

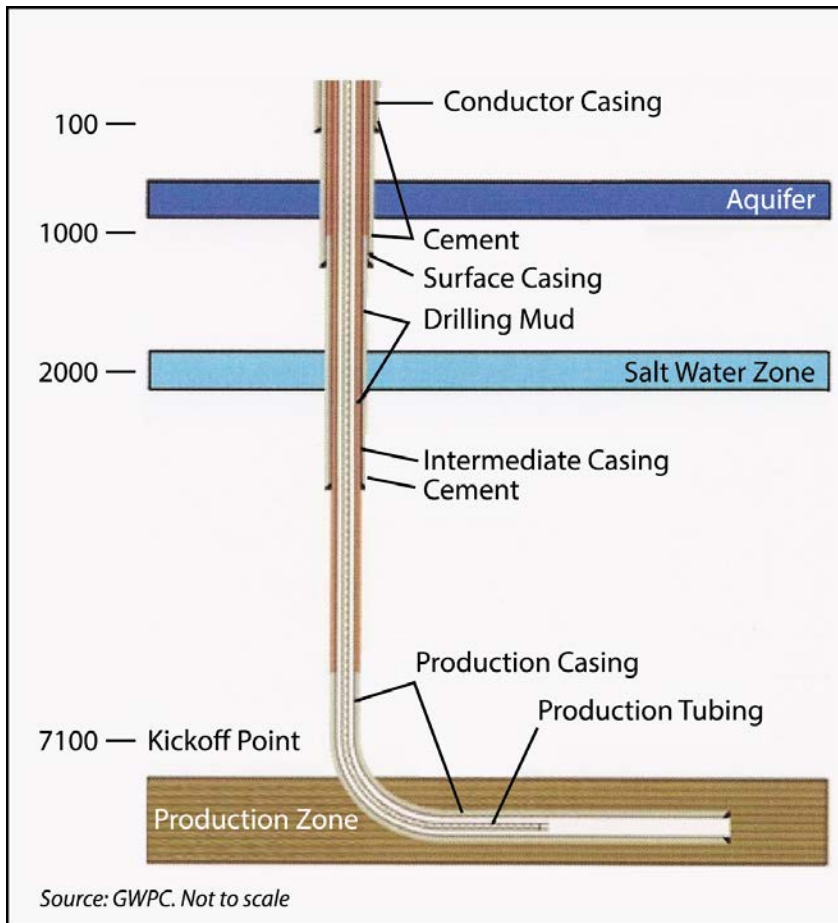
# SUSTAINABLE SHALE OIL AND GAS

Vikram Rao

Research Triangle Energy Consortium

December 1, 2016

# Shale Oil and Gas Extraction Process



**Horizontal drilling can extend up to 10,000 feet laterally**

# Potential Downhole Leak Paths

- Directly from fracturing zones: very unlikely
- Casing shoes
- Integrity of cement job
- Gas more likely than liquid

# Remedies for Downhole Leak Paths

- Best well construction practices
  - Regulatory means
  - Voluntary compliance
    - Needed: means to share practices (DeepStar)
- Example Regulatory means
  - Casing rules: surface casing depth min.
  - Cementing zones of fluid incursion
    - All wells not cemented bottom to top
  - Testing cement: before and bond logs after
  - Detailed plugging procedures/instrumentation

# Potential Surface Leak Paths

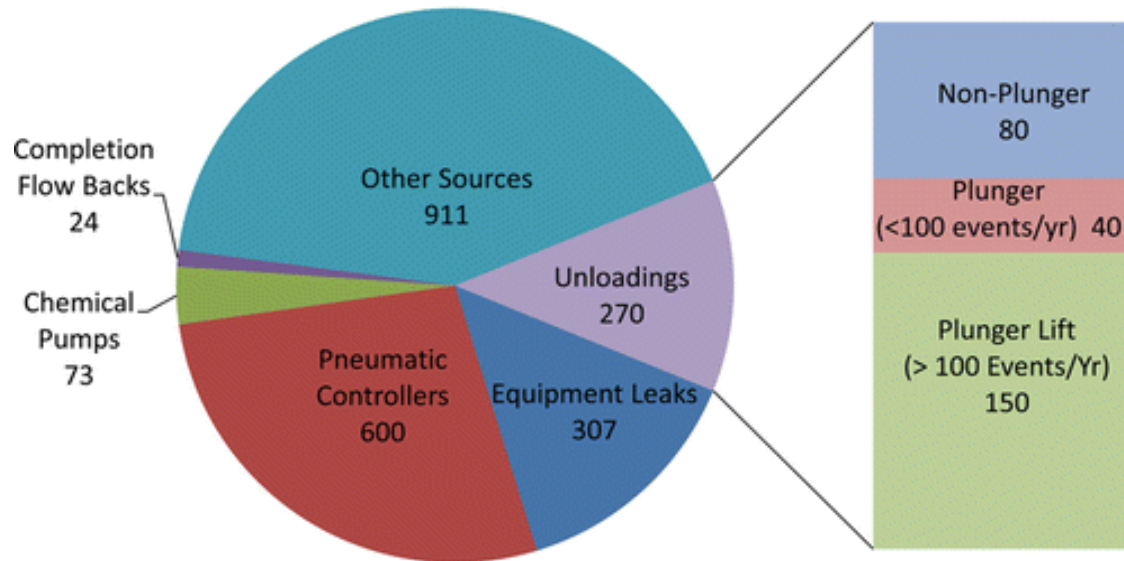
- Spills on or near rig site
- Unintentional leaks from equipment
- Leaks due to design choices
  - Valves using line pressure to actuate
- Leaks due to operational practices
  - Liquids unloading method chosen
- Leaks from waste water impoundments
  - Surface containment versus in-ground

# Forks in Engineering Design Roads

- Most equipment and process design: more and less sustainable choices
  - Curricula should include these considerations
- Materials: rare earth magnets
- Equipment design: DC devices use less energy
- Process design: liquids unloading

# Sources of Fugitive Methane

**Estimated Annual Emissions from Upstream  
Natural Gas Production Sector in the United States  
(Gg Methane)**



# Better Measurements

*That which cannot be measured, cannot be controlled*

- Instrumenting wells for emission detection
  - Use of nano devices
- Some of the capability will have legacy use
- Locating and mapping of all wells
  - Legacy wells and new wells: different technology
- Air emissions: locating and mapping