SLIDES: Drawing the Blueprint for a Sustainable Natural Gas Future

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Core Value

Drawing the Blueprint for a Sustainable Natural Gas Future

Denver, Colorado
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Mark K. Boling
Executive Vice President & General Counsel

Southwestern Energy
The Promise of Natural Gas

• The Environment
• The Economy
• Energy Security
Current Regulatory Environment

- Public Distrust and Fear
- Natural Gas Industry
- Certain Environmental Activists/Groups
- Proposed Federal Legislation

THE PERFECT STORM
Refocusing the Debate

• Dial Down the Rhetoric
• Identify the Real Obstacles to Responsible Development of this Resource
• Develop Workable Solutions to Overcome these Obstacles
Regulatory Considerations

Surface Considerations

Subsurface Considerations
Regulatory Considerations

Subsurface Considerations

Protecting Underground Water Resources

Frac Fluid Disclosure
Protecting Underground Water Resources

Well Integrity Is the Key!
Well Integrity

1. Evaluate Stratigraphic Confinement

2. Well Construction Standards

3. Evaluate Mechanical Integrity of Well

4. Monitor Frac Job & Producing Well
1. Evaluating Stratigraphic Confinement

Virtually all fresh water wells are less than 500 feet deep in the Fayetteville Shale area.

Thousands of feet of rock separates the Fayetteville Shale from shallow, freshwater zones.
• Differences in rock properties (i.e. strength and brittleness/elasticity) between the target formation (Fayetteville Shale) and surrounding formations (Morrow Shale and Hindsville Lime) act to contain hydraulic fractures within the target formation.

• Hydraulic fractures follow the path of least resistance and continue to propagate within the Fayetteville Shale.

*Cross sectional view*
The largest recorded seismic event generates the same amount of energy as would be released when dropping a gallon of milk from chest high to the floor.
In most shallow formations (less than ~2,000'), the hydraulic fracture will propagate in a horizontal direction.
2. Well Construction Standards

Cross sectional view

Surface Casing 550'

4000' of Sediment

400' Usable Fresh Water

2100' Various Atoka Sands & Shales

1300' Upper Hale

600' Morrow Shale

300' Fayetteville Shale

Hindsville
3. Evaluating Mechanical Integrity of Well

- **Internal Mechanical Integrity**
  - Verify appropriateness of proposed casing program (e.g., size, grade, minimum internal yield pressure, etc.)
  - Test casing string to ensure it can withstand maximum stimulation pressure

- **External Mechanical Integrity**
  - Verify quality of cement
  - Identify top of cement
  - Test cement job (FIT, CBL, etc.) when operations indicate inadequate coverage
GOOD MECHANICAL INTEGRITY

FRESH WATER AQUIFER ZONE

CONDUCTOR PIPE

SURFACE CASING

PRODUCTION CASING

SHALLOW PRODUCING ZONE

TARGET PRODUCING ZONE
CEMENT CHANNELING

PRESSURE BUILDS UP

CONDUCTOR PIPE

SURFACE CASING

PRODUCTION CASING

FRESH WATER AQUIFER ZONE

SHALLOW PRODUCING ZONE

TARGET PRODUCING ZONE

CASING

CEMENT

FORMATION
INSUFFICIENT CEMENT COVERAGE

- CONDUCTOR PIPE
- SURFACE CASING
- PRODUCTION CASING

PRESSURE BUILDS UP

FRESH WATER AQUIFER ZONE

SHALLOW PRODUCING ZONE

TARGET PRODUCING ZONE
4. Monitoring Frac Job and Producing Well

• Monitor pump pressure and rate during frac job

• Monitor annular pressures during and after frac job

• Terminate operations and take corrective action if abnormal pressure responses indicate mechanical integrity failure or fracture growth out of target zone
Regulatory Considerations

Surface Considerations

- Air Emissions
- Surface Impact
- Water Supply
- Water Handling
- Water Reuse & Disposal
Surface Considerations

Air Emissions

Emission Type
- NO$_x$
- SO$_2$
- CO
- CH$_4$
- VOCs (incl. BTEX)

Reduction Technology
- Catalytic reduction
- Ultra-low sulfur diesel fuel
- LNG and CNG fuels
- Oxidation catalysts
- Green completions, vapor recovery units, low bleed/no bleed pneumatic devices, plunger lift systems, leak detection

Emission Levels
- EPA
- Industry
- State regulators
- Research groups
Fulfilling the Promise of Natural Gas

- Public Trust
- Public Acceptance

Natural Gas Industry

Environmental Groups

Regulators/Legislators

Straight talk/open dialogue

Debate the real issues

Regulation without the politics
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[Image: Southwestern Energy logo]