Water and Energy in Texas
October 4, 2012

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FTI Consulting
Not all natural gas that is consumed is combusted. According to the 1995 DOE Topical Report, approximately 3.5% of natural gas is used as feedstock for ammonia, methanol, and ethylene production.
Drilling the Well Using Today’s New Technology

- Wells are drilled and constructed to recover the natural resources while protecting the environment and providing for the safety of workers and area residents.

- Drilling is a 24/7 operation
  - Reduces rig time on location

- The drilling phase is a temporary operation, typically lasting 2-3 weeks per wellbore
  - Multiple wells may be drilled in succession

- More and More operators utilize a “closed-loop” drilling system
  - All drilling materials are contained
  - No materials collected in earthen pits
  - Where pits are used, they are lined with impermeable liners
Drilling the well using today’s new technology
Well spacing can vary due to a number of factors including state regulatory requirements, location and formation characteristics.
Idealized Horizontal Well Spacing

Well spacing can vary due to a number of factors including state regulatory requirements, location and formation characteristics.
Drilling the well: Groundwater Protection

• 4 or more layers of protection are installed in the well to isolate the well from the surrounding strata and protect groundwater supplies and the environment
  – Multiple layers of steel casing and cement are utilized
  – Casing set in place below freshwater aquifer zone
Drilling The Well: groundwater Protection

- **Average Depths: 40' - 120'**
- **Average Depths: 350' - 4,500'**
- **Average Depths: 2,500' - 11,200'**
- **Average Depths: 4,400' - 17,000'**

Cemented to Surface

Conductor Casing

Surface Casing

Intermediate Casing

Drilling Mud

Cemented to Surface

Production Casing

Production Tubing

**Chesapeake Energy**

 Depths vary by play

**ENERGY IN DEPTH**
Well completion: Hydraulic fracturing

- After the drilling rig is removed, hydraulic fracturing (“fracing”) begins
  - Not new technology; has been in use since shortly after World War II
  - More than 1 million hydraulic frac jobs since 1947

- Water is mixed with proppant (such as sand) and pumped into the shale reservoir under pressure
  - 99.5% of fracturing fluid is made up of water and sand
    - ~3 - 5 million gallons of water needed per well

- Generally takes 2 – 4 days per wellbore
Well completion: Multi-stage hydraulic fracturing
Well completion: Hydraulic fracturing site layout

- Data Monitoring Van
- Pump Trucks
- Frac Heads
- Chemical Storage
- Blender
- Working Water Tanks
- Sand Storage Units
- Tanks of filtered water for re-use
Typical deep shale gas fracturing mixture

Water and Sand: 99.5%

Other: 0.5%
- Acid
- Friction Reducer
- Surfactant
- Gelling Agent
- Scale Inhibitor
- pH Adjusting Agent
- Breaker
- Crosslinker
- Iron Control
- Corrosion Inhibitor
- Antibacterial Agent
- Clay Stabilizer
Hydraulic Fracturing Fluid Product Component Information Disclosure

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<thead>
<tr>
<th>Fracture Date:</th>
<th>7/19/2011</th>
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<tr>
<td>State:</td>
<td>OHIO</td>
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<td>County:</td>
<td>CARROLL</td>
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<td>API Number:</td>
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<td>Longitude:</td>
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<td>True Vertical Depth (TVD):</td>
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<td>Total Water Volume (gal):</td>
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Hydraulic Fracturing Fluid Composition:

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<tr>
<th>Trade Name</th>
<th>Supplier</th>
<th>Purpose</th>
<th>Ingredients</th>
<th>Chemical Abstract Service Number (CAS #)</th>
<th>Maximum Ingredient Concentration in Additive (% by Mass)</th>
<th>Maximum Ingredient Concentration in HF Fluid (% by Mass)</th>
<th>Comments</th>
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<td>Carrier/Base Fluid</td>
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* 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(j) and Appendix D.
Leading The Innovation Charge

**Water Innovations**
- Onsite Water Recycling
- Wastewater Treatment Facilities
- Abandoned Coal Mine Water
- Reuse of Municipal Wastewater
- Development of Electrocoagulation
- Greener Fluids
- Increased Efficiencies
- Water Pipelines Reducing Truck Traffic
- Involving Small Businesses in Water Reuse & Recycling
- Water Purification Developments

**Drill Site Innovations**
- Emissions Reductions
- Natural Gas STAR
- Nat. Gas powered Vehicles and Equipment
Reducing Water Volumes

- Companies continually are working to reduce the amount of water used in shale development.

- Hybrid stimulation can cut water reduce by 40 percent.

- South Texas companies have reduced volumes by a third across the Eagle Ford Shale in just three years.

Photo Source: Washington County Oregon, Department of Health and Human Services, 2012
Non-Potable Water Use

- Abandoned Coal Mine Water
- Reuse Of Wastewater
- Reuse of returned water from prior Frac jobs
- Non-Potable Deep Aquifers
Water Recycling

- Onsite Water Recycle
  - Closed-loop system offers 100 percent recycling
- Onsite Water Treatment
  - Mobile Facilities
  - Distilling Water
- Esoteric Glass
Greener and More Efficient Fracturing Fluids

- Biodegradable Solutions
  - Orange Peel Extract
  - Food Industry Sources
- Ultraviolet Light
- Electrocoagulation
- Advanced Dry Polymer Blend
Regulation At The State Level

- AOGC Rule B-19
- Pennsylvania DEP Rule 78
- Wyoming – WOGCC Revised Rules – Chapter 3
- Texas – HB 3328, Rule 13
- Louisiana – Department of Natural Resources (DNR)
- STRONGER
Comprehensive Federal Regulation

- **The Clean Water Act** regulates surface water discharges and storm-water runoff.

- **The Clean Air Act** sets rules for air emissions from engines, gas processing equipment and other sources associated with drilling and production activities.

- **The Safe Drinking Water Act** regulates the disposal of fluid waste deep underground (far below fresh water supplies and separated by approximately one mile of impermeable rock).

- **The National Environmental Policy Act** requires permits and environmental impact assessments for drilling on federal lands.

- **The Occupational Safety and Health Act** sets standards to help keep workers safe. These include requiring Material Safety Data Sheets be maintained and readily available onsite for any chemicals used by workers at that location.

- **The Emergency Planning & Community Right-to-Know Act** requires storage of regulated chemicals in certain quantities to be reported annually to local and state emergency responders.
How Much Is 5 Million Gallons Of Water?

- A typical deep shale gas well stimulation = ~3 to 5 million gallons

- It’s the same amount of water consumed by:
  - 1,000 MWh coal-fired power plant in 11 HOURS
  - 1,000 MWh nuclear power plant in 6 HOURS
  - Corn Field over 5 ACRES per SEASON
  - Avg. golf course every 37 DAYS
**Water Use Comparison**

**Gallons of Water Per MWh Electricity Generated**

- **Deep Shale Natural Gas Combined Cycle**: 204 gallons (Avg. consumption for cooling, 14 for fuel)
- **Integrated Gasification (from Coal) Combined Cycle**: 364 gallons (204 for cooling, 160 for fuel)
- **Coal Steam Turbine**: 472 gallons (320 for cooling, 152 for fuel)
- **Nuclear Steam Turbine**: 704 gallons (592 for cooling, 112 for fuel)
- **Concentrating Solar**: 750 gallons

Source: Hightower 2008 (other than CHK data)

*Average consumption for fuels; Chesapeake data

Note: Wind turbines and photovoltaic solar panels have negligible water demands

MWh = megawatt-hour
Reclaiming the site

• Production equipment is installed

• Pipeline carries natural gas to market
  – Depending upon production level, liquid production may be trucked or transported via pipeline

• Produced water is retained on location in tanks until removed via truck

• Site is reclaimed and landscaped
  – Site is reduced to approximately 1 acre
  – Small access road will be retained

• Company returns regularly
  – Maintain equipment / monitor production rate
Reclaimed Drill Site
Questions?
Production Equipment
What can you build with 280 tons of steel?

4 M1 Abrams tanks

16 Caterpillar 953D bulldozers
Drilling Best Management Practices

- Chemical containers, tanks and process vessels
  - Containers greater than 55-gallons placed inside lined secondary containment
    - Secondary containment may include temporary earthen berms with polyethylene underlining the entire contained area
    - Or, a portable containment area constructed of steel, PVC or other suitable material

- Hoses and fittings
  - Where practical, hoses will be run within secondary containment
  - Drip-pots or troughs placed under all hose connections in concentrated chemical transfer service outside of secondary containments
Drilling Best Management Practices

- Pre-job meetings
  - Review safety, operational and environmental concerns

- Equipment staging
  - Staged to allow for visual inspection of potential leak points
  - Staged to take advantage of site construction measures

- Closed-loop drilling system
  - Solids/cuttings will be separated from the drilling fluid and maintained in steel tanks
  - Tanks hauled off and disposed of consistent with regulatory requirements
  - Fluids diverted back to mud tanks for reuse

- Use of air drilling through freshwater aquifers
Questions?