WaterLess Fracturing Technology

"Making the Most of The Reservoir"

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Broome & Tioga County, New York

April 2011

Agenda

- **Technical Benefits of LPG Fracturing**
- **Economic Benefits**
- **Safety**
- **Case Histories**
- **Environmental Benefits of LPG Fracturing**
- **Q&A**

Advantage of LPG Fracturing

- **Enhanced Well Productivity & Performance**
  - Higher Flow Rates
  - Higher Recoveries
- **No Water Used in the Fracturing Process**
- **No Waste Streams Created**
- **Reduced Truck Traffic to and from Location**
- **Quicker Cleanup w/Negligible Flaring**
- **Recyclable**
  - 99% of the Frac Fluid is Recovered
  - In Some Areas it can Be Sold or Used on a Future Job

Superior Revenue for Operators and Royalty Owners

Gas Frac Overview

As of January 1, 2011: 704 Fracs on 307 Location

- **26.4 Millions Gallons** of Propane and **41 Million Pounds** of Proppant
- Largest job to date: 1 Million Pounds on a 10 stage (3900' horizontal)
- Highest pressure treatment to 13,050 psi
- Treating rates to 50 BPM & Proppant Concentrations to 8 lb./gal

Treatments placed into over 45 different reservoirs

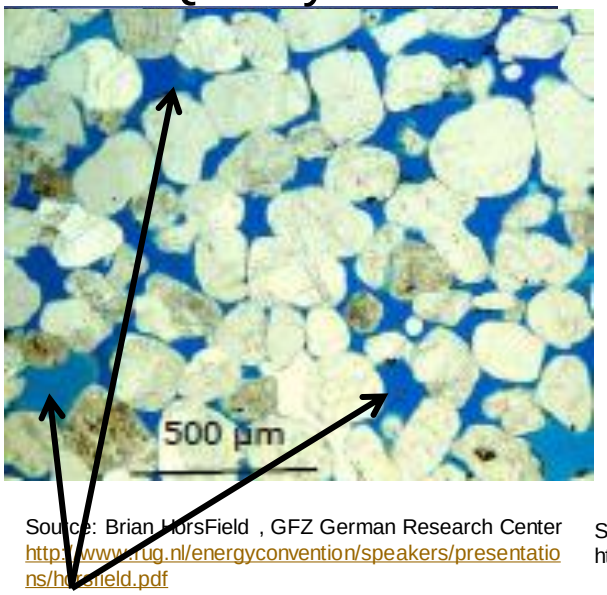
- Oil, Gas, and Condensate reservoirs
- Deepest Treatment to 13150' TVD
- Formation Temperatures from 59°F to 275 °F

Have worked with over 50 clients

- Includes Husky, EOG, Devon, Canadian Natural Resources, Nexen, Paramount, EXCO, Union Gas Operating, and SandRidge

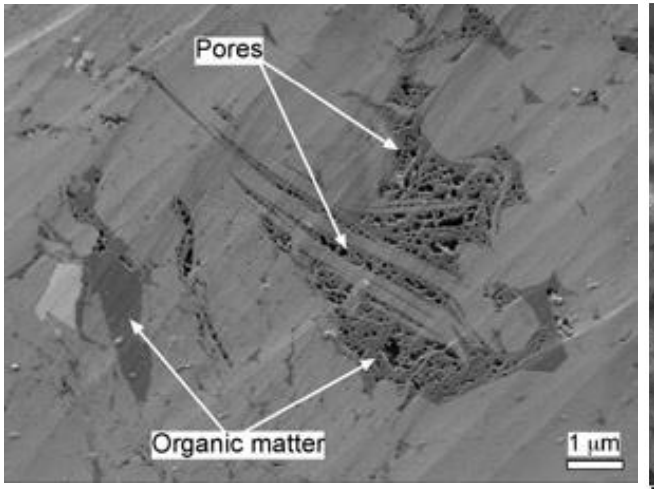
Good vs. Poor Quality Reservoirs

Good Quality Reservoir



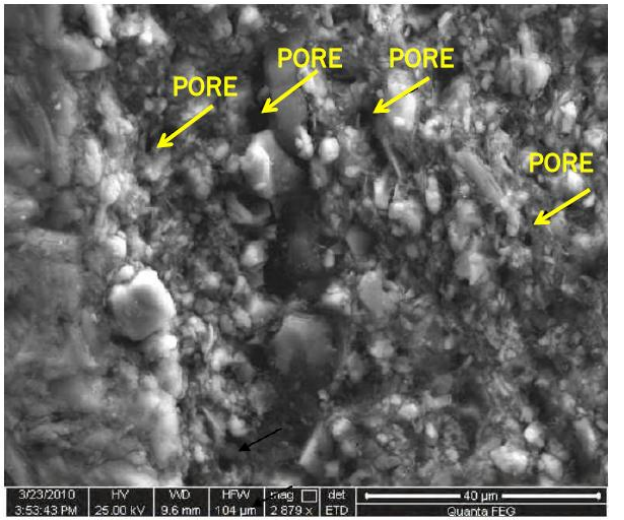
Source: Brian HorsField , GFZ German Research Center
http://www.nrg.nl/energyconvention/speakers/presentations/horsfield.pdf

Barnett Shale



Source: Texas Bureau of Economic Geology, Image by Rob Reed
http://www.beg.utexas.edu/msrl/

Marcellus Shale

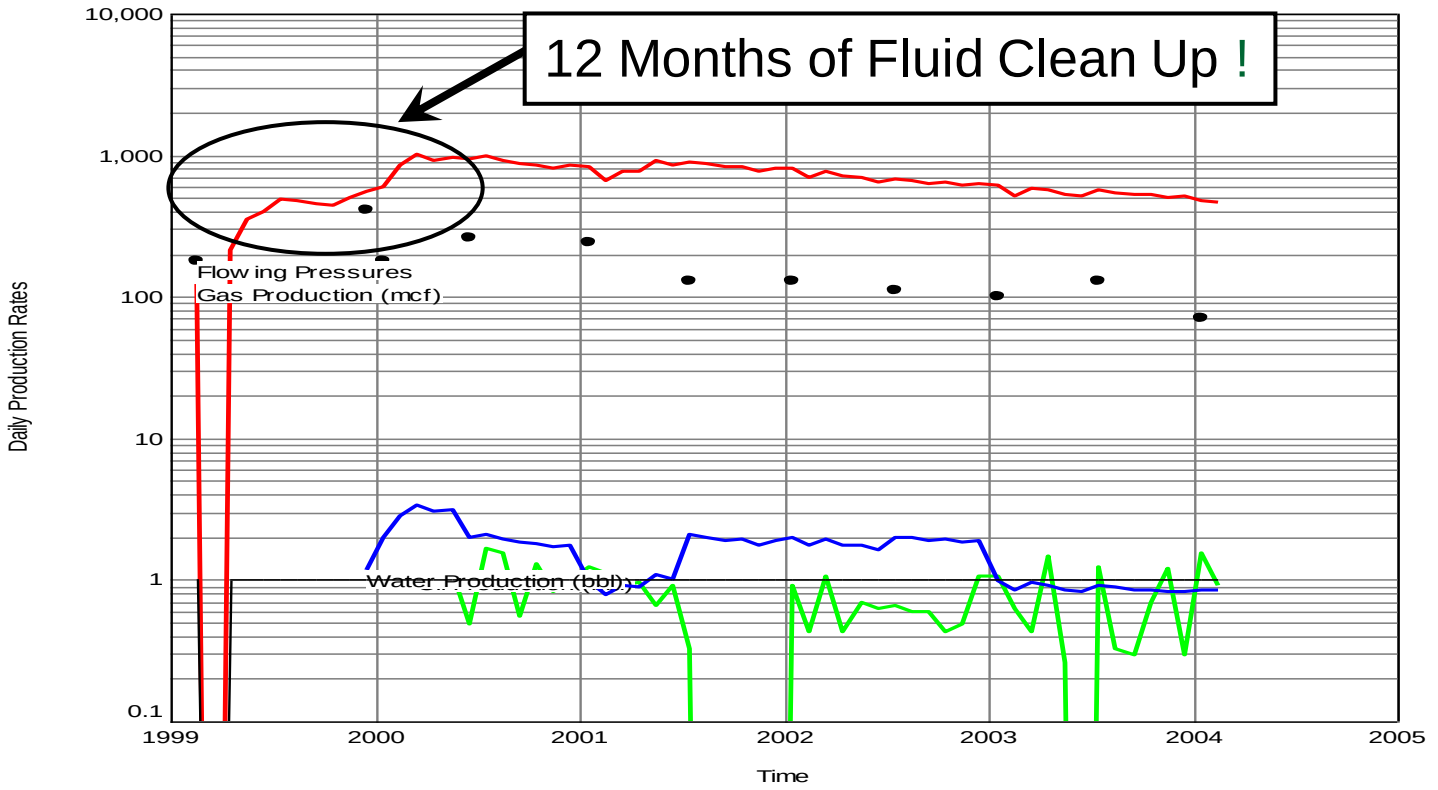


Source: John Harper & Jamie Kostelnik, PGS
http://www.marcellus.psu.edu/resources/PDFs/DCNR.pdf

Blue area is the area where oil and gas resides and flows through. Note how large and numerous they are compared to the Barnett and Marcellus examples. The extremely small and infrequent pores in the Shales make these difficult and "unconventional" reservoirs requiring major stimulation or "frac jobs".

- Human Hair Size is 17 to 180 µm
- Good Quality Reservoir Pore Size ~ 200 µm
- Barnett & Marcellus Pore Size ~ .2 to .05 µm (~1000 to 4000 times smaller pores)

The Challenges of Water Based Fracturing



The rocks we produce from are not completely compatible with water. Water wants to cling to the rocks and in some cases it even will cause the clays to swell and result in plugging the flow of oil and gas. This example illustrates that the damages associated with water that took a year to be resolved and still never allowed the well to reach it's potential of 4 MMCFPD!

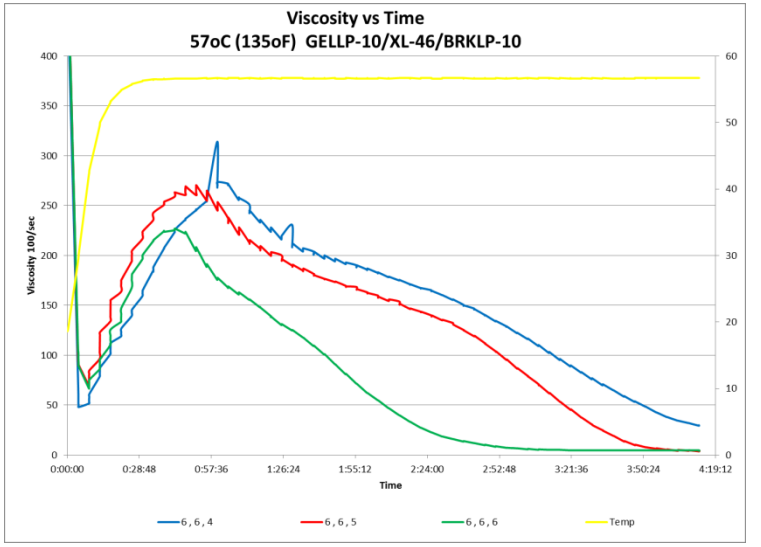
What is The Perfect Fracturing Fluid?

- **Ultimate Reservoir Performance & Certainty**
  - Create the Required Fracture Geometry
  - Effective Proppant Transport
  - Non-Damaging (Water Blocks, Polymer Residue, Clay Swelling)
  - All Created Fracture Volume Contributes to Production
  - 100% Fluid Recovery Leaving only Proppant in the Frac
- **Economic & Environmental Performance**
  - Readily Available
  - All Frac Fluids Recovered are Marketable or Recyclable
  - Reduces Swabbing, Coiled Tubing Jetting, or Extended Flowbacks
  - Eliminates Water Usage, Disposal Needs, & CO_2 Venting
- **Operationally Safe**
  - Jobs can be Conduced Incident Free

The Answer is Cross-Linked LPG

- **LPG can be Handled as a Liquid on the Surface**
- **Easily X-Linked to Create Desired Frac Geometry and Achieve Ideal Proppant Transport**
  - Similar Rheology Properties as a Visco-Elastic Fluid
  - Achievable and "Adjustable" Break Times (.5 to > 4 hrs.)
  - Industry LPG Standards Ensures Fluid Consistency
- **After the Job, it's a Disappearing/Self Energizing → ~100% Fluid Recovery**
  - LPG is soluble w/natural gas
  - 1st contact miscible w/crude oil
  - Very low viscosity, surface tension, & density ½ of water
- **Recovered Frac Fluid is Marketable**
  - No Waste Streams Created
- **Sustainable, Recyclable, and Environmental**
  - No Water Use in the Fracturing Operation
  - Inert to Salts and Other Reservoir Minerals
  - Reduced Truck Traffic to and from Location
- **Readily Available and Widely Used by the Public**
- **Numerous Governmental and Industry Regulations and Procedures Exist to Provide for Safe LPG Operations**

Photo courtesy of Stacey Walker – Chevron Energy Technology Company



Comparison of LPG Properties w/Water

- **LPG (Primarily Propane)**
  - **Viscosity = 0.08 cps (@105F)**
  - **Specific Gravity = 0.51**
  - **Surface Tension = 7.6 dynes/cm**
  - **Non Damaging – Inert with the Formation Clays and Salts**
- **Water**
  - **Viscosity = .66 cps (@105F)**
  - **Specific Gravity = 1.02**
  - **Surface Tension = 72 dynes/cm**
  - **Potentially Damaging – Reactive with Formation Clays and Salts**

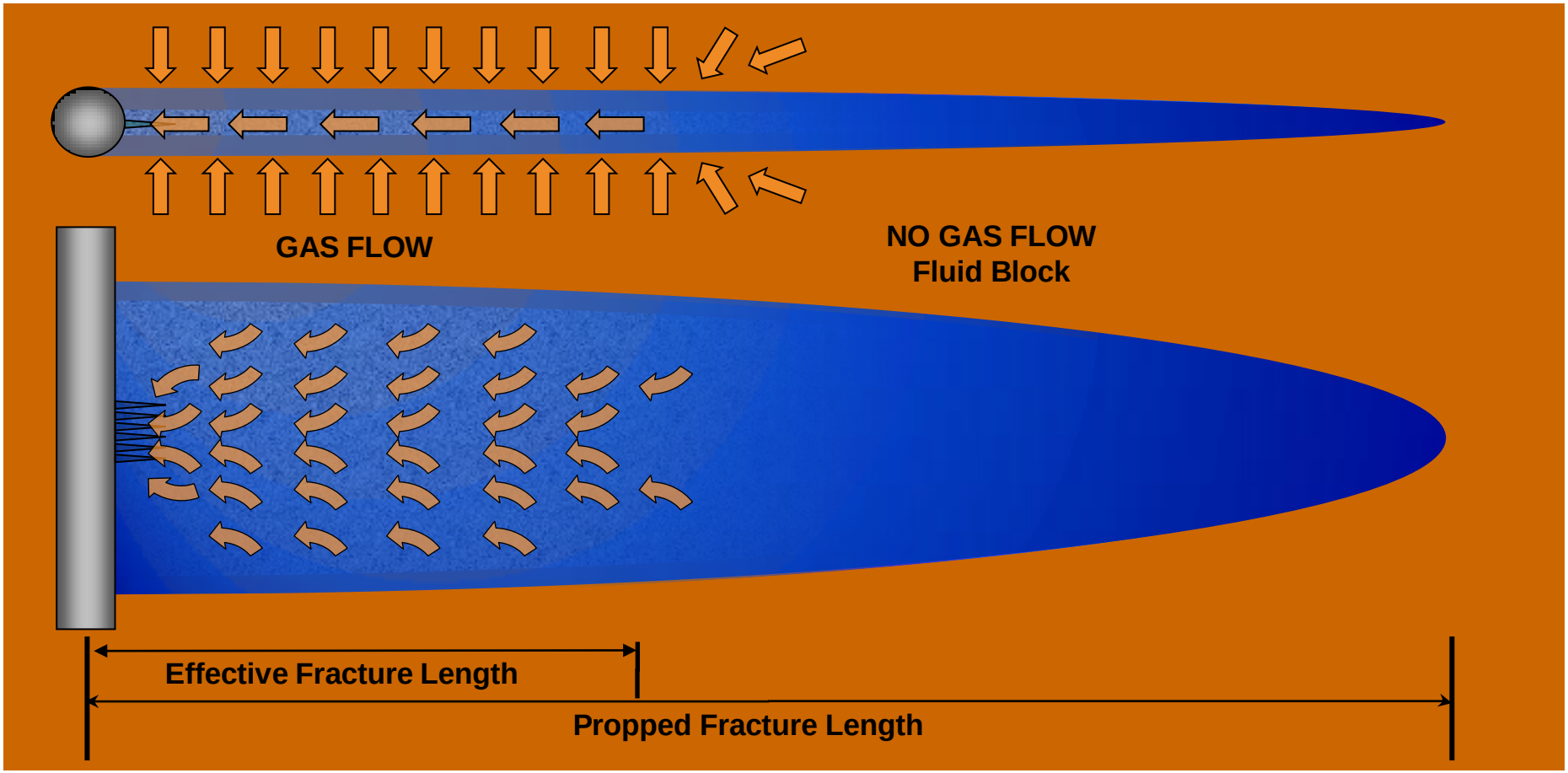
These parameters represent major benefits that LPG/Propane has over the use of water. Viscosity is a measurement of the resistance to flow. The lower the viscosity the easier it is to flow (i.e. it's easier to flow milk than honey out of bottle). In the case of propane, it is 8 times less viscous than water making it 8 times easier to flow out of the fracture than water.

Specific gravity refers to the density of the fluid. Propane is half the density of water. That means for a well at the same vertical depth one filled with Propane will exert half as much pressure on the formation as that of a well full of Water. This is important because obtaining the lowest backpressure on the formation will result in the best clean up of the formation and long term production rates and recoveries.

Surface tension is a measure of the force between a fluid (e.g. propane and water) and a surface (e.g. the rock). The lower the surface tension the easier it is for that fluid to flow past the surface of the rock. Propane takes 10 times less force to move it pass the surface of the rock. This is similar to waxing your car. The wax reduces the surface tension between the water and the paint allowing the water droplet to "roll" off your car.

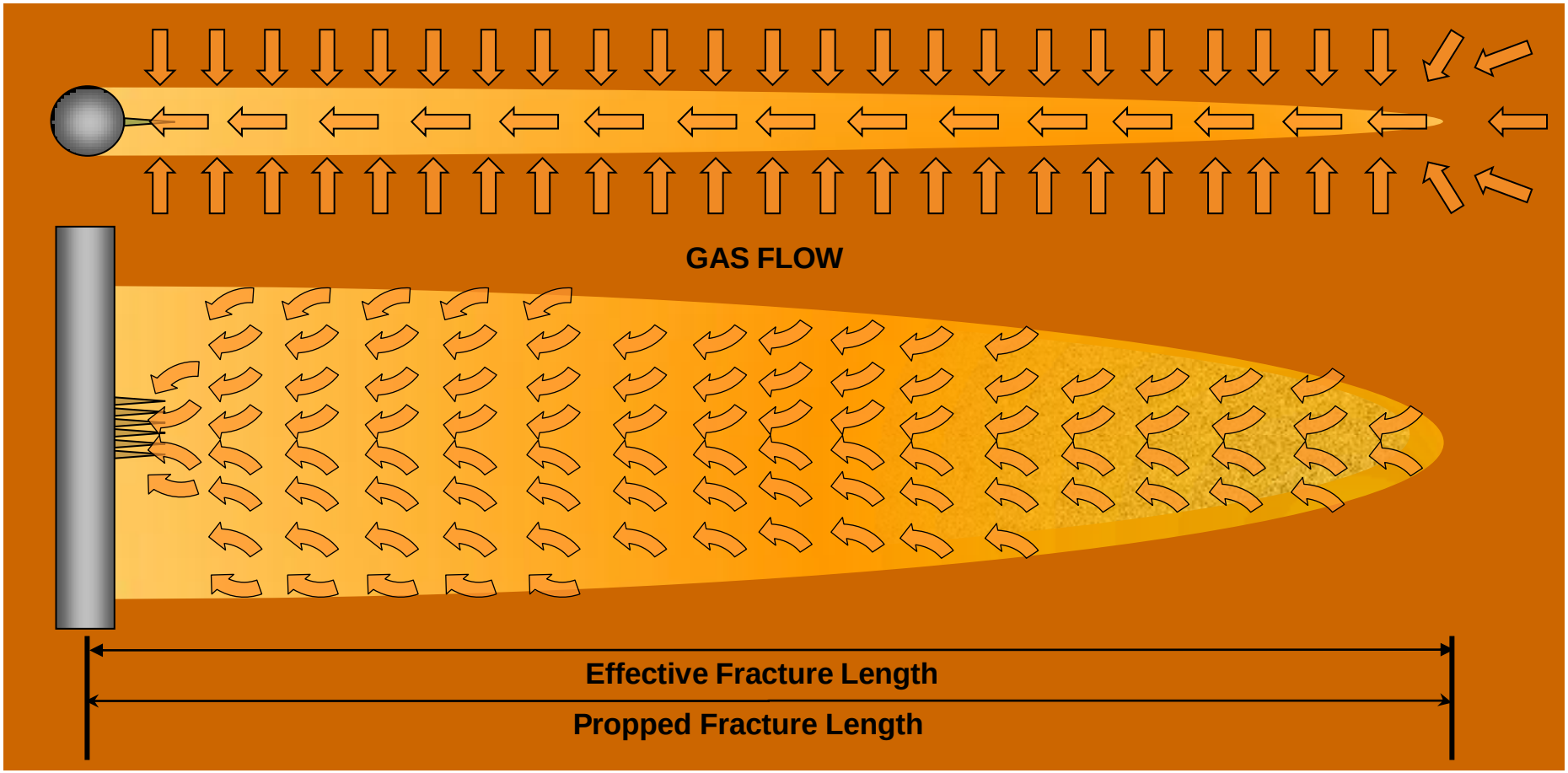
These differences explain why 100% of the propane is typically recovered on LPG frac jobs and only ~20% of the water is recovered on water based frac jobs!

Conventional Fracturing Fluids



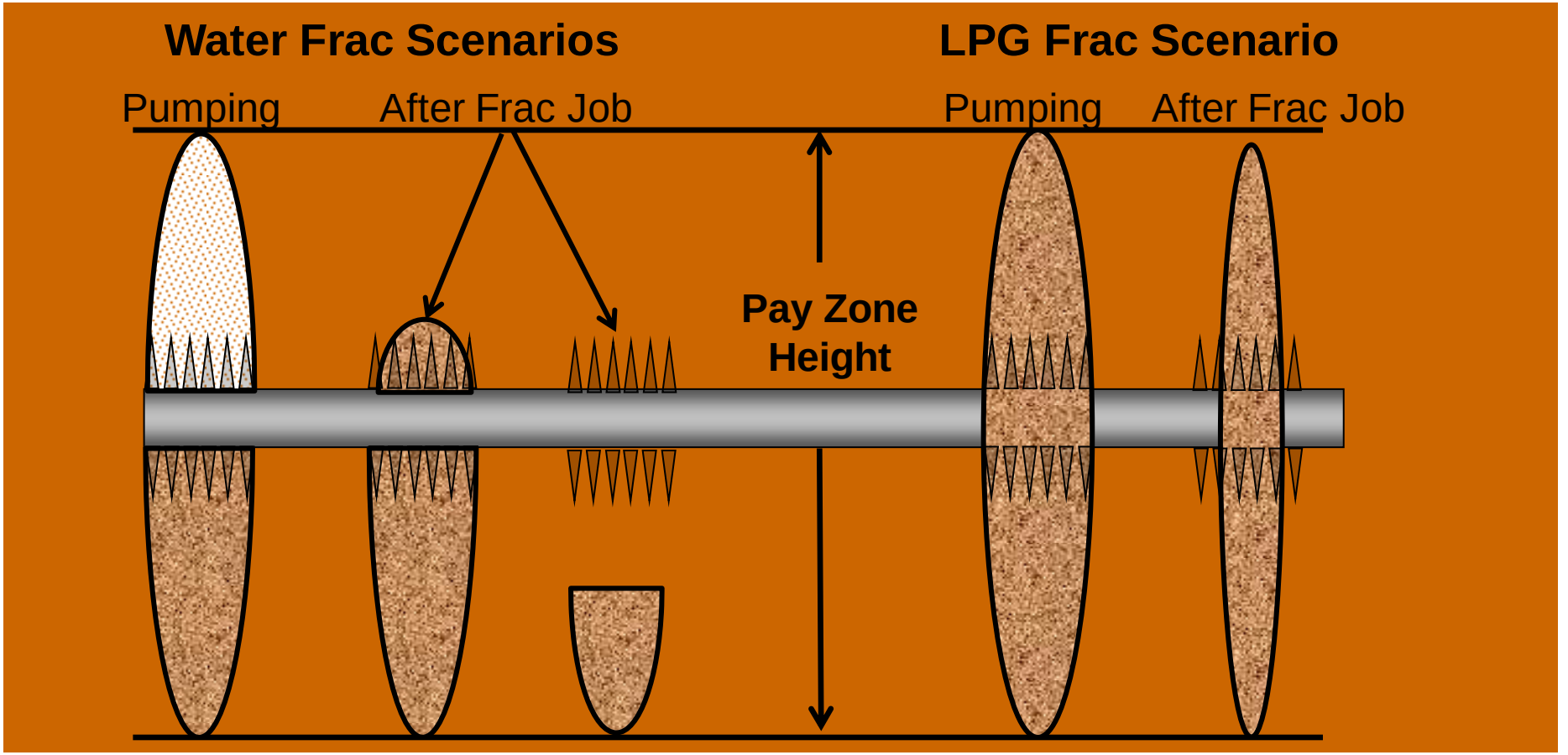
This diagram illustrates the impact of the low water recovery. Although a long fracture length is created, only 20-50% of that length every is capable of contributing to producing the oil and gas reserves it contacts due to the interference water creates.

LPG as a Fracturing Fluid



This diagram illustrates the impact and benefit of 100% LPG recovery. Practically 100% of the propped fracture length created contributes to producing the oil and gas reserves it contacts. Net result is higher initial rates, higher recoveries, and a cost effective solution.

Proppant Settling – Water Frac vs. LPG Frac

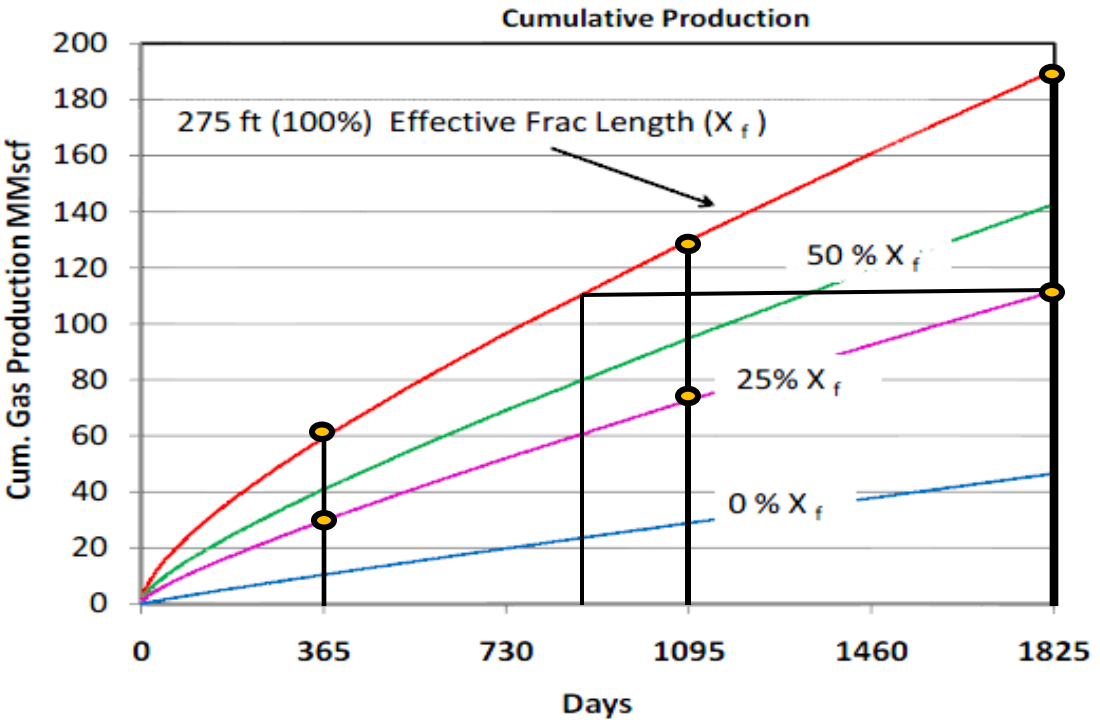


Water fracs use low viscosity fluids and require high pump rates to keep sand suspended. Once the job is completed and there is no pump rate, the sand will settle in a water frac leaving only part of the desired pay zone height contacted. The LPG while being pumped during the frac job is viscous (after the frac closes the fluid returns to a low viscosity) and can support sand. This enables the entire pay zone height to be contacted and produced.

Impact of Effective Fracture Length

Well Parameters

- Thickness 14’
- Porosity 10%
- S_w 20%
- Permeability .1 md
- Pressure 1133 psi
- Propane Created Frac Length & Effective Frac Length 275’
- With Water Effective Length = 70’ (25%)



Production Benefit of a Longer Effective Frac Length - 70’ (25%) vs. 275’ (100%)

- After 1 Year of Production – 30 vs. 60 MMCF
- After 3 Years of Production – 70 vs. 130 MMCF
- After 5 Years of Production – 110 vs. 190 MMCF
- Additional ~2 ¾ Years Needed to Produce the Same Volume of Gas with the Shorter Effective Frac Length

Example Adapted from SPE 124495, Tudor et. al., “100% Gelled LPG Fracturing Process: An Alternative to Water-Based Fracturing Techniques”

Frac Fluids Comparison Summary

	Water	Frac Oil	CO_2	N_2	LPG
Fracture Creation	✓	✓	✓	✓	✓
Proppant Transport	✓	✓	?	✗	✓
Reservoir Compatibility	✗	✗	✓	✓	✓
Load Fluid Recovery	✗	✗	✓	✓	✓
Fluid Recycling	?	✓	✗	✗	✓
Recover to Pipeline	✗	✗	✗	✗	✓
Fluid Availability	✓/?	?	✗	✗	✓
Environmentally-Friendly	✗	?	✗	✓	✓

All fracturing fluids have some favorable characteristics, but only LPG has favorable characteristics in all areas!

Total Cost Advantage of LPG Fracturing

- **Unit Cost or Total Cost?**
- **Key Farming Metric is Yield per Acre**
  - Use of Fertilizer Adds More Cost on a Per Unit Basis - But Results in a Higher Yield Per Acre (and Higher Value to the Farmer)
- **Key Completion Metric is Dollars Spent per MCF Recovered**
  - LPG Fracs Cost More on a per Unit Basis – But Results in Less Dollars Spent per MCF Recovered
  - Total Gas Yields Typically Increase by 20-30+ % with LPG Fracturing

Total Cost Advantage of LPG Fracturing

- **Additional Costs Savings for LPG Fracs**
  - No Water Wells/Ponds, Handling Facilities, Logistics, or Frac Tanks
  - No Disposal Cost – One Way Hauling
  - Less Truck Traffic to Location
  - Reduced Flowback Costs Due to Quick Cleanup
  - No Well Intervention to Kick Off Well

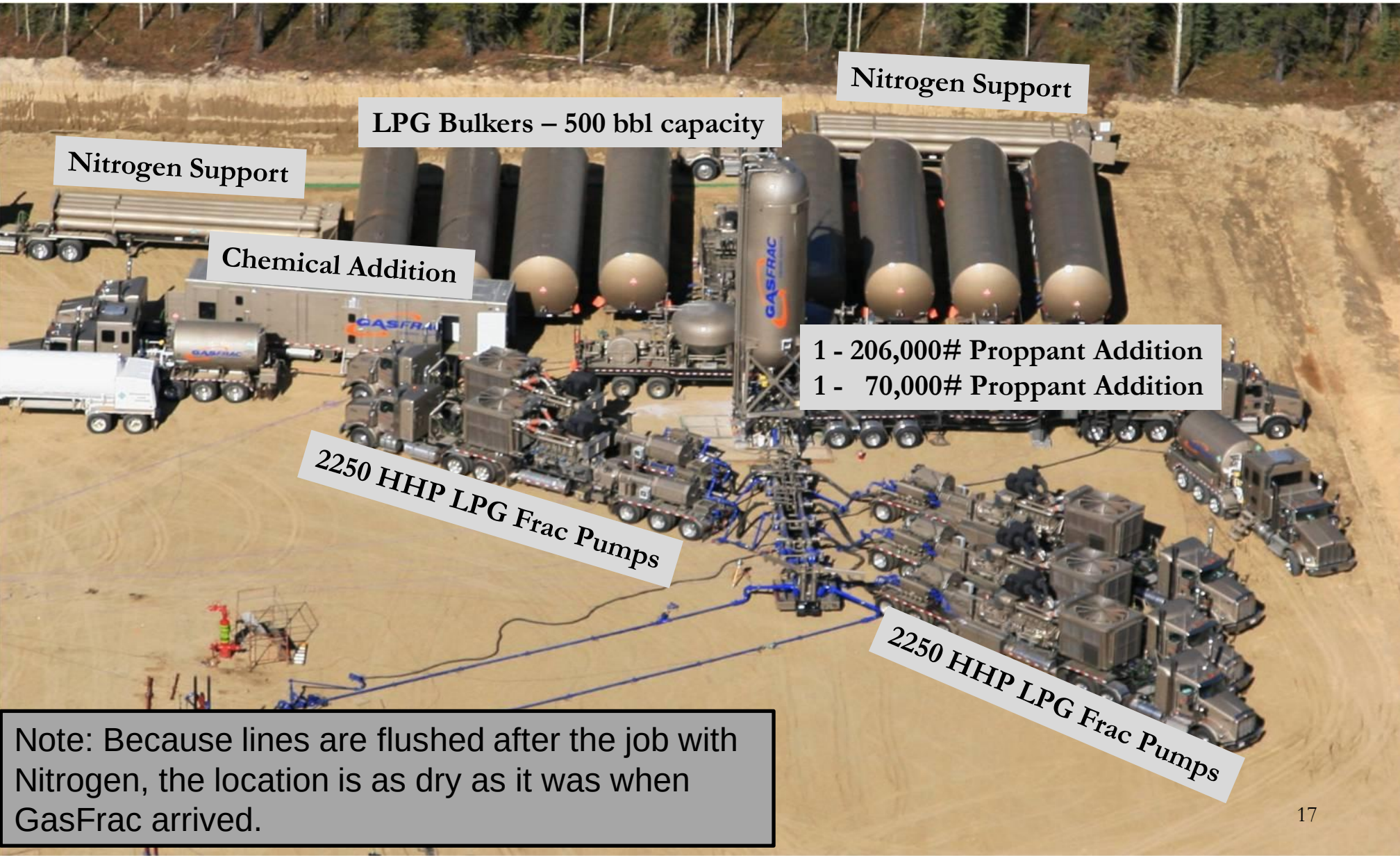
- **Additional Cost Benefit of LPG Fracs**
  - Minimal Gas Lost Due to Flaring During Cleanup
  - Frac Fluid can be Recovered and with the Proper Equipment/Infrastructure it can be Sold with the Gas Stream or as Natural Gas Liquids or Used on a Future Job

Where is the Value for the Landowners?

Maximizing the Recovered Gas (Obtaining Greater Yields from the Land)

- LPG Fracturing Results Have Indicated Oil and Gas Recovery Improvements of 20-30+%
- Average Marcellus Well ~ 4 BCF
- 25% Improvement is Another 1 BCF Produced
- At 5 $/Mcf Gas Price and 20% Royalty
  - An Additional $1 Million Realized by the Landowner over the Life of the Well
  - An Additional $4 Million Realized by the Energy Company

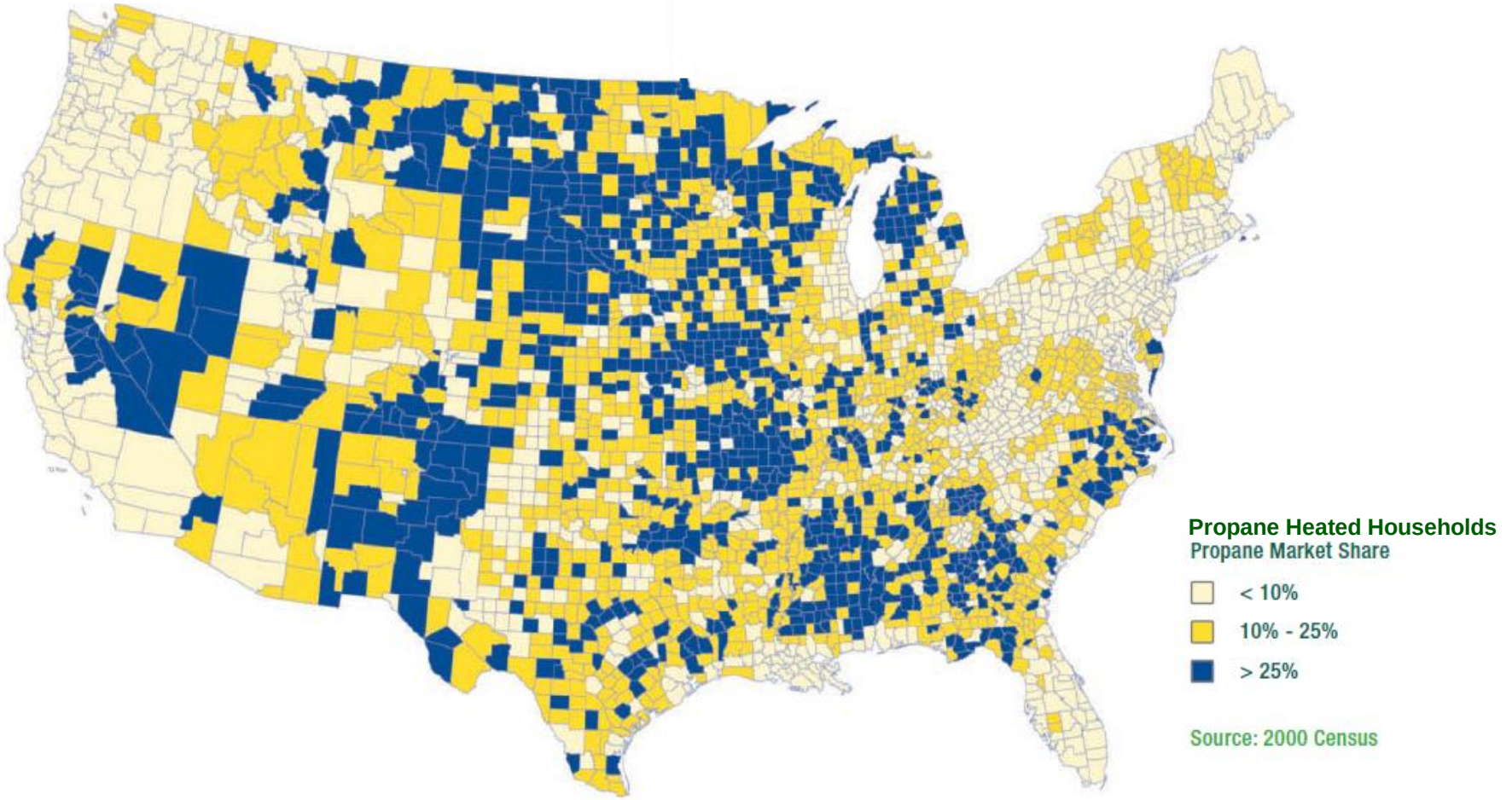
LPG Fracturing Process



Note: Because lines are flushed after the job with Nitrogen, the location is as dry as it was when GasFrac arrived.

How Common is LPG/Propane?

- **U.S. Propane Market is 9.5 Billion Gallons/Year**



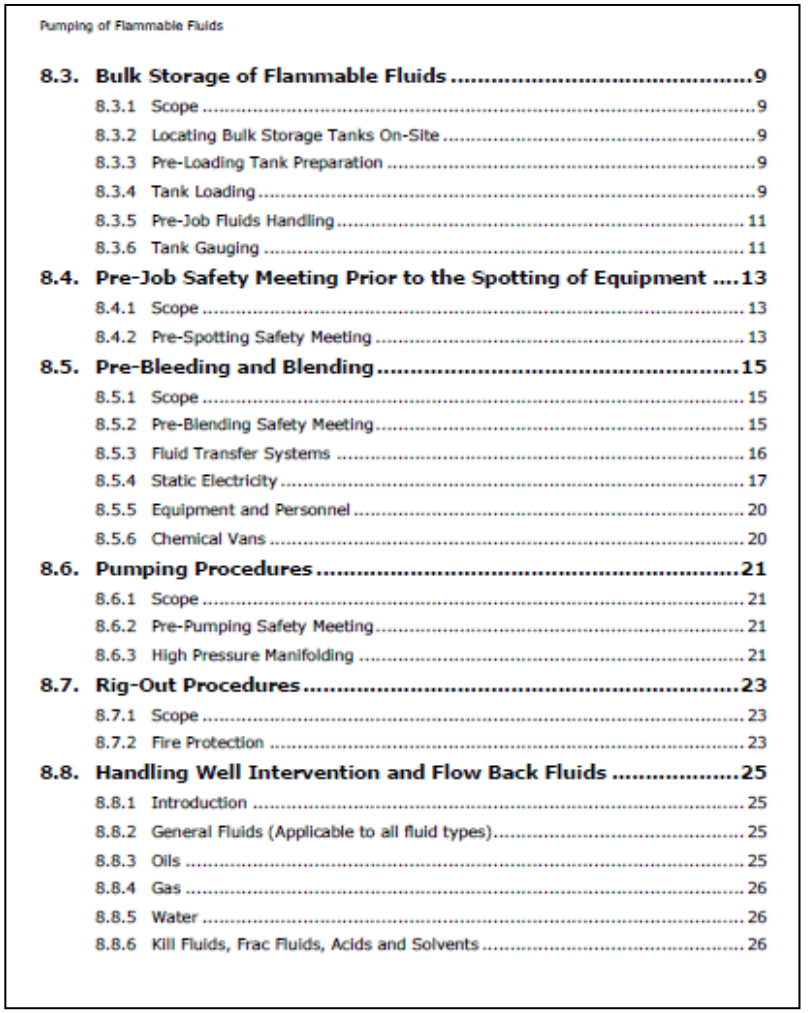
Source: PERC 2010 Propane Market Outlook

LPG Safety - How the Public Handles LPG!

Propane dates back to 1911 and the industry has develop substantial “best practices” for propane to be used by the general public. Even in the worst case when propane vehicles are involved in accidents, the standards are such that the propane is still safe. It is these practices and standards that GasFrac uses and incorporates into all our equipment and procedures.

How are Large Volumes of LPG Pumped Safely?

- **Incorporate Existing Industry Recommended Practices (IRP)**
  - **IRP 4 – Well Testing and Fluid Handling**
  - **IRP 8 – Pumping of Flammable Fluids**
  - **IRP 9 - Basic Safety Awareness**
  - **IRP 16 – Recommend Safety Practices**
  - **IRP 18 – Flammable Fluid Handling**
- **Utilize the Broader LPG/Propane Industry**
  - **Propane Education & Research Council**
  - **Petroleum Service Association of Canada**
  - **Canadian Association of Petroleum Producers**
  - **Propane Gas Association of Canada Inc.**
- **Conducted a 3rd Party HAZOP Evaluation of the Equipment Design, Operating Procedures, and Inspection Schedules with Suggested Modifications Incorporated**



Pumping of Flammable Fluids

IRP 8 Table of Contents

How are Large Volumes of LPG Pumped Safely?

- **Right People**
  - Leadership Composed of Handpicked Experts w/ 25+ Years of Experience in Pumping Services
  - Formal Training Program for all New Hires
  - Building Expertise by Pumping One Type of Fluid Everyday (no cement, acid, or CO2)
- **Right Equipment**
  - Equipment Designed to Pump LPG - NOT Adapted to Pump LPG
    - Specialty Lubrication and Packing for LPG Service
    - Uniform Equipment Across the Operations
  - Inherent Safety Built into the Equipment – Multiple Shut Down Systems
    - Remote Kill Switches and Automatic Over Pressure Shut Down Controls
    - Excess Flow Control Valves on Bulkers
    - Automatic Engine Overspeed Shut Down
  - All LPG Storage Equipment Meets DOT, PGA/API, NFPA, and ANSI Standards and Inspection Requirements
- **Right Process**
  - 100% Closed Loop Process
  - Done Remotely to Eliminate Personnel Risk – All Equipment Monitored via Close Circuit TV
  - Air Monitors (Low Explosive Levels and O_2) Located at Key Locations
  - Nitrogen is Used to
    - Purge all Vessels & Pressure Test Lines
    - Maintain a Gas Blanket on Vessels
    - Flush Lines after the Job

LPG Fracturing Process – Safety First!

- **The LPG Fracturing Processes and Procedures are Based upon an Independent Hazard and Operability Study Completed by a Professional Risk Management Company**
- **The LPG Frac Process is Endorsed by the Energy Boards of Alberta, BC, New Brunswick, and Saskatchewan.**
- **The LPG Frac Process has Received an Insurance Risk Rating Equal to that of Companies Pumping Water Based Fracturing Fluids!**

LPG Application Performance
McCully Field, New Brunswick

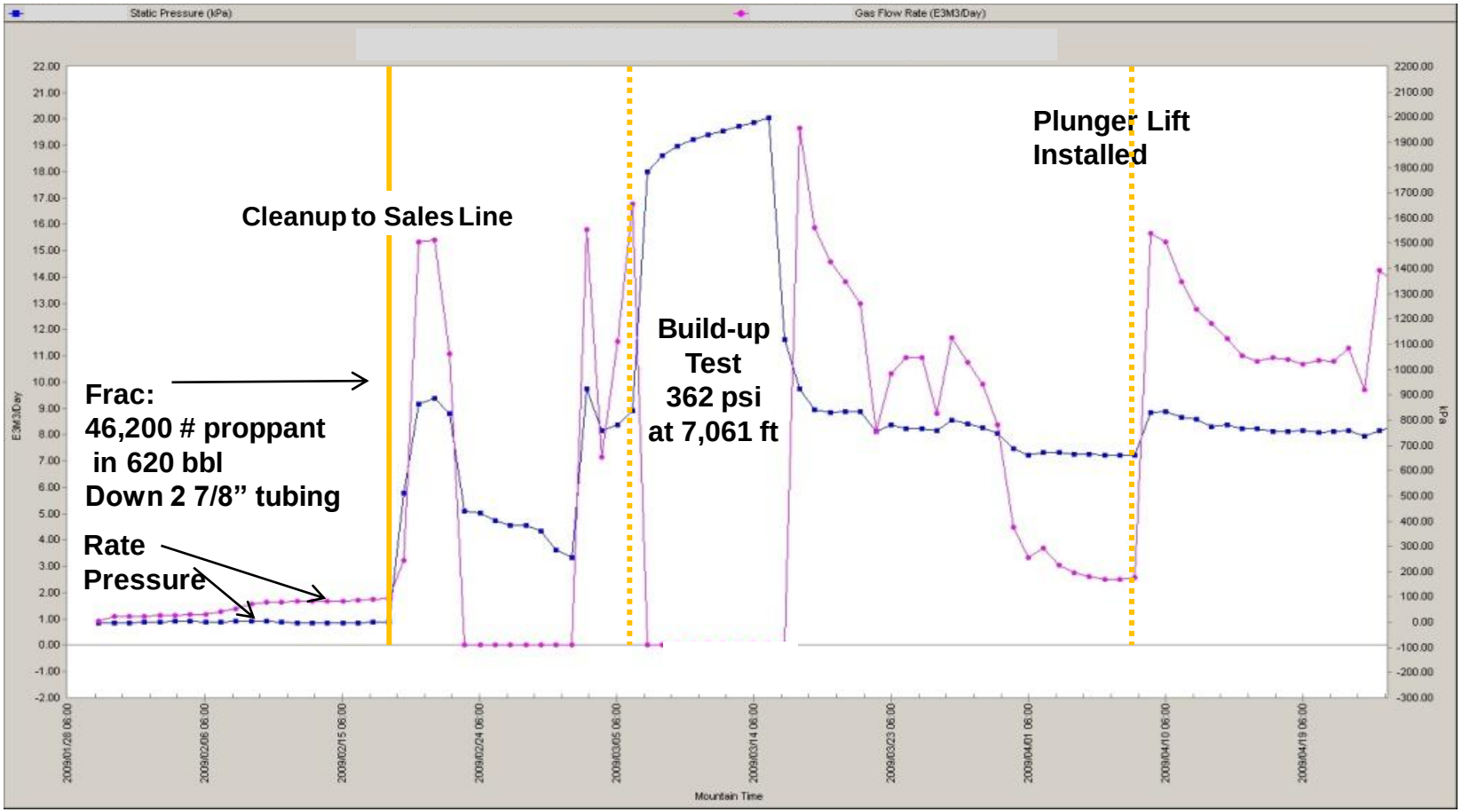
- **<u>Vertical</u> Completions - 50 BPM, 13,000 psi, 70K – 145K lb proppant**

Well	Sands Completed	Frac Type	Test Date	Flow Duration	Tested Rate	Tubing Pressure	Rate @ 500 psi FTHP
C-48	C, D, E, MB	Methanol Water	Oct-08	93 hours	1.4 MMscf/day	630	1.4 MMscf/day
J-47	D, E, F, G	Methanol Water	Oct-08	65 hours	6.8 MMscf/day	713	7.1 MMscf/day
K-48	B, C, D	Methanol Water	Oct-08	96 hours	0.5 MMscf/day	586	0.5 MMscf/day
P-47	E, G	LPG	Aug-09	46 hours	2.6 MMscf/day	2,702	9 - 10 MMscf/day
L-38	E	LPG	Aug-09	79 hours	2.5 MMscf/day	3,536	12 - 13 MMscf/day

October 2008 Data Reported from: http://www.corridor.ca/media/2008-press-releases/20081028.html
September 09, 2009 Data Reported from :http://www.corridor.ca/media/2009-press-releases/20090909.html

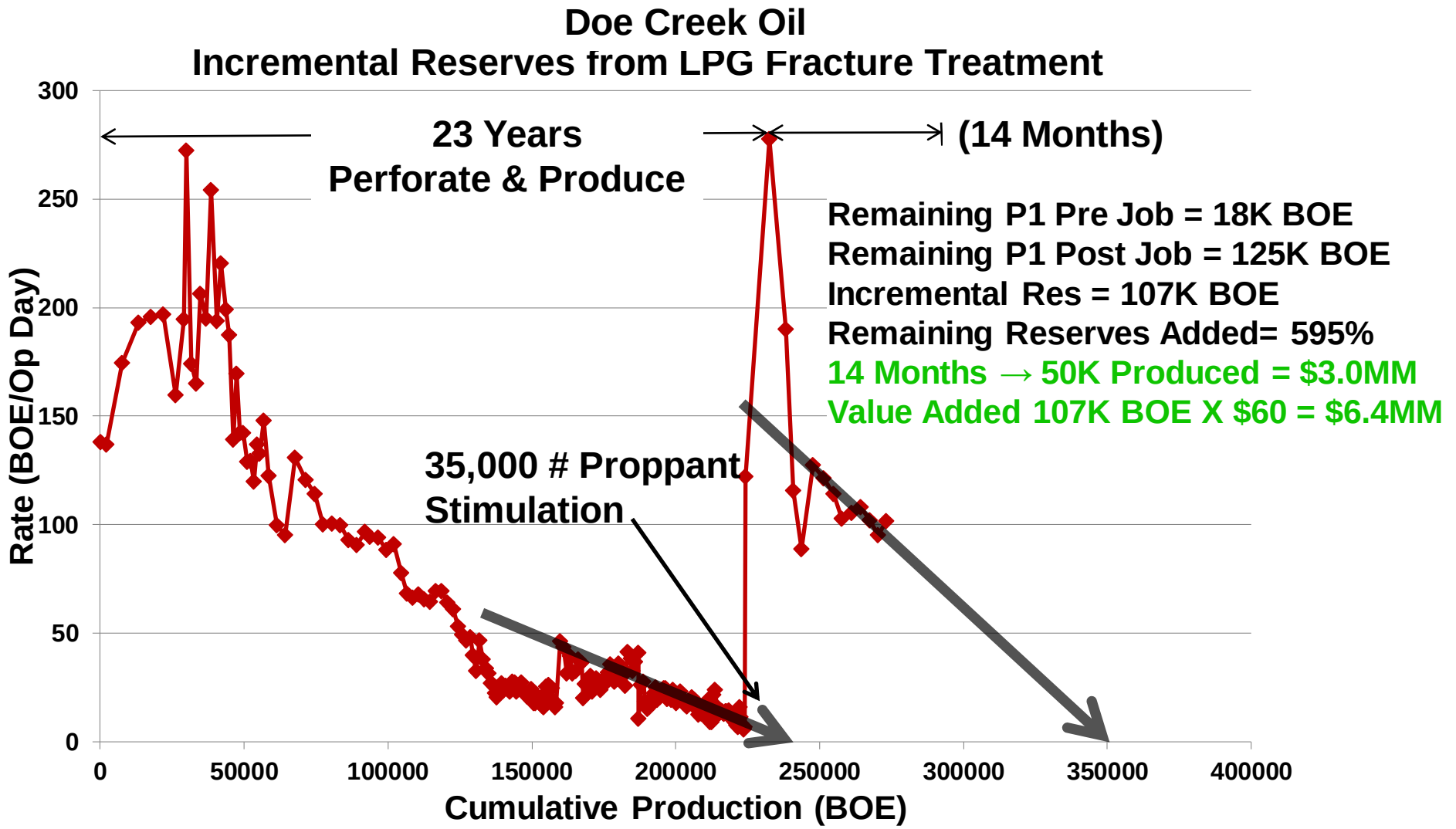
Gas - Very Low Pressure LPG Fracturing

- **Low Pressure Application (7,061 ft @ BHP 362 psi):**



Initial Rate: 60 Mscf/day	Final Rate: 520 Mscf/day &15.8 bbl condensate/day @ 112 psi

Oil – Low Pressure LPG Fracturing Example



Shale Gas Comparison
LPG Vertical Wells vs. Water Horizontal Wells

- **Frederick Brook Shale Same Age as Barnett and Fayetteville**
- **Corridor's Success Results in an Operator "A" Buying into the Play & Bringing their "Best Practices"**

Operator Well	Frac Job Type	Job Size	Post Frac Production	Comments
Corridor G-41	Vertical Well (w/2 stages)	0.25 Million lbs. GasFrac (Waterless)	4.1 MMCFPD @ 2083 psi 57 hours after frac	Average 5.5 MMCFPD the 1st week
Operator "A" B-41	Horizontal Well (w/5 stages)	2.50 Million lbs. 4.7 Million gals of Water	Recovered 10% Load & No Gas	Well is 2000' offset to the G-41
Operator "A" G-59	Horizontal Well (w/5 stages)	2.50 Million lbs. 4.7 Million gals of Water	Recovered 4% Load & Negligible Gas	Water rates have fallen

- **947 Truck Loads of Water vs. 30 Truck Loads of LPG**
- **Is the Reservoir Failing Us or Are We Failing the Reservoir?**

Source: Corridor Public Release dated Dec 6, 2010 "Corridor Updates Elgin Shale Appraisal Program www.corridor.ca

LPG Fracturing - A Superior Alternative.

- Wapiti Field - Cardium Formation in Alberta, Canada

Well	Loc.	Fluid Type	Proppant	Stages	IP BOE/D
1	1-9	CO2 – Frac Oil	495,000	15	133
2	4-17	Frac Oil	484,000	11	260
3	4-22	CO2 – Frac Oil	495,000	15	215
4	12-14	CO2 – Frac Oil	704,000	16	280
5	14-28	**LPG**	333,000	10	1,138

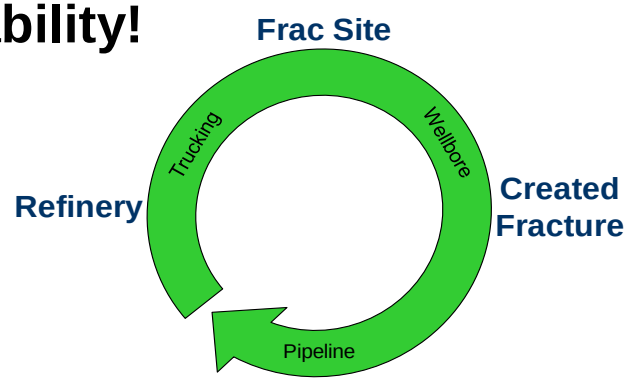
These results highlight the effectiveness and benefits of LPG fracturing. A well with half the amount of sand and a third less stages produces FOUR times the production! With LPG Fracturing with Less can Yield more!

Source: http://cnrp.marketwire.com/client/seaview_energy/release.jsp?year=2011&actionFor=1395711&releaseSeq=1

LPG Fracturing - Environmental Benefits

- **Environmental Impact of LPG Based Frac Fluids can be Minimal**
  - No Potable Water is Used in the Fracturing Process
  - No Biocides Used
  - No Waste Stream Created
  - No Reservoir Minerals, Nuclides, or Salts are Recovered with the LPG
  - Minimal Flaring, Everything Pumped Can be Sold!
  - Smaller Quantities can be Used to Achieve Equivalent Effective Frac Length
  - Less Road Traffic – Less Fluids and No Return Trip for Disposal!
  - LPG can be Recovered with the Natural Gas to the Pipeline or Recovered by Gas Processing where it can be Recycled for Fracturing or Sale.
- **LPG Comes from our Reservoirs and Can be Used to Produce More Oil and Gas from our Reservoirs – Sustainability!**

LPG Fracturing Achieves a Closed Looped Process



New York Department of Environmental Conservation Draft Generic Environmental Impact Statement - 2009

9.3 Green Or Non-Chemical Fracturing Technologies And Additives

Hydraulic fracturing operations involve the use of significant quantities of additives/products, albeit in low concentrations, which potentially could have an adverse impact on the environment if not properly controlled. The recognition of potential hazards has motivated investigation into environmentally-friendly alternatives for hydraulic fracturing technologies and chemical additives.

It is important to note that use of 'environmentally friendly' or 'green' alternatives may reduce, but not entirely eliminate, adverse environmental impacts. Therefore, further research into each alternative is warranted to fully understand the potential environmental impacts and benefits of using any of the alternatives. In addition, the 'greenness' needs to be evaluated in a holistic manner, considering the full lifecycle impact of the technology or chemical.

URS reports that the following environmentally-friendly technology alternatives have been identified as being in use in the Marcellus Shale, with other fracturing/stimulation applications or under investigation for possible use in Marcellus Shale operations:

- ***Liquefied Petroleum Gas (LPG) – The use of LPG, consisting primarily of propane, has the advantages of carbon dioxide and nitrogen cited above; additionally, LPG is known to be a good carrier of proppant due to the higher viscosity of propane gel [55]. Further, mixing LPG with natural gas does not 'contaminate' natural gas; and the mixture may be separated at the gas plant and recycled [55]. LPG's high volatility, low weight, and high recovery potential make it a good fracturing agent.***

EPA Comments on Alternatives to Hydraulic Fracturing

Natural Gas Plays in the Marcellus Shale: Challenges and Potential Opportunities

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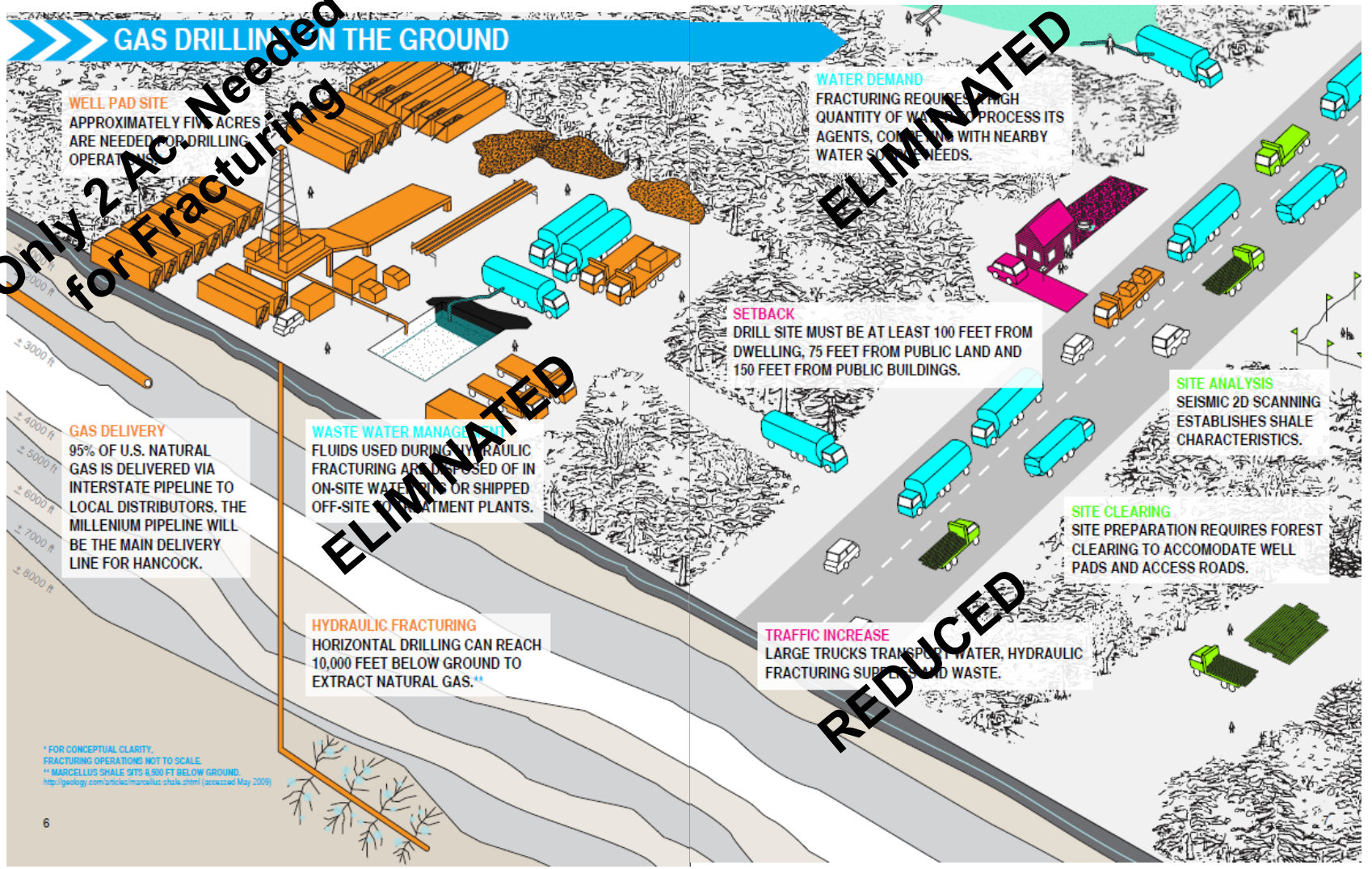
U.S. EPA Region III, Office of Innovation, Environmental Assessment & Innovation Division

RON G. WILHELM
U.S. EPA Office of Radiation and Indoor Air

DAVID J. CAMPBELL
U.S. EPA Region III, Office of Innovation, Environmental Assessment & Innovation Division

"Alternatives to Hydraulic Fracturing. *One of the most effective methods of reducing exposure to contaminated wastewater is to implement processes that do not generate wastewater. GASFRAC Energy Services is testing the use of liquefied petroleum gas (LPG), a fracturing agent that also transports the proppants into the fractures. First introduced in Marcellus Shale drilling in September 2009,LPGis derived from natural gas processing and consists mainly of propane in gel form (24). The process generates no wastewater since all of the LPG is recaptured back up the well."*

LPG Fracturing - Addressing Environmental Concerns



Source: HANCOCK & THE MARCELLUS SHALE , Visioning the Impacts of Natural Gas Extraction along the Upper Delaware, Prepared by the Columbia University Urban Design Research Seminar >> Spring 2009

Summary – Benefits of LPG Fracturing

Reservoir Performance

- Successfully Creates Required Fracture Geometry
- Successfully Transports Proppant
- Successfully Achieves Desired Effective Frac Lengths
- Optimal Long Term Stimulation Performance with Smaller Volumes
- Simple and Quick to Clean Up the Well – Turn to Sales
- High Percentage of the Frac Fluid is Typically Recovered (which is a Marketable Product)
- Favorable Production Rates and Recoveries

Environmental Performance

- No Biocides Used
- No Waste Products to Haul Off or Dispose
- No Water Supply Wells, Earthen Pits, or Water Rights Required
- No Subsidence Issues from Over Drawing Aquifers
- Minimal Flaring Required
- Reduced Truck Traffic to and from Lease
- Reusable and Recyclable Fracturing Fluid

LPG Fracturing Provides a Sustainable Stimulation Fluid for Shale Oil and Gas Development!

LPG Fracturing – "Making the Most of The Reservoir"

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