COLORADO OIL AND GAS CONSERVATION COMMISSION

HYDRAULIC FRACTURING

MAY 2011
Overview

I. Background
II. Relevant Regulations
III. Engineering Review
IV. Environmental and Groundwater Protection
V. Inspection and Complaints
Mission Statement

- Under the Oil and Gas Conservation Act, the Commission’s mission is to: Foster the responsible, balanced development, production, and utilization of oil and gas in a manner consistent with protection of public health, safety, and welfare, including protection of the environment and wildlife resources.

- C.R.S. 34-60-102(1)(a)(I).
Purpose of Hydraulic Fracturing

- To improve the productivity and ultimate recovery of the well.
- Effectively connects the well to the productive formation.
- Creates a high permeability pathway from the productive formation to the well.

Uses a controlled high pressure injection of fluid and proppant (usually sand).
History of Hydraulic Fracturing

- First Treatment: 1947 Hugoton
- MHF's Treatments
- 400,000 Treatments
- 800,000 Treatments
- Over 1,000,000 Wells Hydraulically Fracture Treated

SPE Papers 801, 22392, 36166, IOGCC, Halliburton
COGCC Hydraulic Fracturing Rules

- Rule 205 inventory chemicals
- Rule 317 Well casing and cementing; Cement bond logs.
- Rule 317B setbacks and precautions near surface waters and tributaries that are sources of public drinking water.
- Rule 341 monitor pressures during stimulation.
- Rule 608 Special requirements for CBM wells.
- Rules 903 & 904 pit permitting, lining, monitoring, & secondary containment
- Rule 906 requires Commission, CDPHE and the landowner of any spill that threatens to impact any water of the state.
What’s in the fluids and proppant?

- Though some water sensitive formations are still frac’d with petroleum based fluids, most frac fluids are water based including nitrogen foam systems.
- You still probably would not want to drink it. But you don’t drink other things naturally present in the productive formation either like petroleum or condensate (similar to kerosene, paint thinner and gasoline).
Composition of Frac Fluid

From: Gas Research Institute
## Composition of Frac Fluid

<table>
<thead>
<tr>
<th>Additive</th>
<th>Main Compound</th>
<th>Common Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diluted Acid</td>
<td>Hydrochloricor, Muriatic Acid</td>
<td>Swimming Pools</td>
</tr>
<tr>
<td>Biocide</td>
<td>Glutaraldehyde</td>
<td>Dental Disinfectant</td>
</tr>
<tr>
<td>Breaker</td>
<td>Ammonium Persulfate</td>
<td>Bleaching Hair</td>
</tr>
<tr>
<td>Crosslinker</td>
<td>Borate Salts</td>
<td>Laundry Detergents</td>
</tr>
<tr>
<td>Iron Control</td>
<td>Citric Acid</td>
<td>Food Additive</td>
</tr>
<tr>
<td>Gelling Agent</td>
<td>Guar Gum</td>
<td>Biscuits</td>
</tr>
<tr>
<td>Scale Inhibitor</td>
<td>Ethylene Glycol</td>
<td>Antifreeze</td>
</tr>
<tr>
<td>Surfactant</td>
<td>Isopropanol</td>
<td>Glass Cleaner</td>
</tr>
<tr>
<td>Friction Reducer</td>
<td>Polyacrylamide</td>
<td>Water and Soil Treatment</td>
</tr>
</tbody>
</table>
Proppants (Sand)

- packed proppant (> 5 kg/m²)
  - max. post-job fracture width

- monolayer proppant (≈ 1.5 kg/m²)

- partial-monolayer proppant (< 0.5 kg/m²)

Increasing effective stress on proppant

From BJ Services
Where do the fractures go?

- They stay in the formation of interest.

- Typical fracture:
  “Half” Length: 300’ to 1500’.
  Height: 20’ to 300’.
  Width: 0.1” – 0.3”.

- Energy Force: less than -1 on Richter Scale
Where do the fluids go?

- Some fluids flowback prior to production.
- Flowback is collected in the flowback tanks (or lined pits).
- Most of the rest is produced from the well.
- Small percentages may remain in production formation.
- The frac fluid is reused at another site or disposed of into injection wells or other E&P waste disposal facility.
COGCC POLICIES TO PREVENT GAS/OIL MIGRATION
(FOR NEW WELLS)

1. ENSURE SURFACE CASING IN ALL WELLS IS SET AT LEAST 50 FEET BELOW THE DEPTH OF THE DEEPEST WATER WELL OR AQUIFERS

2. ENSURE PRODUCTION CASING ISOLATES ALL PRODUCTION ZONES
WELL BORE
The following diagrams are vertically distorted in order to depict a wellbore. The wellbore dimensions are in inches and the cross-section is in feet of depth.
PLACE & CEMENT SURFACE CASING
To protect and isolate aquifers

GROUND SURFACE
CEMENTED CONDUCTOR
AQUIFER(S)
CEMENT SURFACE CASING
PRODUCTIVE FORMATIONS

Surface Casing
Cemented steel casing
Below the existing water wells and aquifers
CEMENT PRODUCTION CASING
To isolate hydrocarbons to producing formations by cement and steel casing.
PREPARE FOR PRODUCTION
Perforate and run tubing

Bradenhead valve monitoring during frac’ing per Rule 341
Application for Permit to Drill – Casing and Cementing Plan

<table>
<thead>
<tr>
<th>String</th>
<th>Size of Hole</th>
<th>Size of Casing</th>
<th>Weight Per Foot</th>
<th>Setting Depth</th>
<th>Stock Cement</th>
<th>Cement Bottom</th>
<th>Cement Yell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductor</td>
<td>26&quot;</td>
<td>20&quot;</td>
<td>94#</td>
<td>70'</td>
<td>110</td>
<td>70'</td>
<td>0</td>
</tr>
<tr>
<td>Surface</td>
<td>17-1/2&quot;</td>
<td>13-3/8&quot;</td>
<td>54.5#</td>
<td>500'</td>
<td>340</td>
<td>500'</td>
<td>0</td>
</tr>
<tr>
<td>Intermediate</td>
<td>12-1/4&quot;</td>
<td>9-5/8&quot;</td>
<td>36#</td>
<td>1500'</td>
<td>350</td>
<td>1500'</td>
<td>0</td>
</tr>
<tr>
<td>Production</td>
<td>8-3/4&quot;</td>
<td>7&quot;</td>
<td></td>
<td>10300'</td>
<td>880</td>
<td>10300'</td>
<td>1300'</td>
</tr>
</tbody>
</table>

32. BOP Equipment Type: [✓] Annular Preventer [✓] Double Ram [✓] Rotating Head [☐] None
CDWR Water Well Data

Recipit 0041957 Permit No. 249610
Owner: US BUREAU OF RECLAMATION
Depth 81
Cement Bond Logs

Rule 317.o. requires cement bond logs for all wells.
COLORADO OIL AND GAS CONSERVATION COMMISSION

• Water for Fracing & Other Activities
• Waste Management
• Ground Water Protection, Investigations and Monitoring
• Complaint Response
Sources of Water in Colorado
DNR Division of Water Resources

- Use of Water Must be Legally Allowed
  - Municipal lease/purchase
    (industrial uses)
  - Changed water rights
    (e.g. temp agricultural to industrial)
  - Fully consumed water
    (leased/purchase effluent)
  - Produced water
    (non-trib or decreed trib & augmented)
  - Non-tributary
    (landowner & operator agreement)
Sources of Water in Colorado

- Non-tributary Water
  - 1985 Law (SB5)
  - Allows Non-tributary water withdrawal when mining minerals (includes O&G)
  - Premised on incidental withdrawal
    - Amount that can be withdrawn
    - Duration
  - Land ownership not required
  - O&G reservoirs are deep, therefore not economic, not productive, and not suitable quality
MANAGEMENT OF E & P WASTE

- PRODUCED WATER
  - Injection (COGCC UIC or EPA on Tribal Lands)
  - Evaporation (COGCC Pits & Centralized E&P)
  - Commercial Facilities (CDPHE – Solid Waste)
  - <3,500 TDS dust suppression (COGCC)
  - Discharge (CDPHE – WQCD)
  - Reuse & Recycle (COGCC)
MANAGEMENT OF E & P WASTE

• DRILLING FLUIDS, FLOWBACK (FRAC) & OILY WASTES
  • Injection (COGCC UIC or EPA on Tribal Lands)
  • Commercial Facilities (CDPHE – Solid Waste)
  • Land treatment (COGCC)
  • Centralized E&P Waste Facility (COGCC)
  • Reuse & Recycling (COGCC)
900 SERIES RULES - Management of E&P Waste

- Rule 901 - General
- Rule 902 to 905 – Pits: permitting (Form 15 & Form 2A), lining, O&M, closing
- Rule 906 – Spills/releases: reporting, cleanup, surface owner notification
- Rule 907 – Management reused/recycling, tracking, plans, disposal methods produced water, drilling fluids, oily wastes, frac fluid, etc
- Rule 908 – Centralized E&P Waste Management Facilities
- Rule 909 – Site Investigation, Remediation, Closure
- Rule 910 – Cleanup Concentrations
Properly drilling, completing, operating, and P&A to ensure and maintain isolation of productive zones from GW & SW.

Properly storing, treating, reusing/recycling, transporting, and disposing of wastes.

Properly installing and maintaining associated equipment & E&P waste management facilities.

Rapid response to and thorough remediation of impacts from spills and releases.
GROUND WATER PROTECTION
INVESTIGATIONS & MONITORING

- Analytical results from more than 5,000 water wells.
- Collected by the COGCC, Operators, other agencies
- Studies by COGCC to establish Baseline and Current Conditions
- Collected in response to complaints and requests
- Required by Orders of the Commission (Cause 112)
- Required by Rules (317B, 318A.e.4., 608, 908)
- Required as part of Site Investigation and Remediation activities.
- Blue – water samples
- Green – oil/gas well samples
COMPLAINT RESPONSE

- Collect samples from water wells, soil or other media for field and laboratory analyses.
- Collect samples of gas, oil, condensate, produced water, flow back, or other wastes from nearby oil and gas wells.
- Compare analytical results to background and water regional water quality.
- Compare stable isotopic signatures and composition of gas samples to determine source.

If a complaint is verified:
- Operator must remediate impacts to meet standards.
- Operator must mitigate impacts.
COMPLAINTS

- Response within 24 to 48 hours
- Water testing and analysis
- Reports
- Right to hearing
INSPECTIONS

- 15 Inspectors located throughout the state
- Over 17,000 inspections in 2010
- Most inspections are unannounced
OTHER ONGOING ACTIONS TO ENSURE THAT HYDRAULIC FRACTURING PROTECTS PUBLIC HEALTH AND ENVIRONMENT

- FracFocus.org Website
- “STRONGER” review
- Diesel investigation
- Water well investigations
COGCC Public Website

www.colorado.gov/cogcc

- Denver Office Phone Number: (303) 894-2100
- Statewide Complaint Line: (888) 235-1101