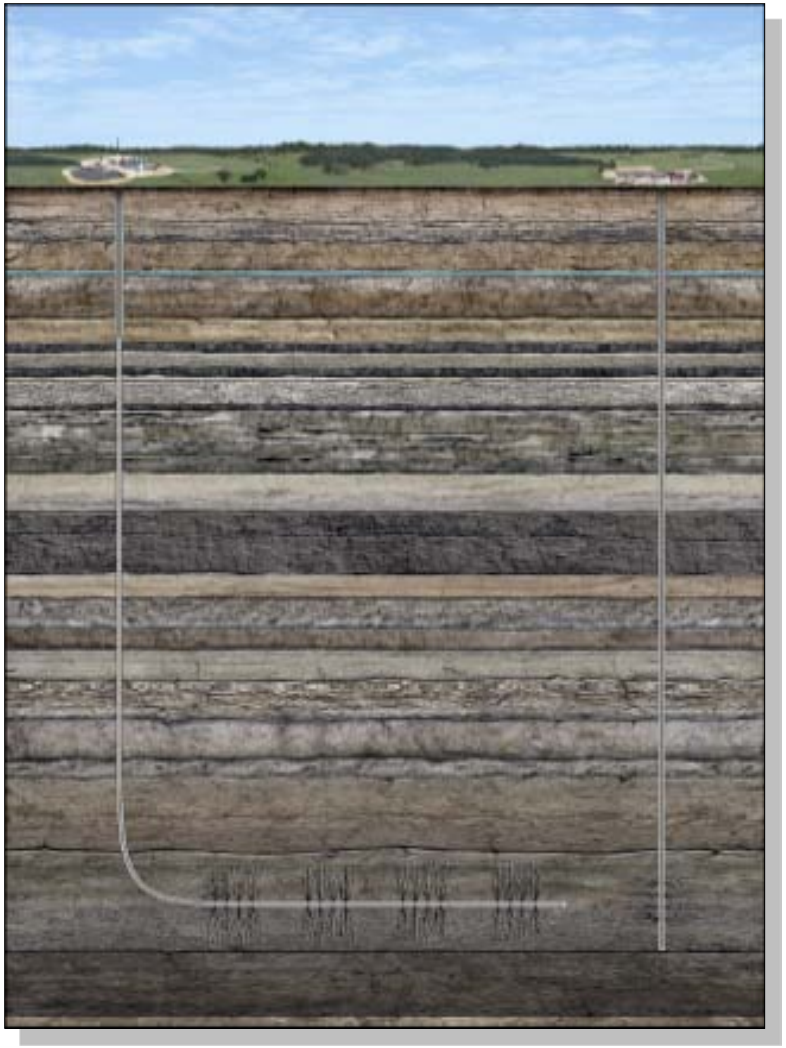
- Patented in 1948; “shooting” wells date back to 1860s.
- Method: Pumping fluids at high pressures into producing formations to create fissures to allow more natural gas to escape.
- Typically takes place in horizontal wells, which may extend thousands of feet of horizontally at depth.
- Fracturing fluids are composed typically of:
  - 90% water
  - 9.5% sand
  - 0.5% other chemicals

Source: Freeing Up Energy, Hydraulic Fracturing: Unlocking America’s Natural Gas Resources, API, July 19, 2010. (API, Freeing Up Energy).

Hydraulic Fracturing of Marcellus Shale Well Source: DOE, Fracing Primer

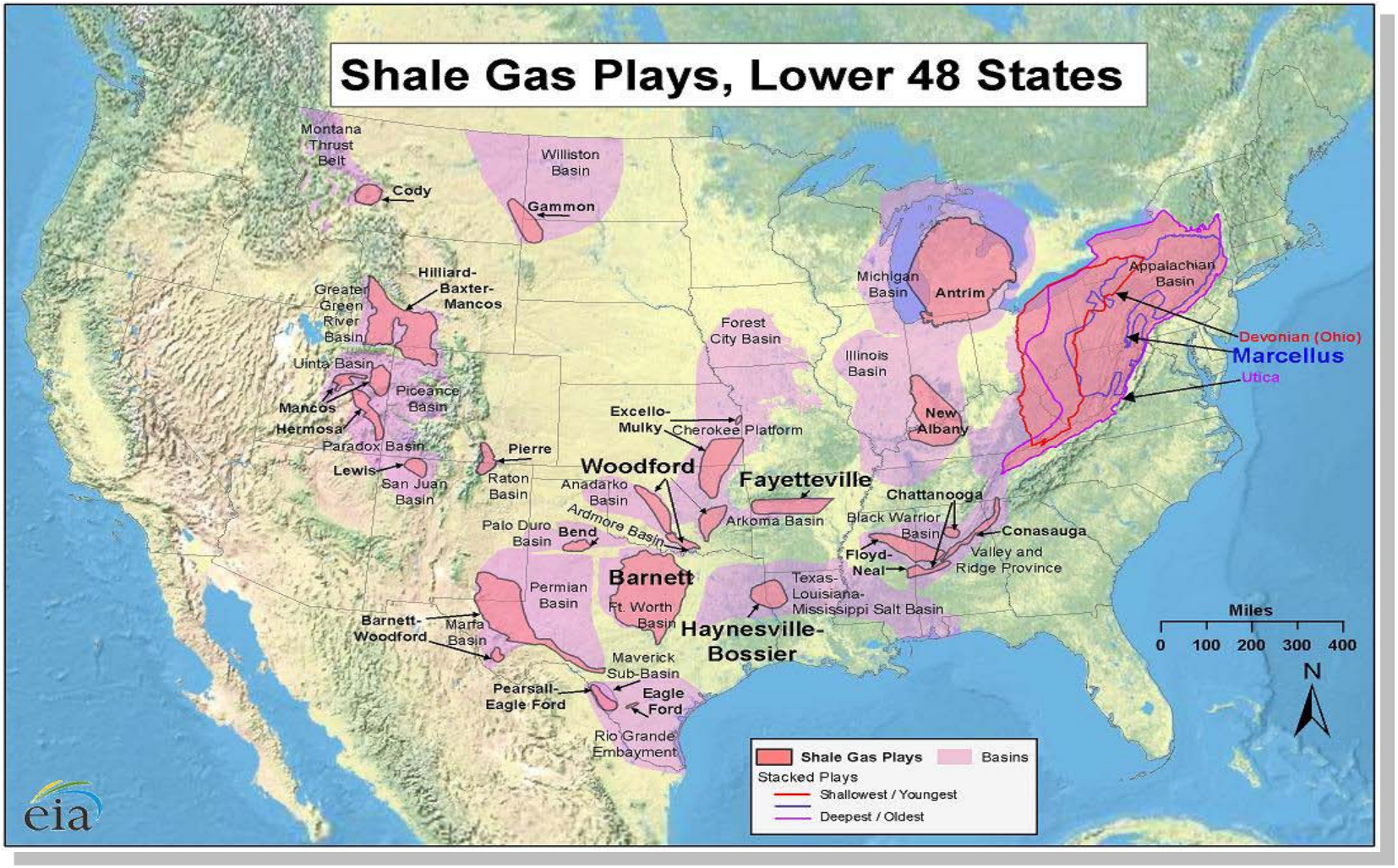


Source: DOE



Horizontal and Vertical Well Completions
Source: DOE, Fracing Primer

U.S. Shale Plays

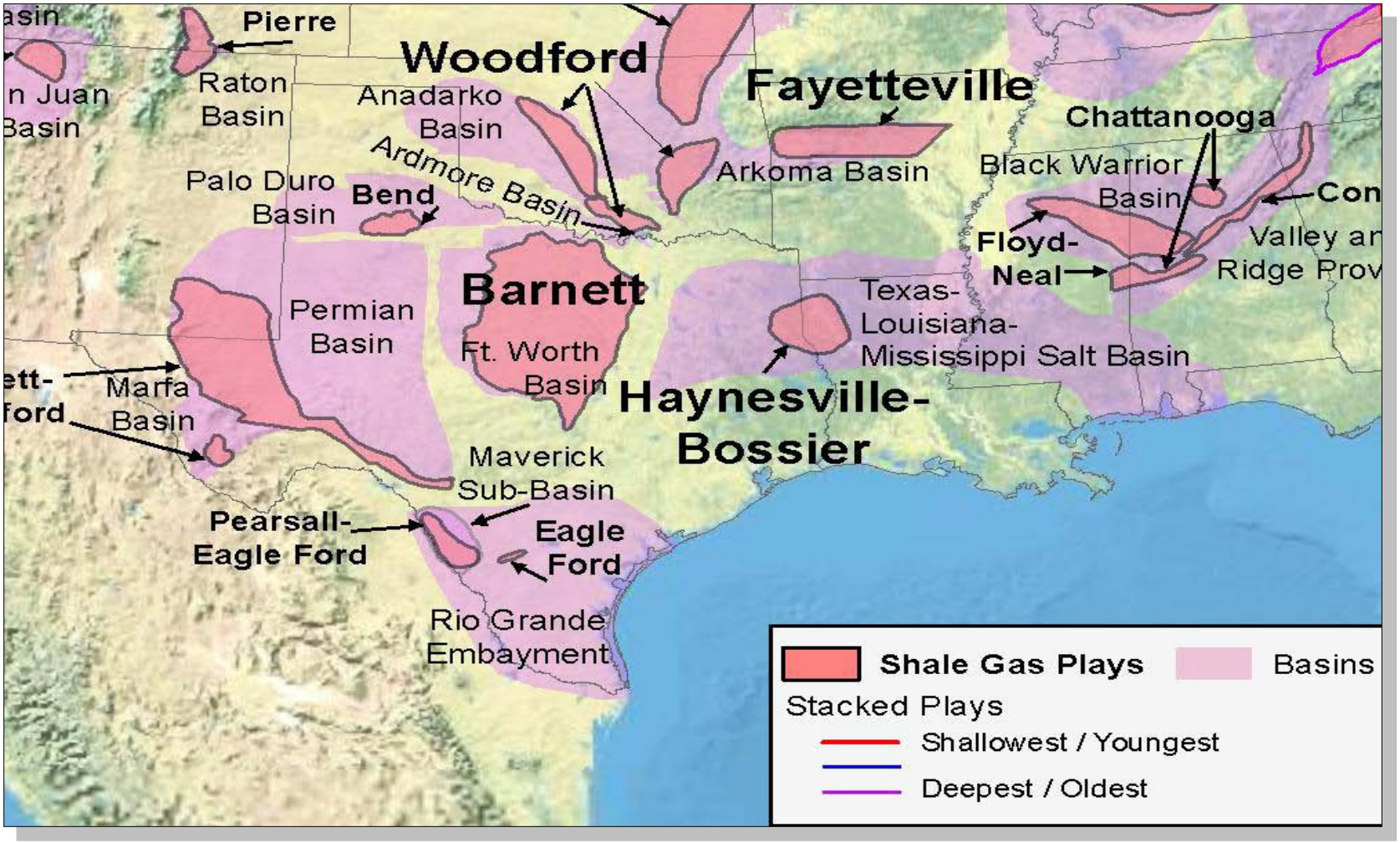


Source: U.S. Energy Information Administration (EIA), http://www.eia.doe.gov/energy_in_brief/about_shale_gas.cfm.

Three Primary Texas Shale Plays

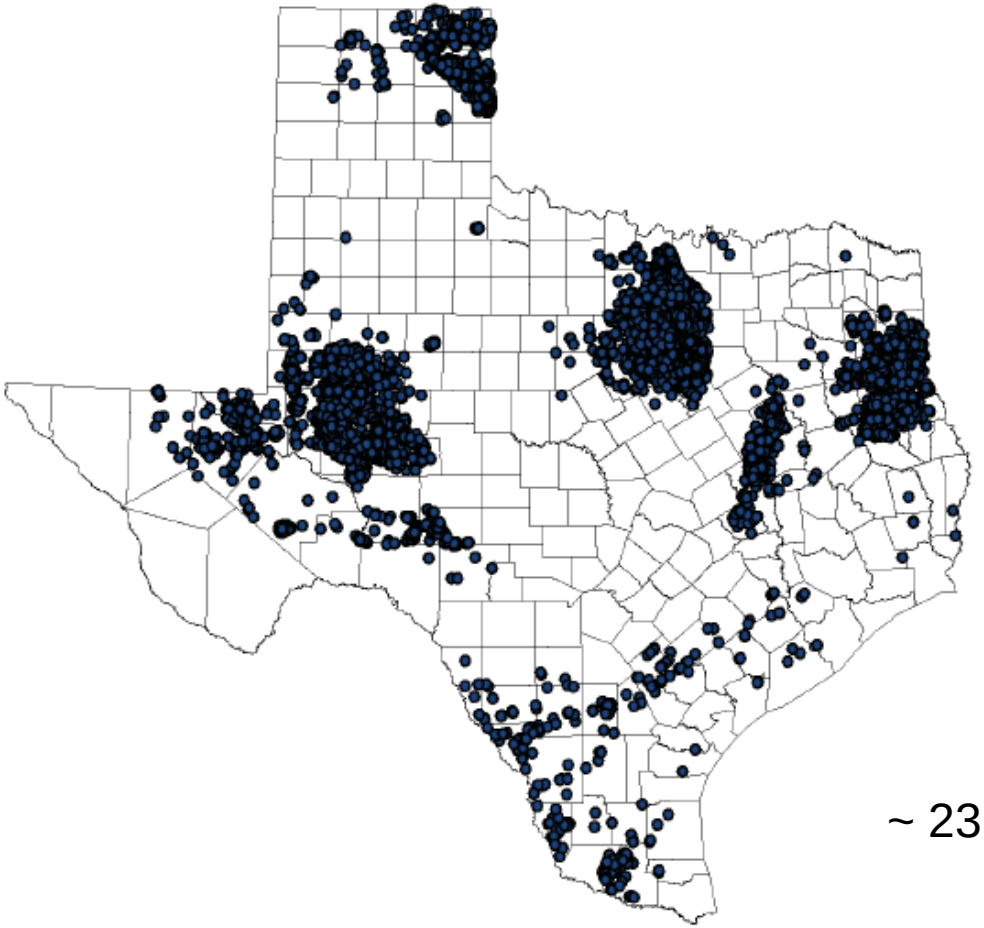
- Barnett (Gas)
  - Ft. Worth area
- Haynesville (Gas)
  - Far East Texas – Extends into Louisiana
- Eagle Ford (Gas and Oil)
  - South of San Antonio

Texas Shale Plays



Source: EIA, http://www.eia.doe.gov/energy_in_brief/about_shale_gas.cfm.

All Texas Frac Jobs 2005-2009



~ 23,500 Wells

Source: TWDB Frac Study

Shale Natural Gas Reserves and Production (BCF)

U.S. Proven Reserves & Production:

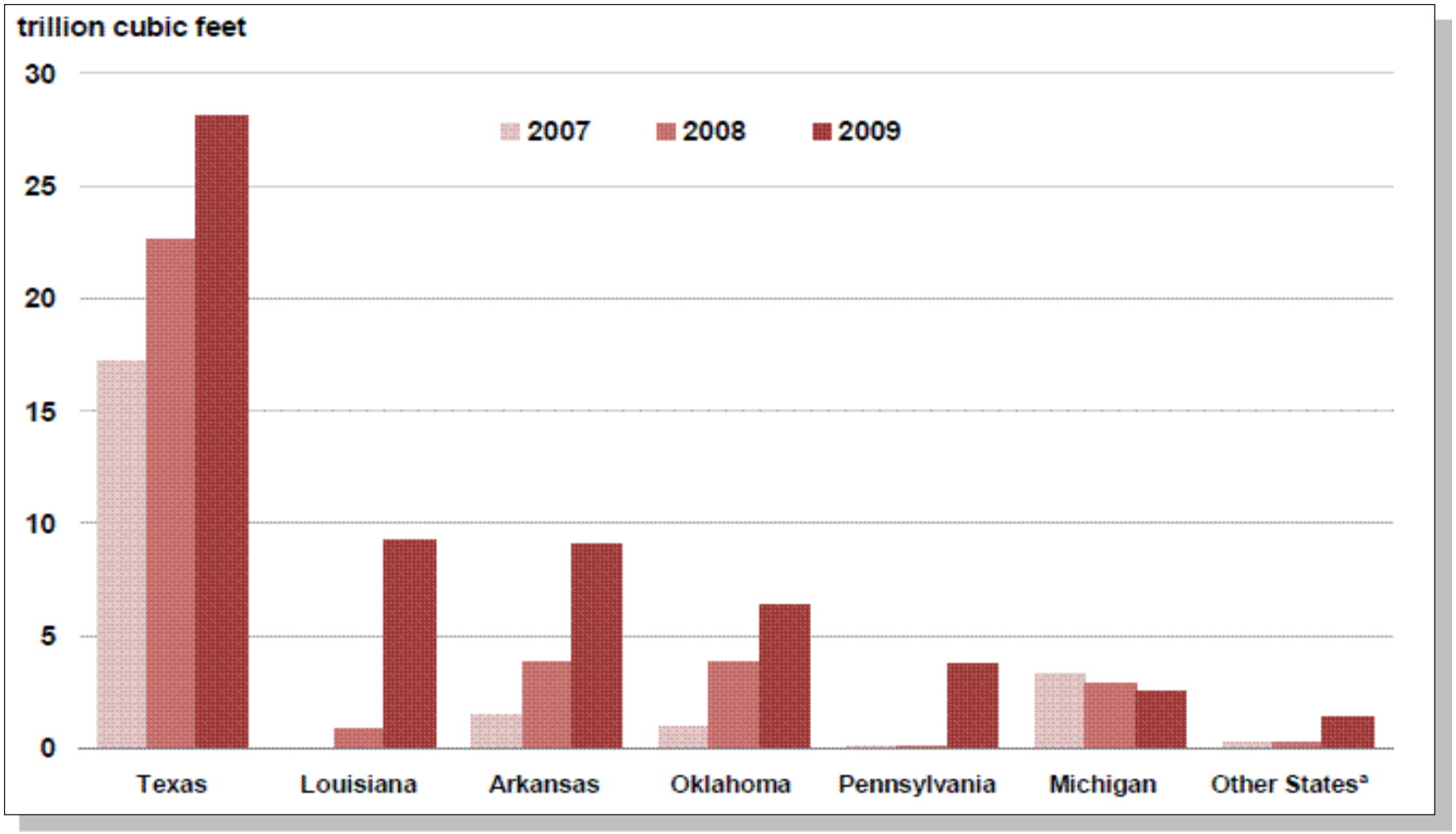
- Reserves
  - 2007: 23,304
  - 2008: 34,428
  - 2009: 60,644
- Production
  - 2007: 1,293
  - 2008: 2,116
  - 2009: 3,110

Texas Proven Reserves & Production:

- Reserves
  - 2007: 17,256
  - 2008: 22,667
  - 2009: 28,167
- Production
  - 2007: 988
  - 2008: 1,503
  - 2009: 1,789

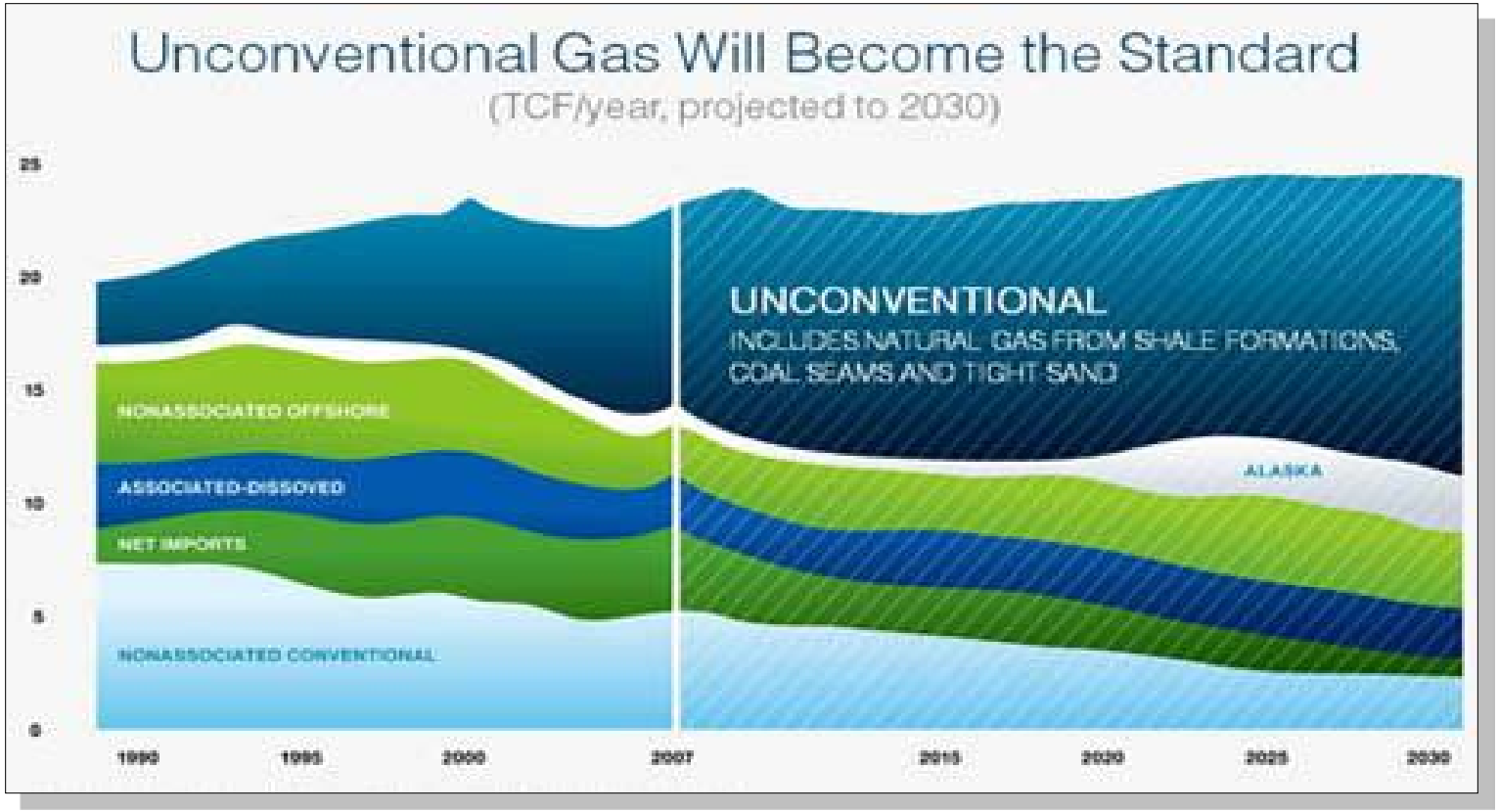
Sources: EIA, http://www.eia.doe.gov/dnav/ng/ng_prod_shalegas_s1_a.htm and EIA, http://www.eia.doe.gov/dnav/ng/ng_enr_shalegas_dcu_NUS_a.htm.

Shale Natural Gas Reserves



Source: EIA, http://www.eia.doe.gov/oil_gas/natural_gas/data_publications/crude_oil_natural_gas_reserves/cr.html.

Shale Natural Gas Production



Source: America's Natural Gas Alliance (ANGA), http://www.anga.us/learn-the-facts/abundance/market-stability.

Federal Regulation

- Safe Drinking Water Act exempts fracing (except w/ diesel fuel) from regulation as "underground injection" by the Energy Policy Act of 2005. (42 U.S.C. 300h(d)(1)(B)(ii)).
  - Bills introduced March 15, 2011 to remove exemption (HR 1084).
  - Similar bills introduced in Senate (S 587) and in past (2009 – HR 2766).

- April 12, 2011: EPA Deputy Administrator Bob Perciasepe testified before Congress that using diesel in fracing requires an SDWA permit or is a violation.
  - Some members of industry have previously stated that diesel is used, but also report being unable to obtain diesel fracing permits from EPA in past despite efforts.

- April 26, 2011: EPA Administrator Lisa Jackson announced EPA will issue guidance soon on the use of diesel fuel in fracing.

Other Federal Studies and Reports

- April 16, 2011:
  - Congressional report prepared by Waxman, Markey, and DeGette outlining chemicals used in fracing, including benzene, lead, and methanol.
  - Alleged use of 29 chemicals that are known or possible carcinogens.
- April 2011:
  - Prepublication of report by Cornell Professors that CO2 emissions from shale fracing are greater than coal.

Sources: U.S. House Committee on Energy and Commerce, Chemical Used in Hydraulic Fracturing (April 2011) and Robert Howard, et al, Methane and the Greenhouse-Gas Footprint of Natural Gas from Shale Formations (2011).

EPA Hydraulic Fracing Study Plans

- February 8, 2011 EPA releases Draft Hydraulic Fracturing Study Plan
- Study designed to examine “life cycle” of fracing, particularly potential affect to drinking water resources and human exposure to chemicals.
- Study will analyze and research questions involving:
  - Water Acquisition; Chemical Mixing; Well Injection; Flowback and Produced Water; and Wastewater Treatment and Waste Disposal
- Study will include:
  - Retrospective case studies, possibly in Barnett Shale counties of Wise and Denton Counties
  - Prospective cases studies, possibly in Flower Mound/Bartonville.
- Study expected to be completed in 2012, with 2014 follow-up.
- In 2004, EPA conducted study finding that hydraulic fracturing in coal-bed methane wells pose little to no threat to underground drinking water.

Sources: EPA Frac Study Plan and Evaluation of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs (EPA 816-R-04-003), 2004.

Texas Regulation

- Railroad Commission of Texas (RCT) has primary oversight authority, not Texas Commission on Environmental Quality (TCEQ)
- May 2009 RCT Chairman letter: “not…a single documented contamination case associated with hydraulic fracturing.”
- No specific regulation of Frac methods, but generally covered by RCT oil and gas rules.
- Bills filed in 2011 to increase fracing regulation died (Except SB 3328)

Existing RCT Regulations

- Groundwater protection regulations include:

  Rule 5 - Permit required for drilling and deepening of wells (does not specifically cover fracing operations).

  Rule 8 - Groundwater protection and regulates storage and disposal of oil and gas wastes.

  Rule 9 - Disposal wells for oil and gas waste

  Rule 13 - Establishes casing, cementing, drilling, and completion of well requirements.

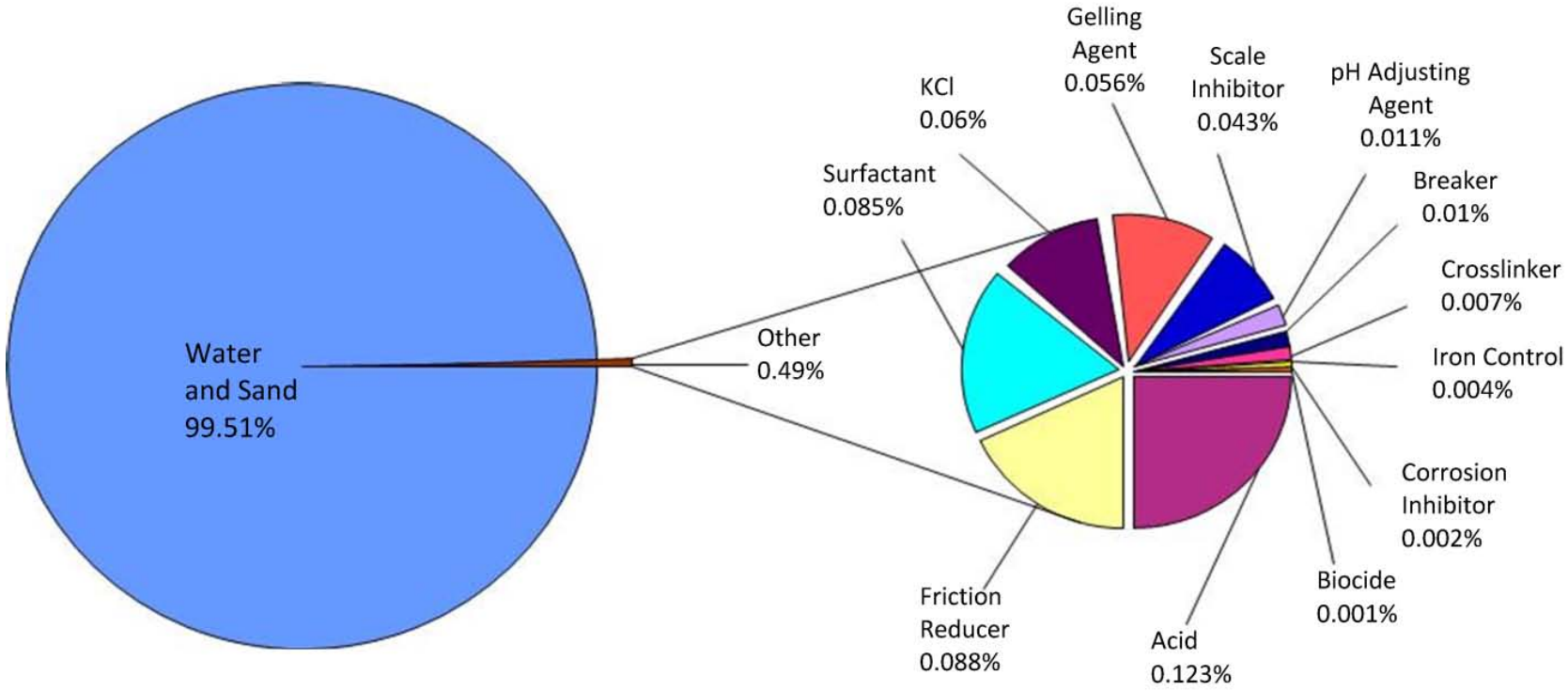
  Rule 46 - Requires permit for fluid injection for enhanced oil recovery but does NOT regulate fracing.

  Rules are at 16 TAC Section 3.XX

Texas HB 3328
Frac Fluids Disclosure

- **Mandates Disclosure** of the composition of hydraulic fracturing fluids used in fracturing wells
  - **Site Specific – Well by Well**
  - **MSDS Chemicals and Non-MSDS** (intentionally added) to be posted on Internet and filed with RCT
  - **Trade Secret Protection** per Public Information Act
- **RCT** has begun rulemaking (to be adopted by July 1, 2012)

Volumetric Composition of Frac Fluid



DOE, Modern Shale Gas Development in the United States: A primer

Fracing Chemical Additives

Additive Type	Main Compound(s)	Purpose	Common Use of Main Compound
Acid, Diluted (15%)	Hydrochloric acid or muriatic acide	Help dissolve minerals and initiate cracks in the rock	Swimming pool chemical and cleaner
Biocide	Glutaraldehyde	Eliminates bacteria in the water that produce corrosive byproducts	Disinfectant; sterilize medical and dental equipment
Breaker	Ammonium persulfate	Allows a delayed break down of the gel polymer chains	Bleaching agent in detergent and hair cosmetics, manufacture of household plastics
Corrosion Inhibitor	N,n-dimethyl formamide	Prevents the corrosion of the pipe	Used in pharmaceuticals, acrylic fibers, plastics
Crosslinker	Borate salts	Maintains fluid viscosity as temperature increases	Laundry detergents, hand soaps, and cosmetics
Friction Reducer	Polyacrylamide; Mineral oil	Minimizes friction between the fluid and the pipe	Water treatment, soil condition; Make-up remover, laxatives, candy
Gel	Guar gum or hydroxyethyl cellulose	Thickens the water in order to suspend the sand	Cosmetics, toothpaste, sauces, baked goods, ice cream

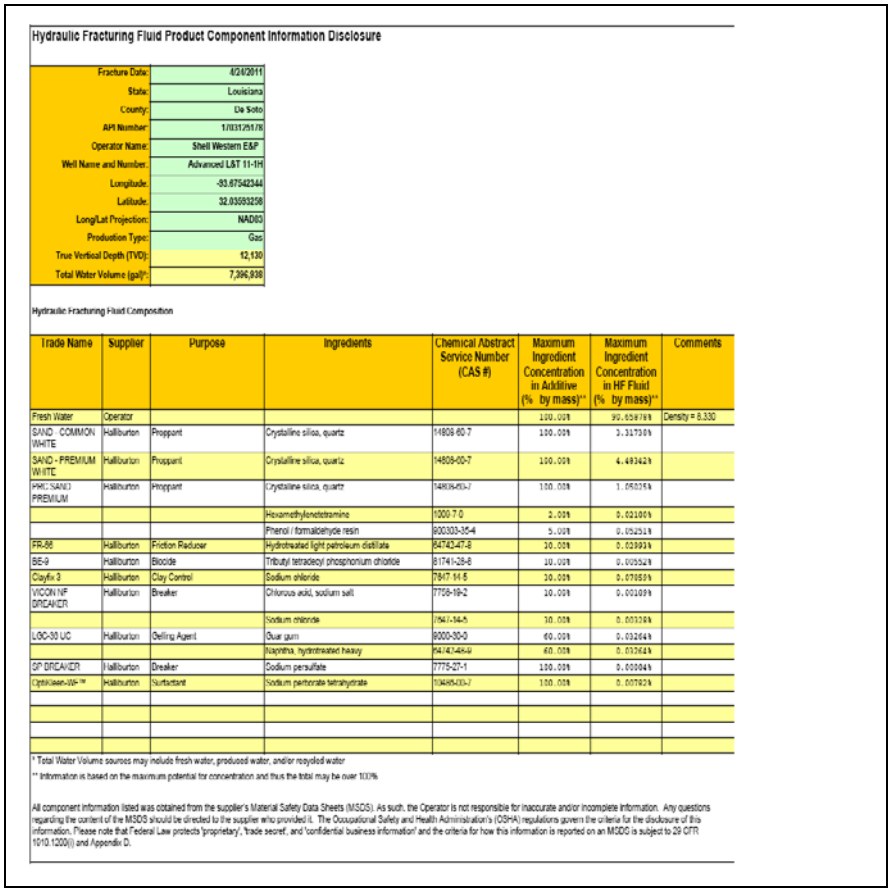
Source: DOE, Modern Shale Gas Development in the United States: A Primer

Fracing Chemicals Additives

Additive Type	Main Compound(s)	Purpose	Common Use of Main Compound
Iron Control	Citric acid	Prevents precipitation of metal oxides	Food additive, flavoring in food and beverages; Lemon Juice ~7% Citric Acid
KCl	Potassium chloride	Creates a brine carrier fluid	Low sodium table salt substitute
Oxygen Scavenger	Ammonium bisulfite	Removes oxygen from the water to protect the pipe from corrosion	Cosmetics, food and beverage processing, water treatment
pH Adjusting Agent	Sodium or potassium carbonate	Maintains the effectiveness of other components, such as crosslinkers	Washing soda, detergents, soap, water softener, glass and ceramics
Proppant	Silica, quartz sand	Allows the fractures to remain open so the gas can escape	Drinking water filtration, play sand, concrete, brick mortar
Scale Inhibitor	Ethylene glycol	Prevents scale deposits in the pipe	Automotive antifreeze, household cleansers, and deicing agent
Surfactant	Isopropanol	Used to increase the viscosity of the fracture fluid	Glass cleaner, antiperspirant, and hair color

Source: DOE, Modern Shale Gas Development in the United States: A Primer

FracFocus.Org



Hydraulic Fracturing Fluid Product Component Information Disclosure

Fracture Date:	4/24/2011
State:	Louisiana
County:	De Soto
API Number:	17031251170
Operator Name:	Shell Western E&P
Well Name and Number:	Advanced L&T 11-1H
Longitude:	-93.87542344
Latitude:	32.03593258
Long/Lat Projection:	NAD83
Production Type:	Gas
True Vertical Depth (TVD):	12,130
Total Water Volume (gal)*:	7,396,938

Hydraulic Fracturing Fluid Composition

Trade Name	Supplier	Purpose	Ingredients	Chemical Abstract Service Number (CAS #)	Maximum Ingredient Concentration in Additive (% by mass)**	Maximum Ingredient Concentration in HF Fluid (% by mass)**	Comments
Fresh Water	Operator				100.00%	90.65979%	Density = 8.330
SAND - COMMON WHITE	Halliburton	Proppant	Crystalline silica, quartz	14808-60-7	100.00%	3.31730%	
SAND - PREMIUM WHITE	Halliburton	Proppant	Crystalline silica, quartz	14808-60-7	100.00%	4.48342%	
PRC SAND PREMIUM	Halliburton	Proppant	Crystalline silica, quartz	14808-60-7	100.00%	1.05025%	
			Hexamethylenetetramine	1000-7 0	2.00%	0.02100%	
			Phenol / formaldehyde resin	900303-35-4	5.00%	0.05251%	
FR-66	Halliburton	Friction Reducer	Hydrotreated light petroleum distillate	64742-47-8	30.00%	0.02993%	
BE-9	Halliburton	Biocide	Tributyl tetradecyl phosphonium chloride	81741-28-8	10.00%	0.00552%	
Clayfix 3	Halliburton	Clay Control	Sodium chloride	7647-14-5	30.00%	0.07058%	
VICON NF BREAKER	Halliburton	Breaker	Chlorous acid, sodium salt	7758-19-2	10.00%	0.00108%	
			Sodium chloride	7647-14-5	10.00%	0.00108%	
LOC-30 UC	Halliburton	Gelling Agent	Guar gum	9000-30-0	60.00%	0.03264%	
			Naphtha, hydrotreated heavy	64742-48-9	60.00%	0.03264%	
SP BREAKER	Halliburton	Breaker	Sodium persulfate	7775-27-1	100.00%	0.00004%	
OptiKleen-WF™	Halliburton	Surfactant	Sodium perborate tetrahydrate	10486-00-7	100.00%	0.00782%	

* Total Water Volume sources may include fresh water, produced water, and/or recycled water

** Information is based on the maximum potential for concentration and thus the total may be over 100%

All component information listed was obtained from the supplier's Material Safety Data Sheets (MSDS). As such, the Operator is not responsible for inaccurate and/or incomplete information. Any questions regarding the content of the MSDS should be directed to the supplier who provided it. The Occupational Safety and Health Administration's (OSHA) regulations govern the criteria for the disclosure of this information. Please note that Federal Law protects 'proprietary', 'trade secret', and 'confidential business information' and the criteria for how this information is reported on an MSDS is subject to 29 CFR 1910.1200(i) and Appendix D.

Average Water Demands of Well Fracing

- Barnett
  - Water Use (gallons/well): 2,300,000
- Haynesville
  - Water Use: 2,700,000
- Marcellus (PA)
  - Water Use: 3,800,000

Source: EPA Frac Study Plan

Source of Frac Water

- Water used may come from ground or surface water
- Water typically stored on-site in 20,000-gallon portable steel ("frac") tanks, impoundments, or centralized locations serving multiple sites.
  - In Barnett water may be stored in impoundments ranging from 8 million to 163 million gallons
  - 163 million gallons may serve 2,000 gas wells
- Efforts to recycle flowback water produced in fracturing process
  - Estimates range from 10 to 40 percent recovery of flowback water in first 2 weeks.

Source: EPA Frac Study Plan

Tanker Trucks
Source: DOE, Fracing Primer

Lined Fresh Water Supply Pit from Marcellus Shale
Source: DOE, Fracing Primer

Prevalence of Frac'd Wells

- US: 35,000 wells fractured per year.
- US: Estimated annual water use of 70 to 140 billion gallons.
  - Equivalent water use of 40-80 cities with population of 50,000 or 1 to 2 cities of 2.5 million.
- Barnett Shale: Estimated annual water use of 2.6 to 5.3 billion gallons, estimated to peak at 9.5 billion gallons in 2010 or 1.7 % of all freshwater demand in Barnett Shale area.

Sources: EPA Frac Study Plan

Existing Texas Water Use for Fracing (2008 Data)

Play	Water Use (thousand AF)
Barnett Shale	25.45
Haynesville Shale	0.11
Eagle Ford Shale	0.07
Woodford/Barnett PB/Pearsall Shale	0.09
Anadarko Tight Formation	2.22
East Texas Tight Formation	4.26
Permian Basin Tight Formation	3.09
Gulf Coast Tight Formation	0.6
Caballos/Tesnus Tight Formation	0.17
Sum Shale (filtered at >0.001 Mgal)	25.71
Sum Tight Fm. (filtered at >0.001 Mgal)	10.33
Sum All (filtered at >0.001 Mgal)	36.04

Source: TWDB Frac Study

Future Texas Frac Water Demand

- Fracing will increase from the current ~ 37,000 AF to a peak of ~ 120,000 AF by 2020-2030
  - Expected Texas peak water demand by mid-2020s.
- Water use is contingent on price of gas
- Gas prices > $10/Mcf:
  - All gas plays, even with marginal permeability, are expected to be fraced
- Gas prices < $5/Mcf
  - Less gas wells will likely be drilled, less water use expected

Source: TWDB Frac Study

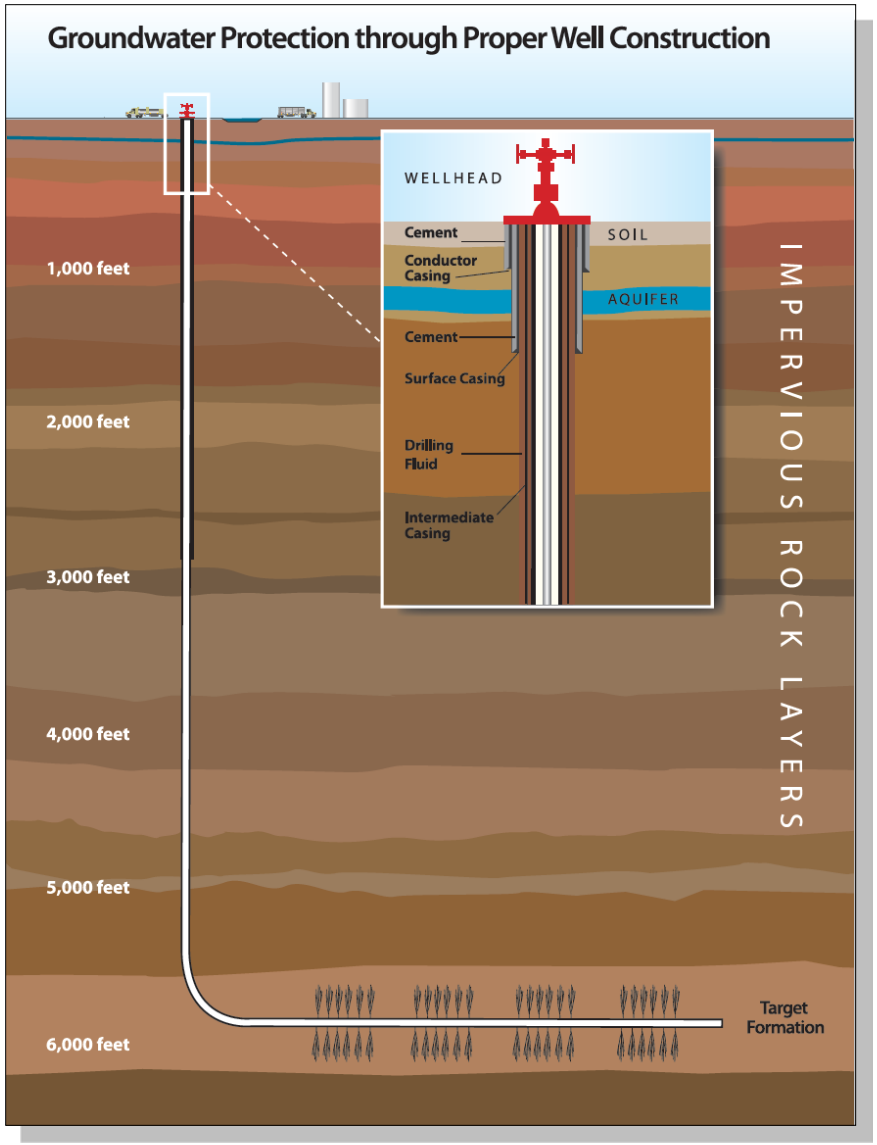
Cost of Frac Water (Large Frac)

Assume 10M Gal/Well

- $0.70 per bbl = $167,000
- $3.00 per 1000 = $ 30,000
- $100 per AcreFt= $ 3,070

Risk to Groundwater

- Little to no evidence of direct impact to groundwater.
- Potential contamination of groundwater if mechanical integrity of well is compromised.
- Lowering aquifer water levels by water consumption from fracing may:
  - Affect water quality by exposing mineral to oxygen-rich environment;
  - Increasing salination and potential chemical contamination;
  - Increase bacterial growth;
  - Cause upwelling of lower quality water from deeper within aquifers.



Sources: http://www.api.org/policy/exploration/hydraulicfracturing/ and EPA Frac Study Plan

Depths of Freshwater and Formation

- Barnett
  - Freshwater Depth: 1,200
  - Formation Depth: 6,500-8,500 ft.
- Haynesville
  - Freshwater Depth: 400
  - Formation Depth: 10,500-13,500
- Marcellus (PA)
  - Freshwater Depth: 850
  - Formation Depth: 4,000-8,500

Source: EPA Frac Study Plan

Risks to Surface Water: Flowback

- After fracing, pressure decreases and frac fluid flows back to the surface.
  - Amount of frac fluid recovered as flowback varies from 25% to 75%.
  - Flowback rate in first few days can exceed 100,000 gallons per day
  - Will drop to ~ 50 gallons per day over time
- As of 2009, none of 27 states with fracing require reporting of flowback
- Flowback can have frac fluids and high TDS values, concentrations of major ions (e.g. barium, bromide, calcium, iron), radionuclides, VOCs, and other natural occurring elements.

Source: EPA Frac Study Plan

Handling/Disposing of Flowback

- Flowback and produced water are held in storage tanks and water impoundment pits prior to and during treatment, recycling, and disposal.

- Underground injection is primary method for disposal for flowback and produced water.
  - Concerns regarding injection capacity and cost of trucking wastewater to injection site.
- Potential for use of publicly owned treatment works (POTW) or commercial treatment facilities if in populated areas.
  - POTWs not designed to treat fracing wastewaters
- Releases, leaks, and/or spills involving storage and transportation of flowback and produced water could contaminate shallow drinking water aquifers and surface water bodies.
- Reuse is possible, with treatment.

Source: EPA Frac Study Plan

Range Resources: EPA Emergency Order

- December 7, 2010: EPA issues emergency order alleging contamination of two wells.
- Order requires Range Resources, amongst other requirements, to:
  - Provide drinking water within 48 hours to affected residents;
  - Install explosivity meters within 48 hours;
  - Identify gas flow, eliminate gas flow if possible, and remediate areas of aquifer that have been impacted.
- Alleges methane contamination, not fracing fluid specifically
- Alleges that state and local authorities had not taken sufficient action to address endangerment
- Emergency Order under Section 1431 of SDWA.
  - No notice, no opportunity for Range Resources to comment, and no presentation evidence.
  - Failing to comply with Emergency Order could lead to $16,500 per violation per day penalty.

EPA/DOJ Suit & RCT Finding

- January 18, 2011: U.S. DOJ files complaint against Range Resources for not complying with EPA's emergency order.
- January 20, 2011: Range Resources appeals order.
- March 22, 2011: Following investigation, RCT Commissioners unanimously vote to clear Range Resources of EPA allegations. EPA did not testify at hearing.

Subsurface Trespass in Texas

- In *Coastal Oil v. Garza Energy Trust*, the Texas Supreme Court held that the rule of capture prevented a neighbor from recovering damages when subsurface hydraulic fracturing extended into the neighbor's land.
  - Court held that since the only claim of damage from trespass was damages from drainage resulting from fracing, the claim was precluded by rule of capture.
- Texas Supreme Court intentionally avoided question of whether fracing extending beneath another's land was itself a subsurface trespass.
  - Long history of case law where Texas Supreme Court has decided not to address question.
  - In 1992, Texas Supreme Court in *Geo Viking, Inc. v. Tex-Lee Operating Company* said fracing constituted a trespass when it extended onto neighboring property but withdrew the opinion 6 months later.

Sources: *Coastal Oil v. Garza Energy Trust,* 268 S.W.3d 1 (Tex. 2008) and *Geo Viking, Inc. v. Tex-Lee Operating Company,* 839 S.W.2d 797 (Tex. 1992) (per curiam op withdrawn on reh'g).

Regulatory Forecast

- Greater disclosure of chemical additives (site specific)
- Recordkeeping and reporting
- Narrowing of UIC exemptions
- Ban on use of certain additives
- Restrictions on Disposal of Flowback Fluids

QUESTIONS?

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