HORIZONTAL DRILLING AND HYDRAULIC FRACTURING CONSIDERATIONS FOR SHALE GAS WELLS

Brian K. Bohm, P.G.
J. Daniel Arthur, P.E., SPEC
ALL Consulting

Bureau d'audiences publiques sur l'environement (BAPE)
Saint-Hyacinthe, Québec
October 13-14, 2010

ALL CONSULTING

OVERVIEW

- Introduction
- Unconventional Natural Gas
- Shale Gas
  - History
  - Plays
  - Projections
- Horizontal Drilling
  - Well Pads
  - Drilling Operations
  - Protection of Groundwater
- Hydraulic Fracturing
  - HVHF Design
  - HVHF Operations
  - Fracturing Fluids
  - Fracture Fluid Composition
  - Groundwater Risk
  - Water Sourcing
  - Water Disposal/Reuse
- Additional Information

ALL CONSULTING

INTRODUCTION

- Shale gas holds tremendous potential for North American energy supply.
- Environmental considerations, especially those related to horizontal drilling and water use for high volume hydraulic fracturing (HVHF), have generated spirited debate among all stakeholders.
- Many of the concerns raised by the public stem from a lack of technical awareness of how shale gas development occurs.

ALL CONSULTING

UNCONVENTIONAL NATURAL GAS

- Unconventional resource plays are a growing source of natural gas in North America
  - Coal Bed Methane
  - Tight Sands
  - Gas Shales
- Since 1998, Unconventional natural gas has increased by nearly 65% in the U.S.
- As of 2007, total gas from unconventional plays approached almost 50% of the total natural gas production in the U.S.

Source: John Perez, Copyright ©, 2008

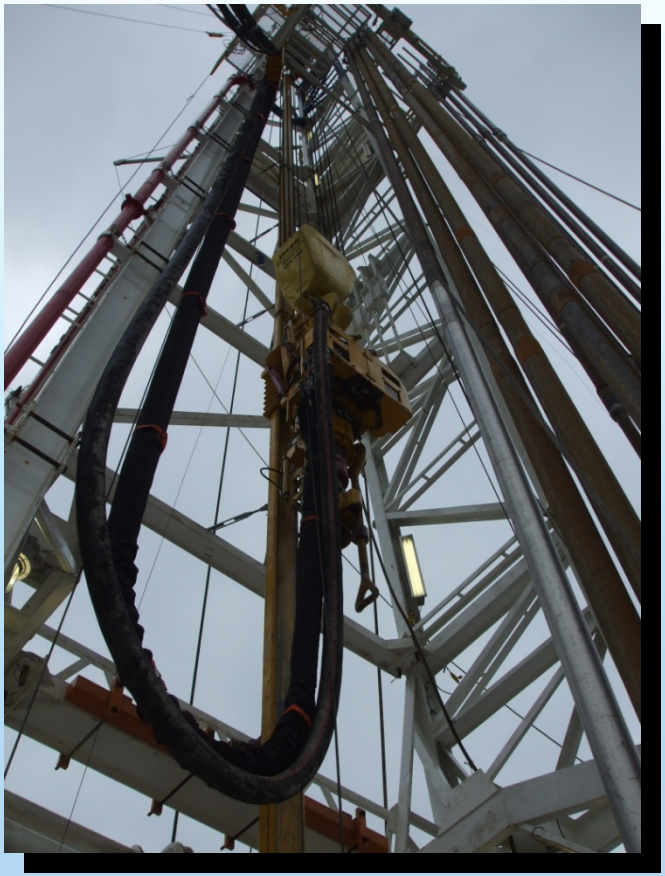
ALL CONSULTING

SHALE GAS HISTORY

- First Commercial Gas well – Fredonia, NY (1821)
  - Production from "Dunkirk Shale" at a depth of < 30 feet
- Ohio Shale – Big Sandy Field (1880)
- Barnett Shale – Ft. Worth Basin development (1982)
- First use of HVHF in Barnett Shale (1986)
- First horizontal well drilled in Barnett Shale (1992)
- US shale gas expands (2003)
- Horn River Shale, Canada (2006)
- Montney Shale, Canada (2007)

ALL CONSULTING

THE SHALE GAS TRIFECTA



Three factors made shale gas production economically viable:

- Advances in horizontal drilling
- Advances in hydraulic fracturing
- Increases in natural gas prices

ALL CONSULTING

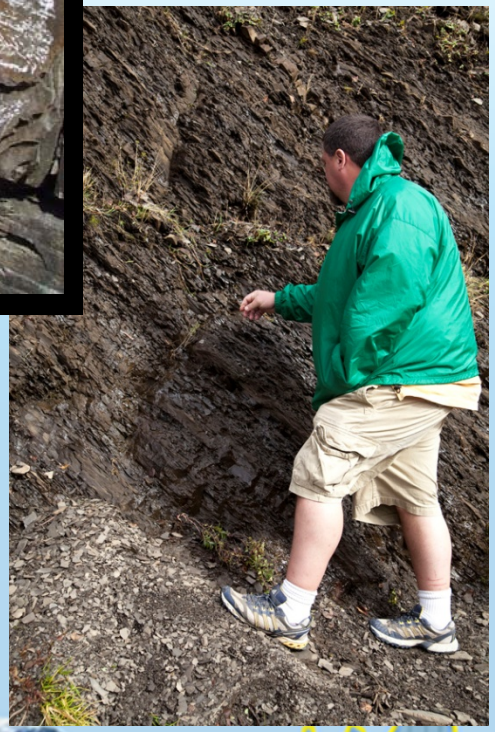
N.A. SHALE GAS PLAYS

ALL CONSULTING

SHALE GAS BENEFITS

- The United States: national energy security, the economy, environment
- Individual States: the economy, tax revenues, local resources, jobs

Marcellus Shale
Pennsylvania



Utica Shale
Quebec

ALL CONSULTING

HORIZONTAL DRILLING

Barnett Shale Well, Johnson County, Texas

- Shale gas multi-well pads typically require 2-5 acres initially:
  - Reclaimed to less than 2 acres after drilling is complete
- Multiple wells on a pad
  - 4-8 wells is typical
  - 12-16 is possible given certain conditions
- Pad preparation takes approximately one week

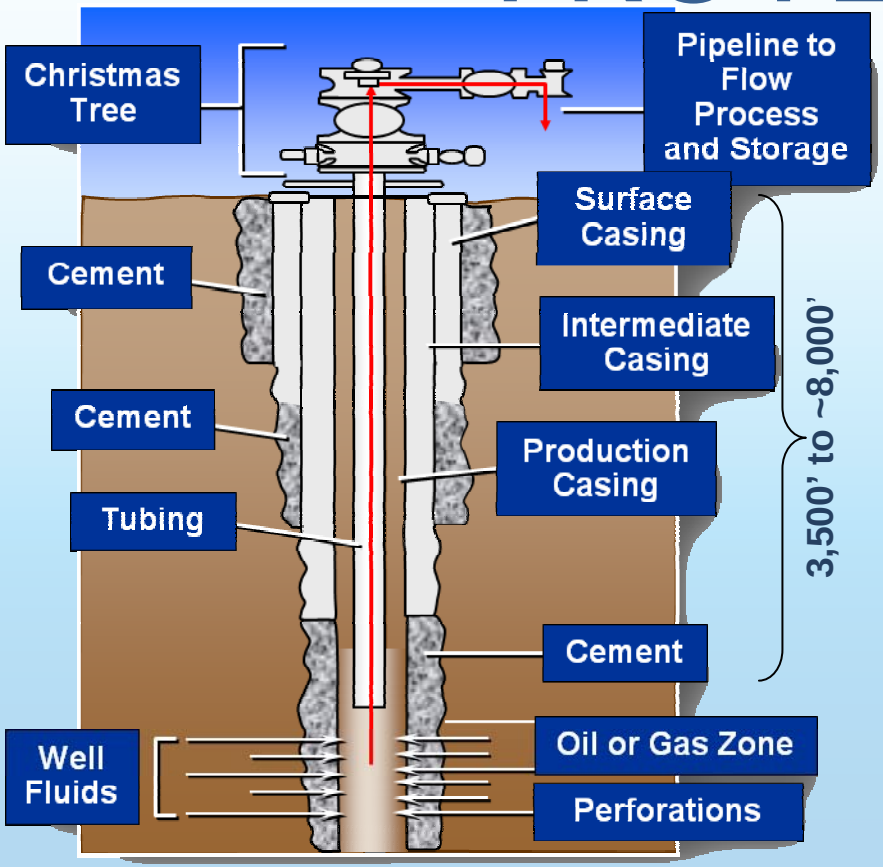
ALL CONSULTING

DRILLING THE WELLS

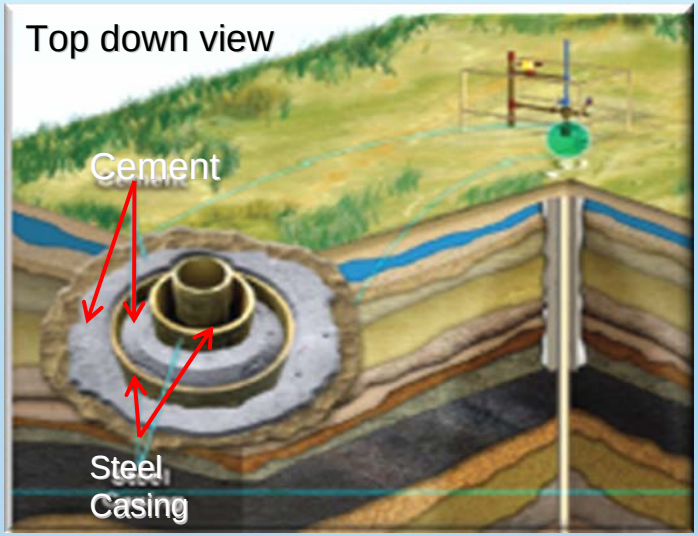
- Drilling operations operator 24/7 with a well taking ~90 to 120 days to drill
- Depths range from 0.8 km to over 3 km below surface
- Wells are oriented for maximum production based on geology
- Horizontal drilling allows operators to drill under homes and schools from almost a mile away
- Computer driven, state-of-the-art technology

ALL CONSULTING

GROUNDWATER PROTECTION



- Groundwater resources are protected by multiple casing strings and cement coupled with strict construction requirements



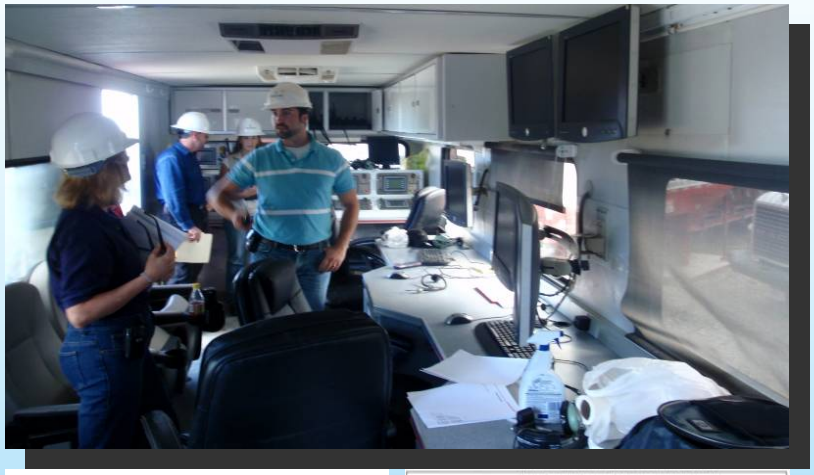
ALL CONSULTING

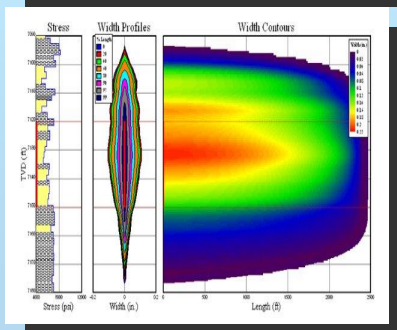
HIGH VOLUME HYDRAULIC FRACTURING

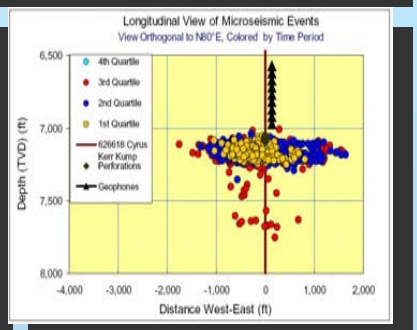
- Necessary due to low matrix permeability
- Key to successful fracture treatments is to keep fractures created in the target zone
- Fracturing out of the target zone is not cost effective:
  - Adds extra cost to stimulation job
  - Could adversely affect productivity of the well

ALL CONSULTING

Hydraulic Fracturing Design







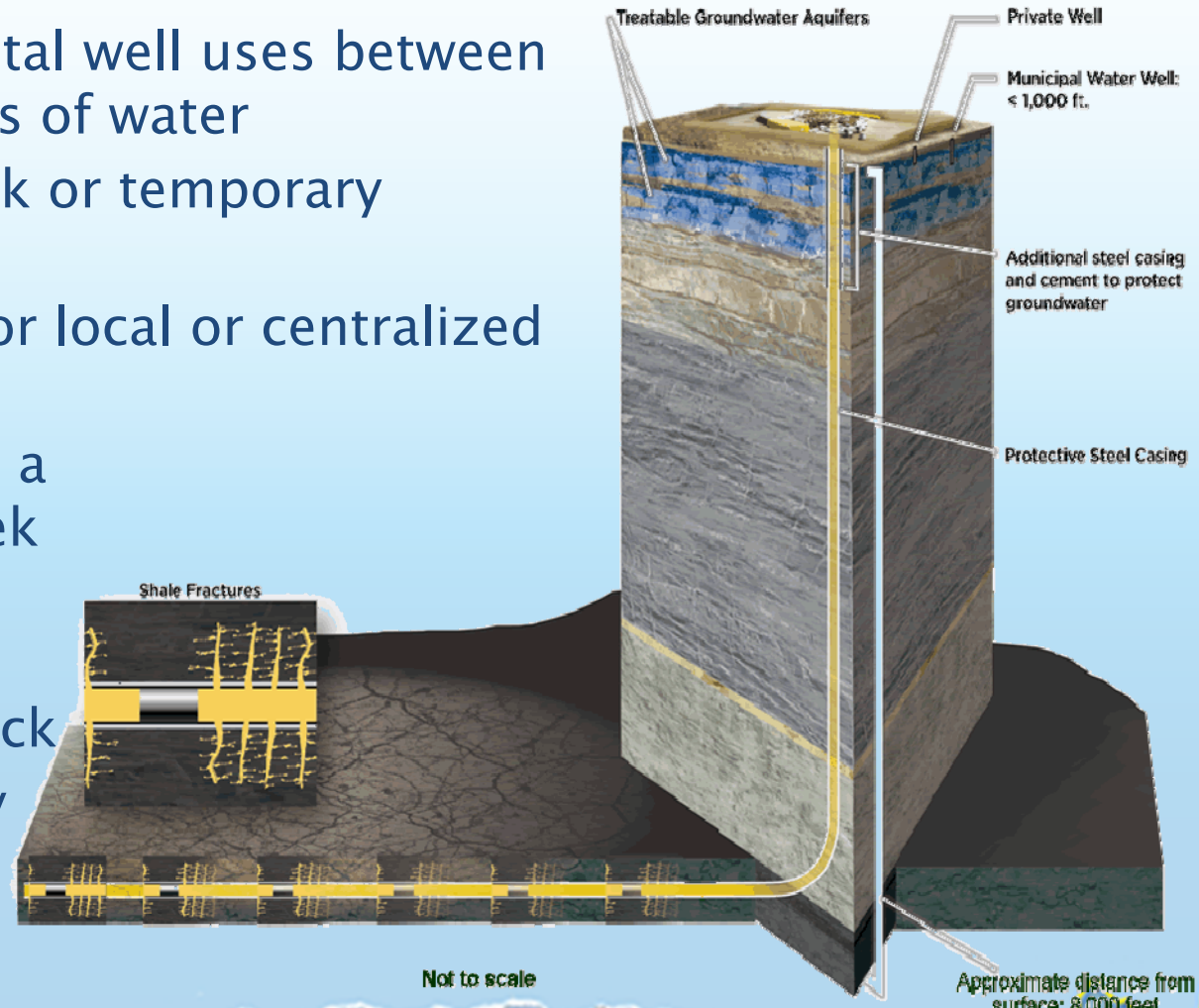
HVHF Operations

- Extensive up-front work with computer modeling to help design stimulation job
- Models are used to evaluate variables
  - Fluid volumes
  - Proppant size
  - Pressures during treatment
  - Fluid design
- Monitoring of fracture propagation during the stimulation job
  - Micro-seismic fracture mapping
  - Tiltmeter measurements

ALL CONSULTING

HVHF OPERATIONS

- Fracturing a horizontal well uses between 3 to 5 Million gallons of water
  - Delivered by truck or temporary pipeline
  - Stored in tanks, or local or centralized impoundments
- Fracturing job takes a few days to one week
- 15% to 30% of the fracture fluid is recovered as flowback
- Produced water may continue long term



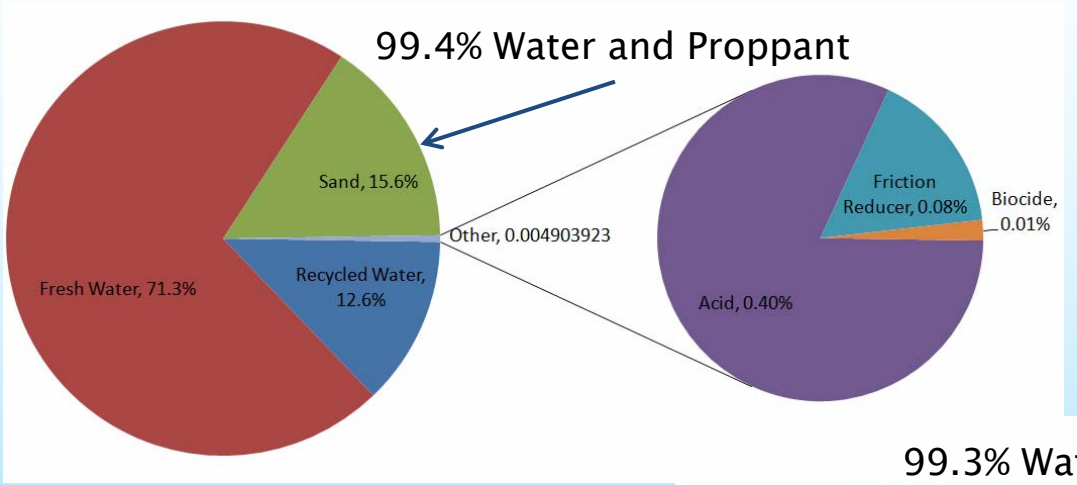
ALL CONSULTING

Fracture Fluids

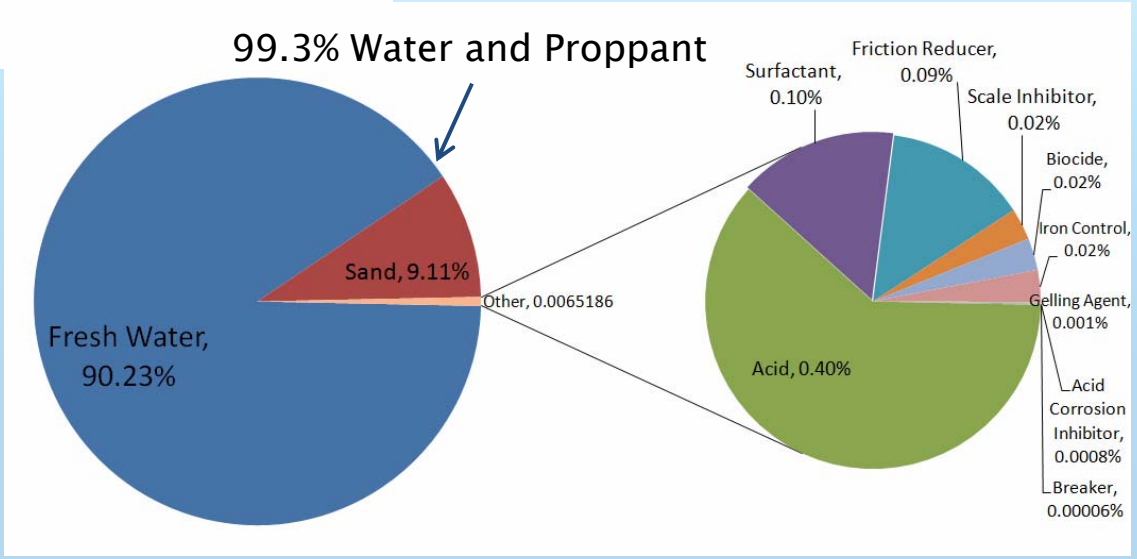
- 98-99.5% of slickwater fracturing fluid is water
- Each additive has an engineered purpose
- Proppant (sand)

ALL CONSULTING

HF FLUID COMPOSITION



HF Fluid with 15% Recycled Water



HF Fluid with 100% Fresh Water

ALL CONSULTING

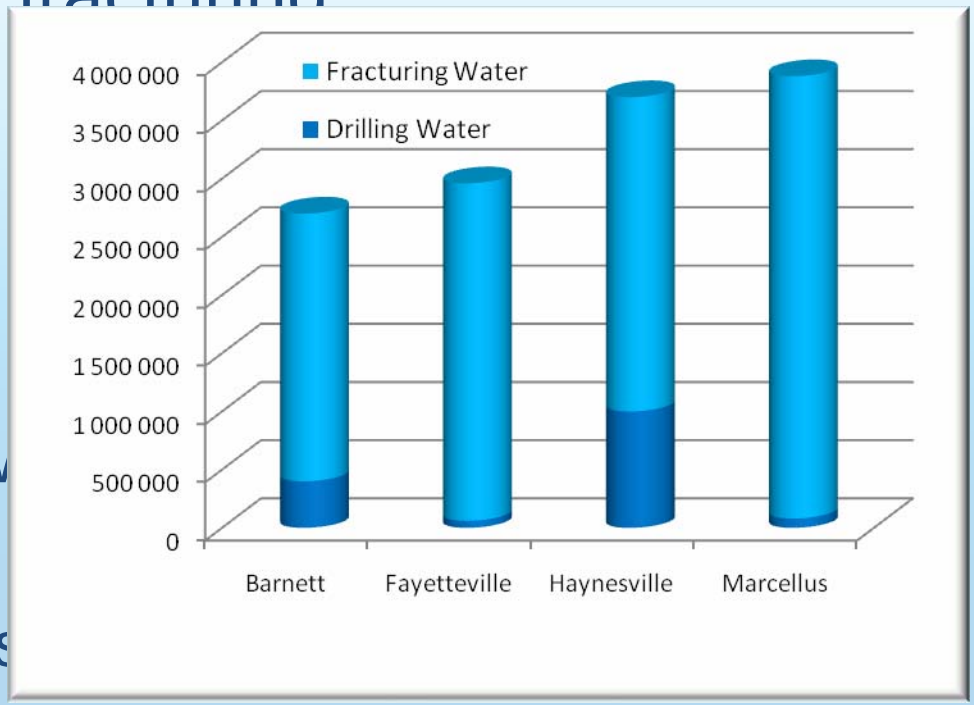
GROUNDWATER RISK

- A 1989 API & DOE study determined that in basins with "reasonable" likelihood of corrosion, the risk probability of injectate reaching a USDW ranged from 1 in 200,000 to 1 in 200,000,000 for UIC wells
  - Injection is on a continuous basis
- Shale Gas Hydraulic Fracturing Differences
  - Very short in duration
  - Within multiple installed concentric casing strings and cement
- Risk is very low

ALL CONSULTING

WATER SOURCING

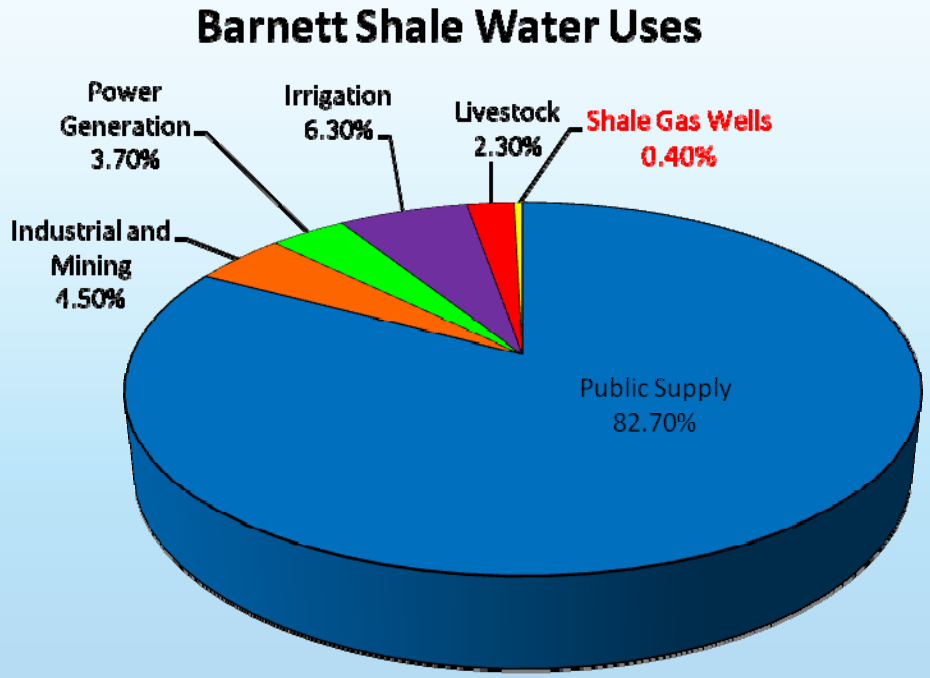
- Options available to meet water needs for drilling and fracturing
  - Surface Water
  - Groundwater
  - Municipal Water
  - Industrial Water
  - Recycled Produced W
  - Collected Water
  - Private Water Purchas



1,000,000 gallons = ~3,785 m^3

ALL CONSULTING

SOURCING CHALLENGES

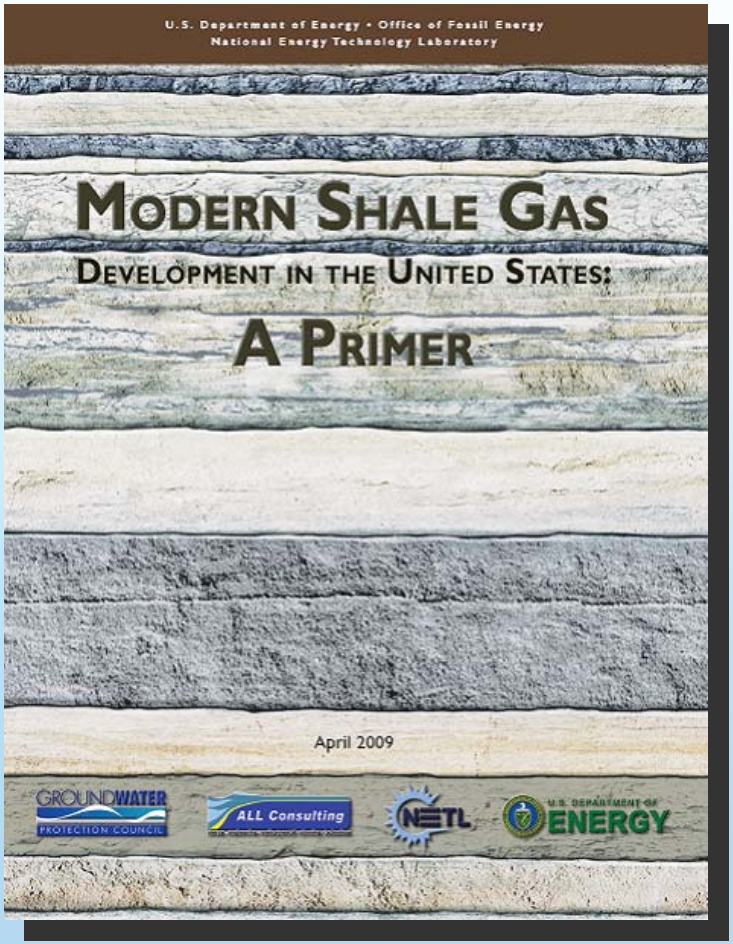


Groundwater Use in Barnett shale counties ranges from 1.95 percent in Somervall County to 85 percent in Cooke County

- Options vary by location and operator
- Competing water users and availability must be considered

Water Sourcing → Well Drilling → Well Completions → Flowback Water → Produced Water → Production Operations

INVITATION TO READ



http://www.all-llc.com/page.php?92

ALL CONSULTING

CONTACT INFORMATION

Brian K. Bohm, P.G.
J. Daniel Arthur, P.E. SPEC
ALL Consulting, LLC
1718 S. Cheyenne Avenue
Tulsa, Oklahoma 74119
www.ALL-LLC.com

ALL CONSULTING