# Hydraulic Fracturing - Using Geology and Planning to Avoid Environmental Impacts*

**James M. Kerr, Jr.[1], Angus R. McGrath[1], Thomas M. Fendler[1], and Michael J. Teeling[1]**

Search and Discovery Article #80323 (2013)**
Posted October 21, 2013

*Adapted from oral presentation given at AAPG Rocky Mountain Section Meeting, Salt Lake City, Utah, September 22-24, 2013


[1]Stantec Consulting Services, Inc. (James.Kerr@stantec.com)

## Abstract

The collection of accurate geologic, geochemical, and hydrogeologic data and the proper planning of the drilling program through completion and production can help identify background conditions and avoid environmental impacts commonly associated with hydraulic fracturing. Once a prospect is identified, it is important to understand the geology above the target zone and any connection to current or future groundwater resources; collectively known as well pad risk evaluation or analysis. The drilling program, including casing setting depths, should be planned to take into account potable water-bearing zones, identification of saline zones and shallow gas zones that may be encountered during drilling.

Additional considerations such as the collection of geochemical groundwater parameters and/or depth discrete gas samples during drilling may be warranted depending upon the location of the well pad. Cement bond logs and pressure tests should be run to verify proper casing installation and integrity. Pre-drill and post-drill monitoring and sampling programs should be developed to determine baseline conditions and protect against future liability. Personnel should be available to respond to public inquiries of water quality concerns if there is a perception of impacts related to drilling activities. Well head testing, SPCC Plans, Facility Response Plans (if required), and Spill Response Planning and Drills should be conducted to avoid and/or minimize environmental impacts. Finally, a team with the proper Incident Command System (ICS) training and experience should be identified that can immediately respond in the event that a release related to drilling, hydraulic fracturing or production activities occurs.

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AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
An International Organization

Stantec

## PRESENTER

James M. Kerr, Jr., PG

## CONTRIBUTORS

Thomas M. Fendler, PG

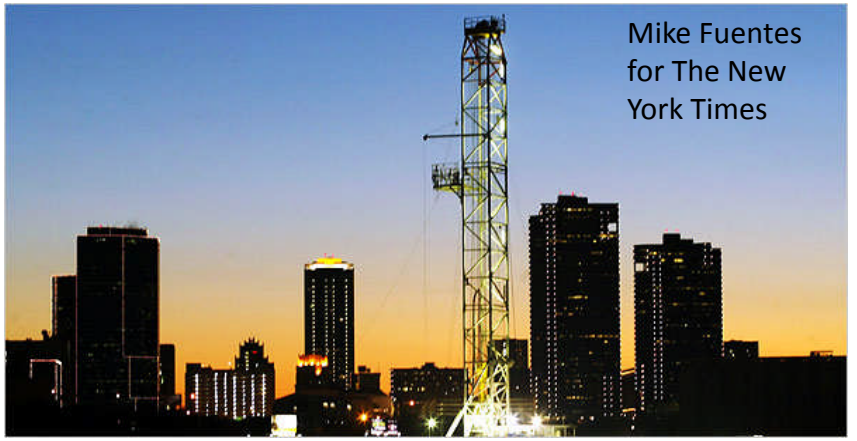
Angus E. McGrath, PhD Chem.

Michael J. Teeling, PG


Stantec

# Diverse Well Locations





# Increased Drilling Activities & Better Informed Public Has Created Change

- Social Media
- Moratoriums & Bans on Drilling and Hydraulic Fracturing
- Regulation – State & Federal
- Increased Litigation


# Proactive Steps

- Pre-drill Planning/Well Pad Risk Analysis
- Pre-drill Sampling
- Proper Well Construction & Mechanical Integrity Testing
- Post Completion/Production Monitoring & Sampling
- Improved Communication
- Contingency Planning
- Incident Command System (ICS)
- Emergency Response Drills

# Pre-Drill Planning/Well Pad Risk Analysis

- Geologic
- Geochemical
- Hydrogeological
- Casing Plan

# Pre-Drill Sampling

- Domestic Water Wells
- Public Water Wells
- Springs
- Rivers And Creeks
- Surface Water Bodies

# Pre-Drill Parameters

## Colorado/Wyoming (Wyoming Rules are Proposed)

- pH
- Specific conductance
- Total dissolved solids (TDS)
- Dissolved gases (methane, ethane, propane)
- Alkalinity (total bicarbonate and carbonate as CaCO3)
- Major anions (bromide, chloride, fluoride, sulfate, nitrate and nitrite as N, phosphorus)
- Major cations (calcium, iron, magnesium, manganese, potassium, sodium)
- Other elements (barium, boron, selenium and strontium)
- Presence of bacteria (iron related, sulfate reducing, slime forming)
- Total petroleum hydrocarbons (TPH) and BTEX compounds (benzene, toluene, ethylbenzene and xylenes)
- Field observations such as odor, water color, sediment, bubbles, and effervescence

## Recommended Additions

- Dissolved oxygen (DO) and oxidation reduction potential (ORP)
- Dissolved gases (methane, ethane, propane) – If detected at > 10 mg/L use isotopic characterization
- Field observations add ferrous iron & turbidity

# Mechanical Integrity Test - Rule

- …"a mechanical integrity test of a well is a test designed to determine if there is a significant leak in the casing, tubing, or packer of the well, and there is significant fluid movement into an underground source of drinking water through vertical channels adjacent to the wellbore."

COGCC Rule 326 Page 300-54

# Mechanical Integrity Test - Requirements

"The mechanical integrity test shall include one (1) of the following tests to determine whether there are significant fluid movements in vertical channels adjacent to the well bore":

A. Cementing records;

B. Tracer surveys;

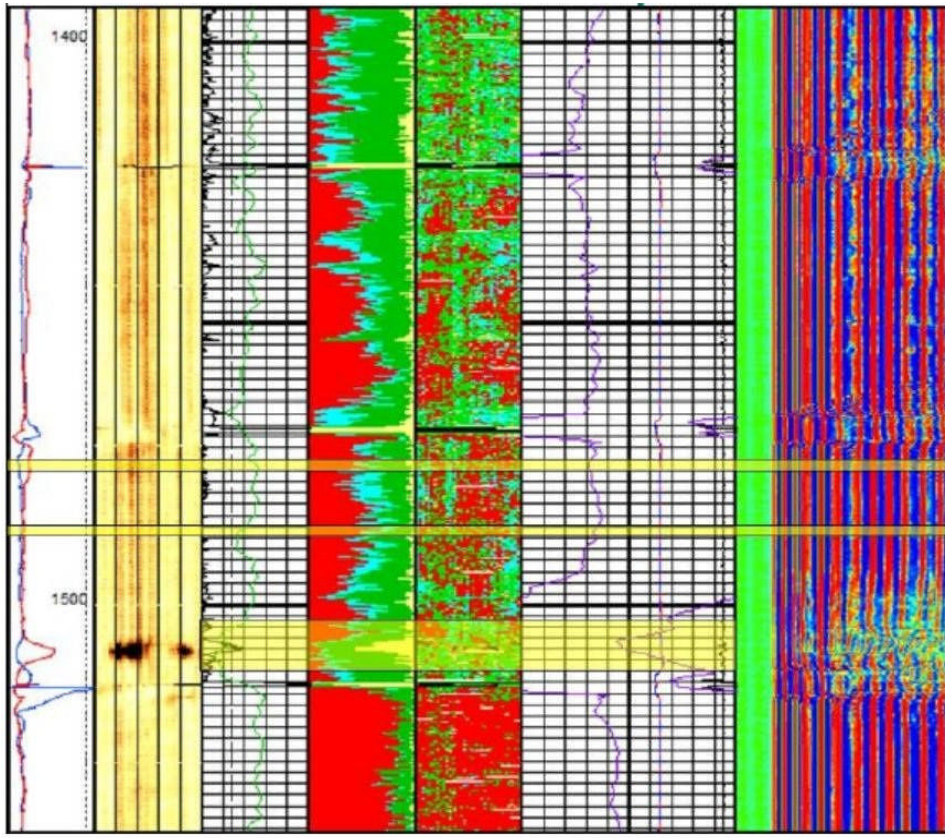
C. Cement bond log or other acceptable cement evaluation log;

D. Temperature surveys; or

E. In lieu of A.-D., any other equivalent test or combination of tests approved by the Director."

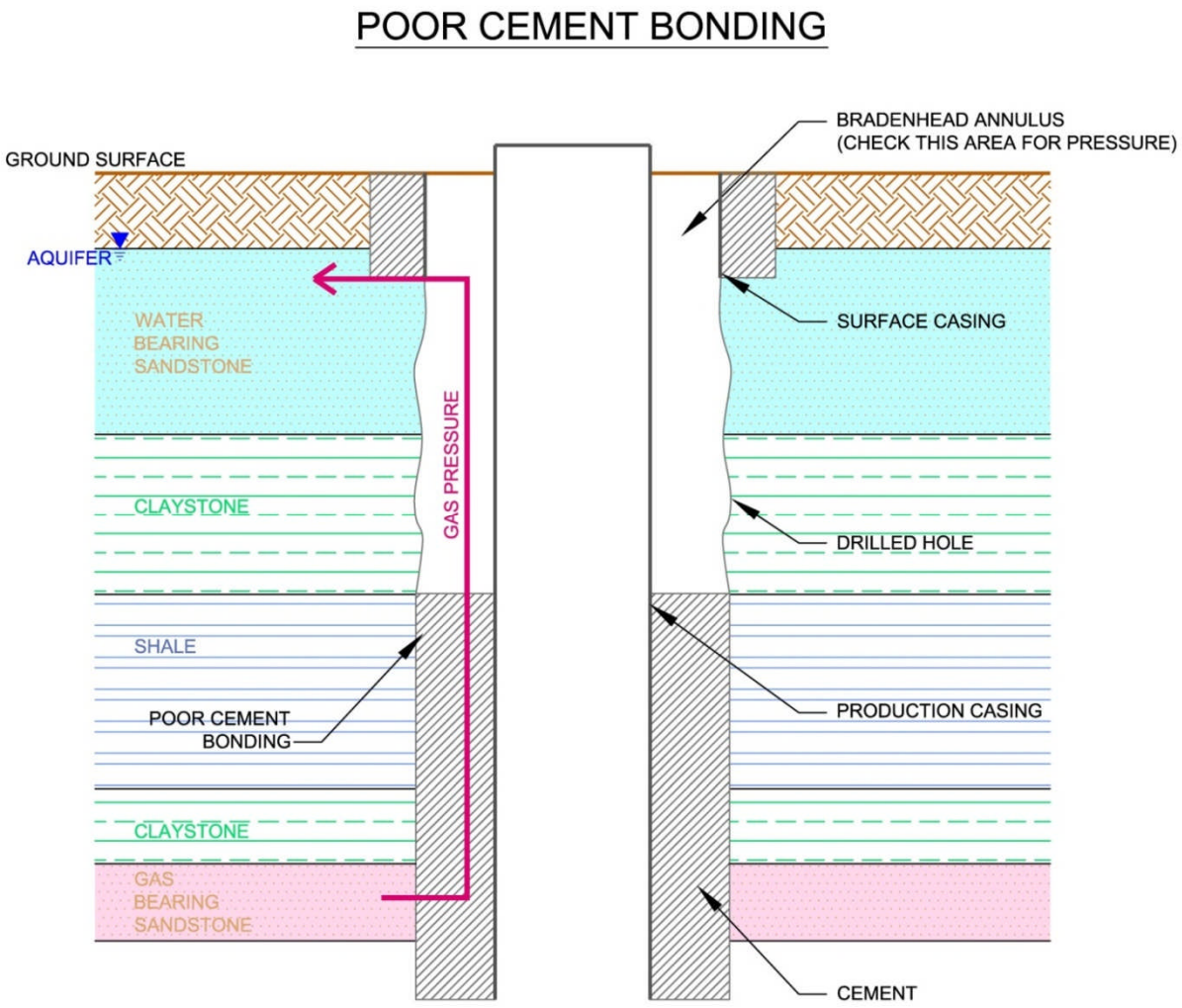
COGCC Rule 326.2 Page 300-55

# Mechanical Integrity Test
# Cement Bond Log (CBL)

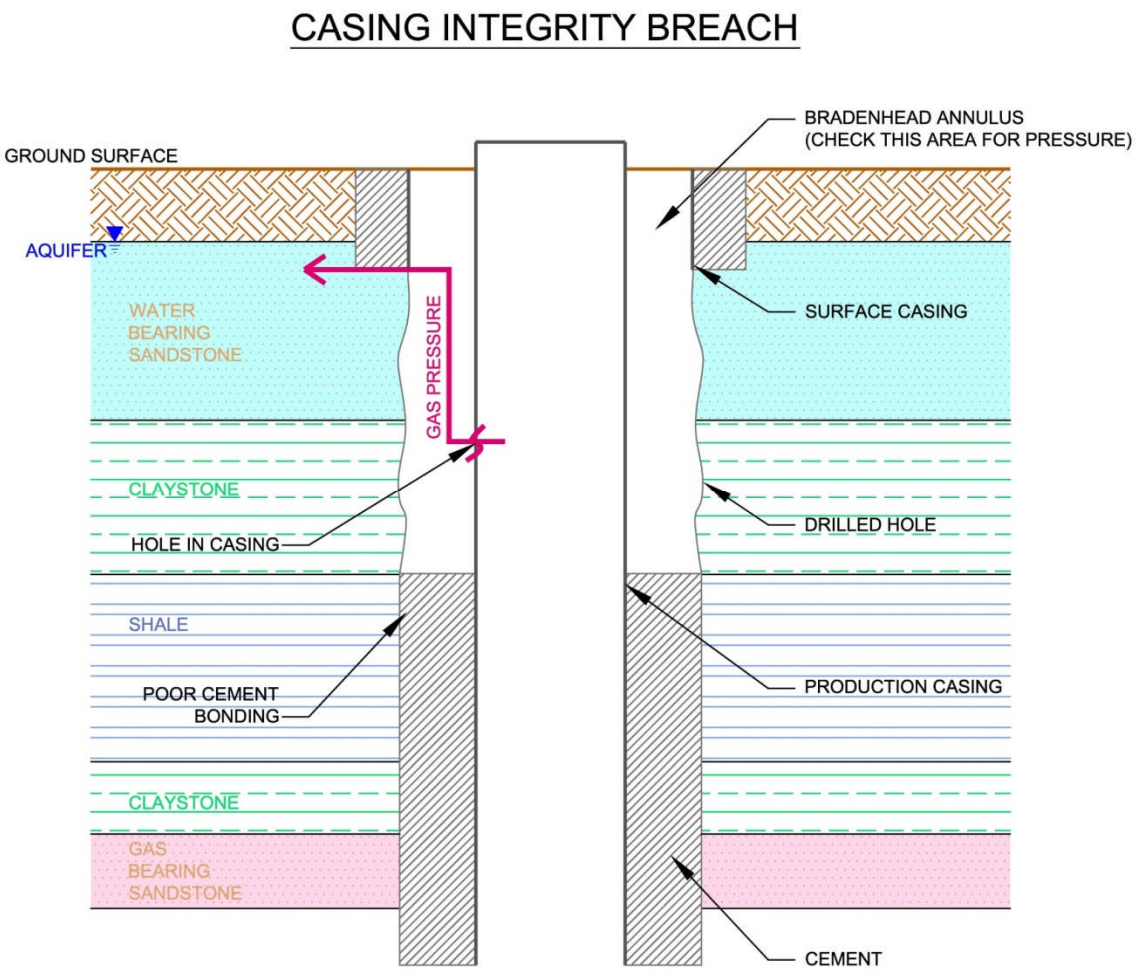



**Ultra sonic imaging tool, CBL-VDL, GR and CCL log**

# Mechanical Integrity Test
# Bradenhead Testing



# Mechanical Integrity Test
# Bradenhead Testing

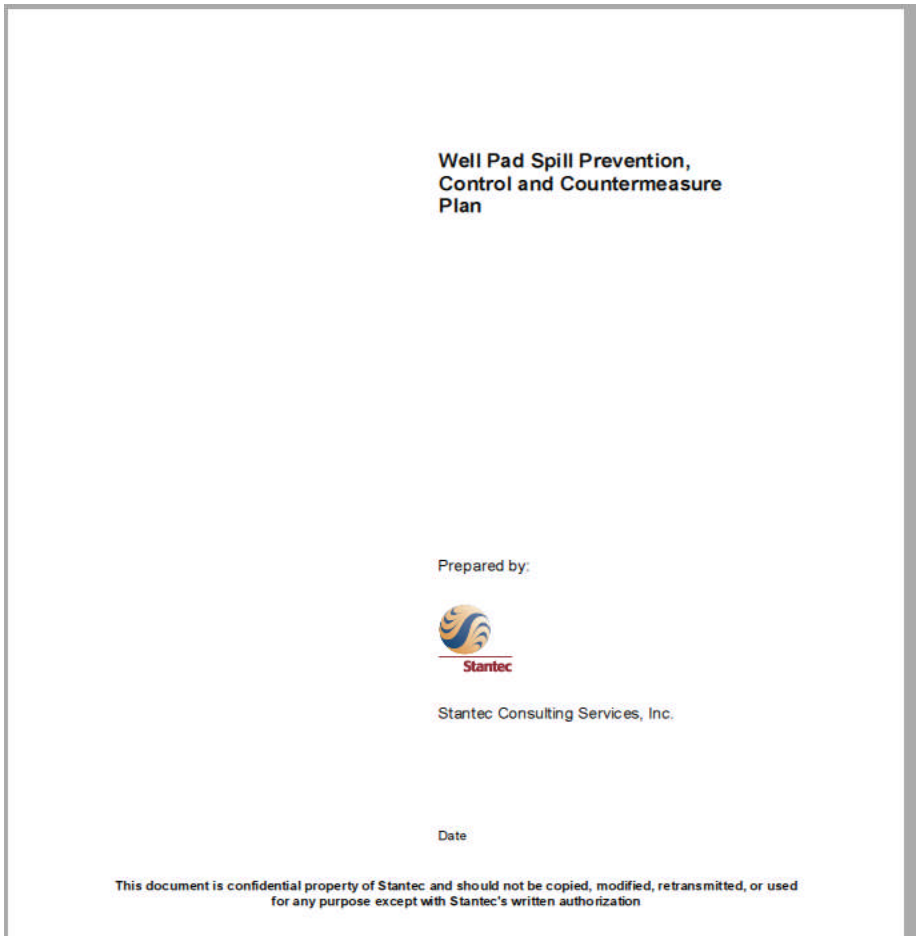


# Post Completion/Production Sampling
# Post Drill Sampling
# (Based on Local & State Requirements)

# Improved Communication
# Stakeholder Relations

# Improved Communication
# Community Outreach

# Contingency Planning - Various Plans (SWMP, SPCC, ERP, FRP, etc.)



**Well Pad Spill Prevention, Control and Countermeasure Plan**

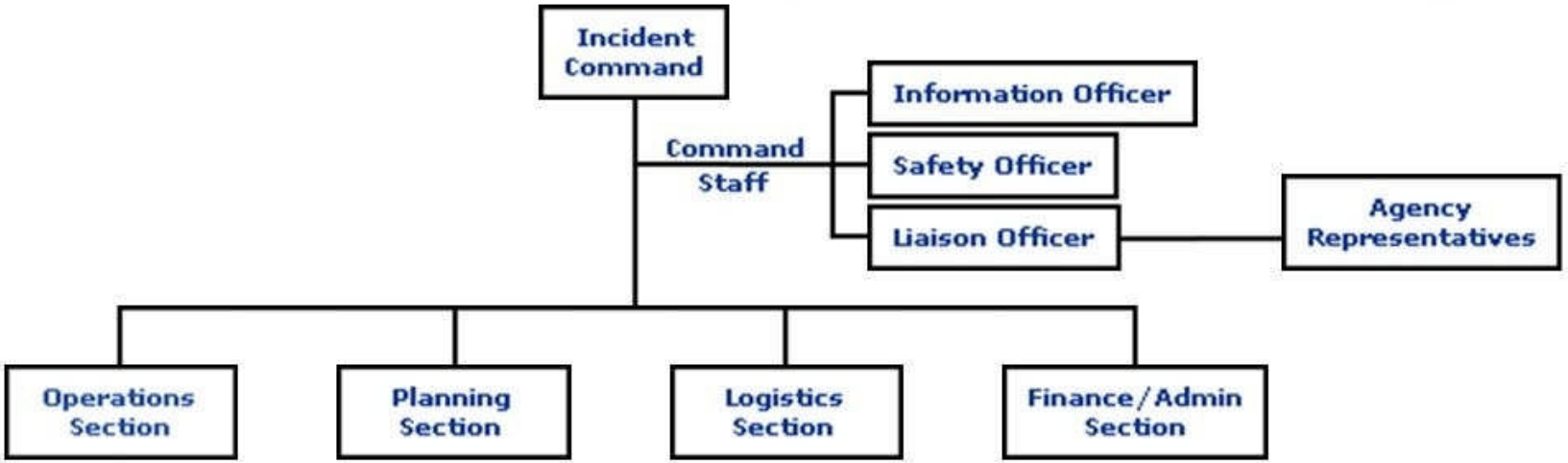
Prepared by:

Stantec

Stantec Consulting Services, Inc.

Date

# Incident Command System (ICS)



# Emergency Response Drills