Water Environment Federation
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New Jersey Water Environmental Association

THE HOW, WHY AND TRUTH ABOUT HYDRAULIC FRACTURING

Thomas E. Suhy P.E.
BAKER HUGHES INC

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Important Considerations

- Hydraulic Fracturing is a PROVEN and SAFE technology that is key to unlocking our nation's growing 100-year supply of clean burning natural gas
- Fracturing fluids consist of 99.86-percent water and sand, the rest consists of highly diluted common chemicals that are contained and safely managed
- More than 3 million pounds of fully cemented steel casing strings are utilized to fully protect freshwater aquifers
- The fracturing process takes place more than one mile below the water aquifers

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Overview

- History
- Why do we frac?
- Design
- Water Concerns
- Public Image
- What's in the Future?

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History Of Fracturing

- Misnomer: “Frack” does not equal “Frac”
- Since 1800’s
  - Nitroglycerin
  - Gelled gasoline (Napalm)
  - Acid stimulations
- First hydraulic frac in 1947 or (49)
  - Halliburton
  - Kansas or Oklahoma

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History Of Fracturing

Today

History Of Fracturing

- By 1988
  - 40 years to perfect the process
  - Common practice
  - 1 million performed
- Today
  - 2.5 million done
  - 35,000 per year
  - 60%-80% of all wells

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Why Do We Frac?

- Objective of Fracturing
  - Crack the rock
  - Connect natural fracs
  - Insert proppant (sand) to hold the crack open
- Ultra “tight” reservoirs
  - Nano-darcy permeability
  - Frees trapped gas
  - Creates path for gas flow to casing
  - 80% of shale gas would be unrecoverable
  - Non economic play

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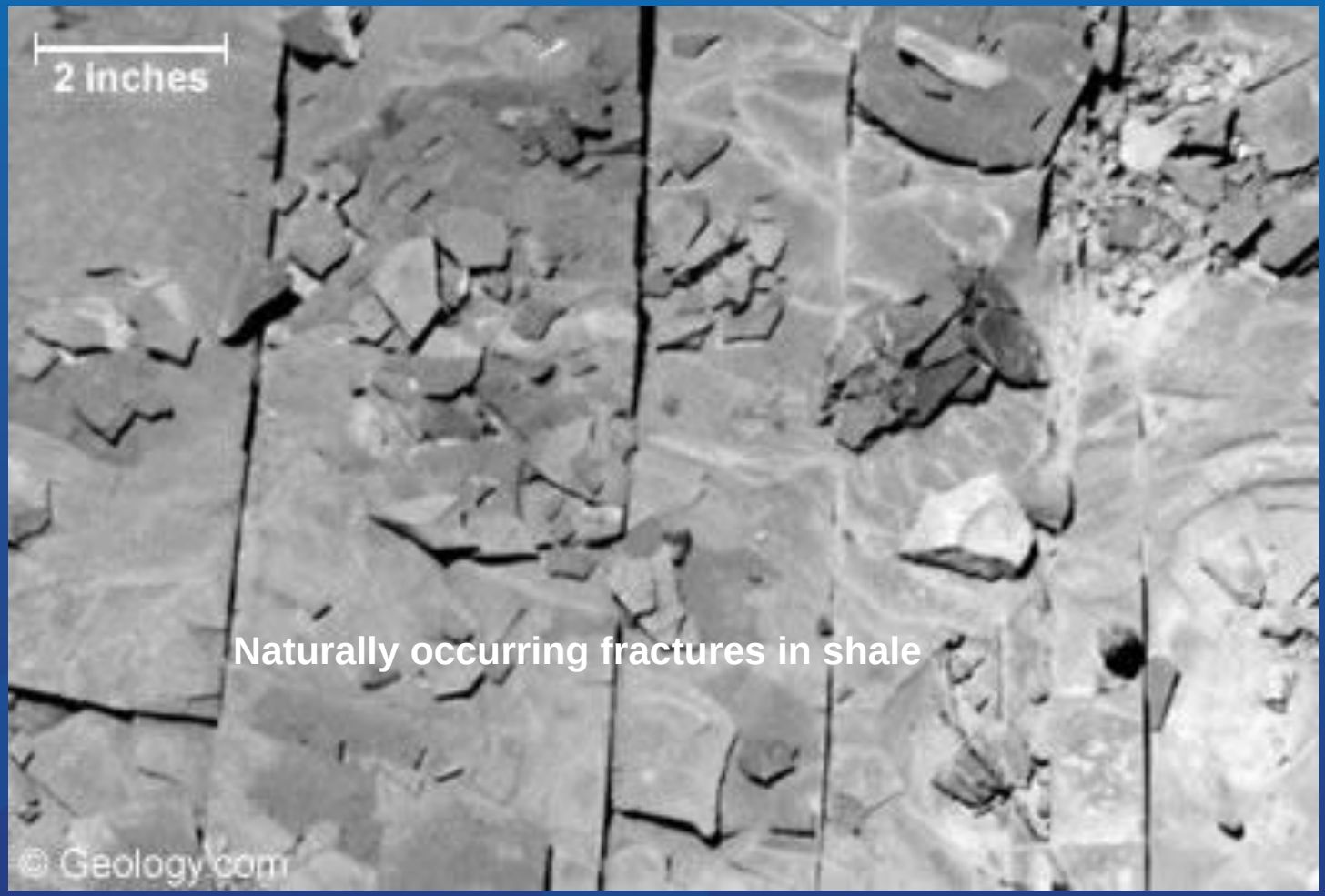
Why Do We Frac?



Frac Design and Development

- Fluids
  - Explosives and corrosives
  - Produced oil
  - Diesel oil
  - Gases and Foams – CO_2 - N_2
  - Highly viscous gelled water
  - Slick water

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Frac Design and Development

- Slick water fluids
  - Less complex
    - Simple chemical additives
    - Friction reducers, biocides, scale inhibitors
    - Low concentrations (< 1 Gal/1000 Gal)
  - More mechanical
    - High pump rate carries proppant into fracture

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Frac Design and Development

- Proppants
  - Walnut shells
  - Unrefined sand
  - Highly refined sands
    - Roundness
    - Mesh size
    - High strength
  - Ceramics
  - High strength minerals
  - Man-made low density proppants

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Frac Design and Development

- Pumping Equipment
  - Low rate 30-50 BPM (42 gal/Bbl)
  - Low pressure < 5000 psi
  - Low sand load 50K# – 100K#/well
  - High rate fleets
    - 80-125 BPM
    - Pressures 7000 – 10,000 psi
    - High sand loads 300K# – 500K# stage
- Downhole Equipment
  - 3-5 stages per vertical well
  - 12 – 20 stages per horizontal well

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Frac Design and Development: Drilling

- Wells drilling design
  - Vertical well
    - Limited formation exposure (50’-200’)
    - Smaller drainage area
  - Horizontal well
    - Greater formation exposure – 5000’+
    - 1 Hz well = 4-10 Vrt wells
    - Smaller surface foot print
    - Better economics
    - Better production performance

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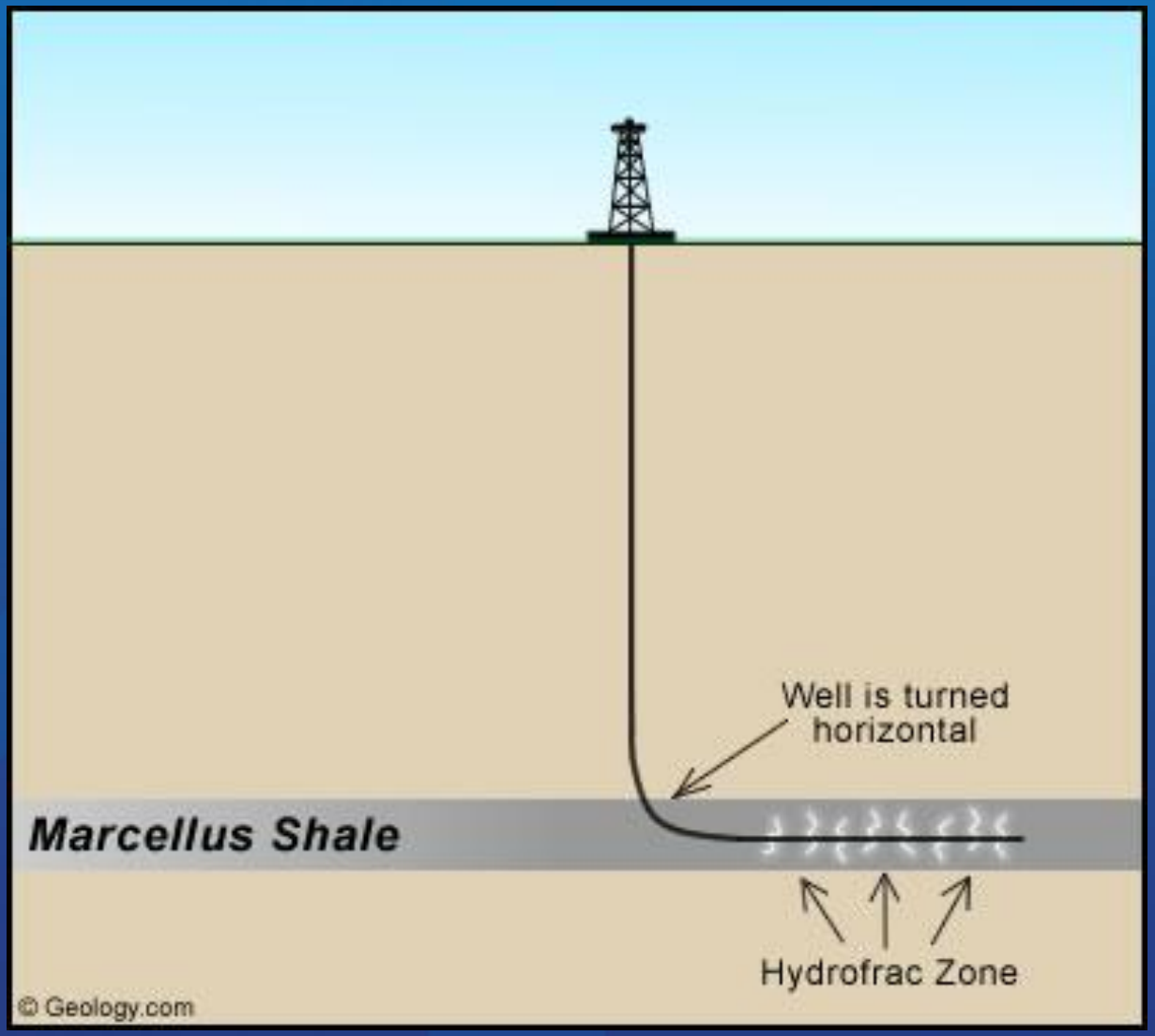
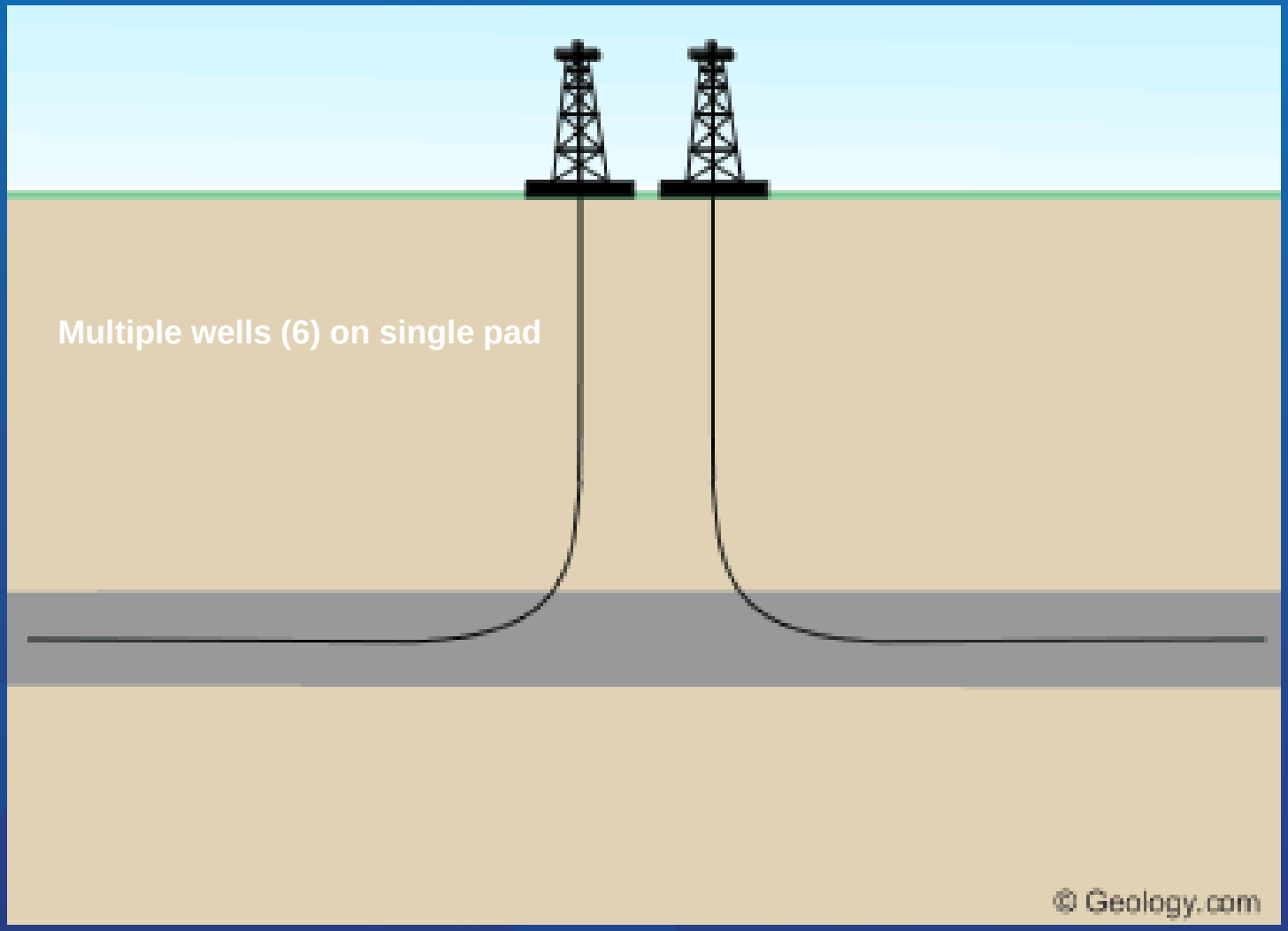
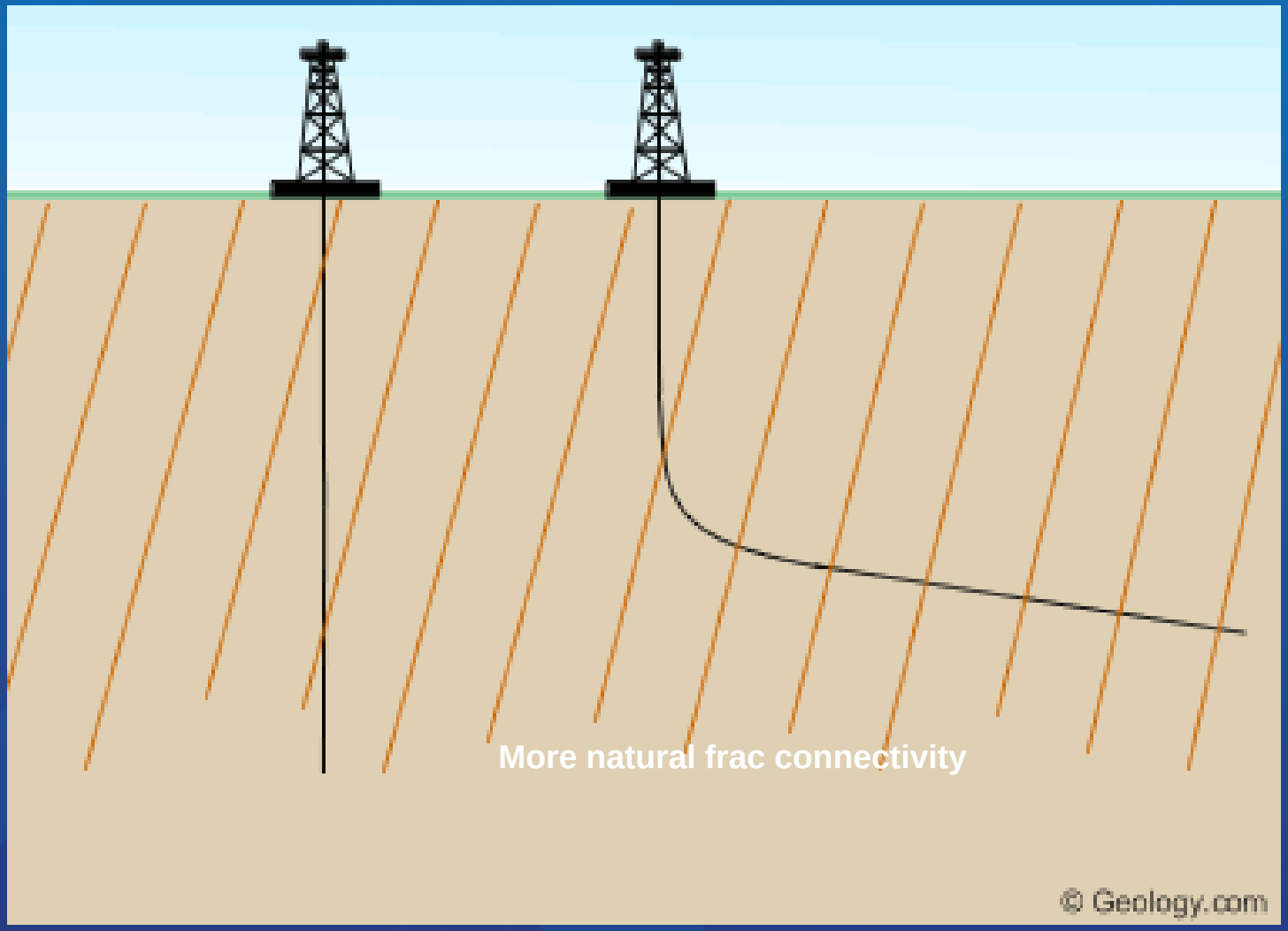
Frac Design and Development: Drilling



Frac Design and Development: Drilling



Frac Design and Development: Drilling



Water Concerns: Usage

- Volume water used
  - 3-5 million gals per well
    - 30 million per day (8-10 wells) in Marcellus shale in PA
    - Sounds larger than it really is
  - Some comparisons:
    - One round of golf in Las Vegas – 2500 gals
    - One night of irrigation on LV golf course – 2 million gals
    - Snow making: Sunday River, Maine – 540K gals/hr
    - One Olympic pool – 660K gals
    - Electric power plant – 5930 million gals/day
    - Anheuser-Busch (USA) – 31.5 million gals/year

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Water Concerns: Usage

- Volume water used to produce MMBTU
  - Marcellus Shale Gas: 0.60 gals
  - Coal: 13 – 32 gals when slurry used
  - Nuclear: 8-14 gals
  - Ethanol: 2510 – 29,100 gals if irrigated
  - Bio-diesel (soy): 14,000 – 75,000 gals if irrigated

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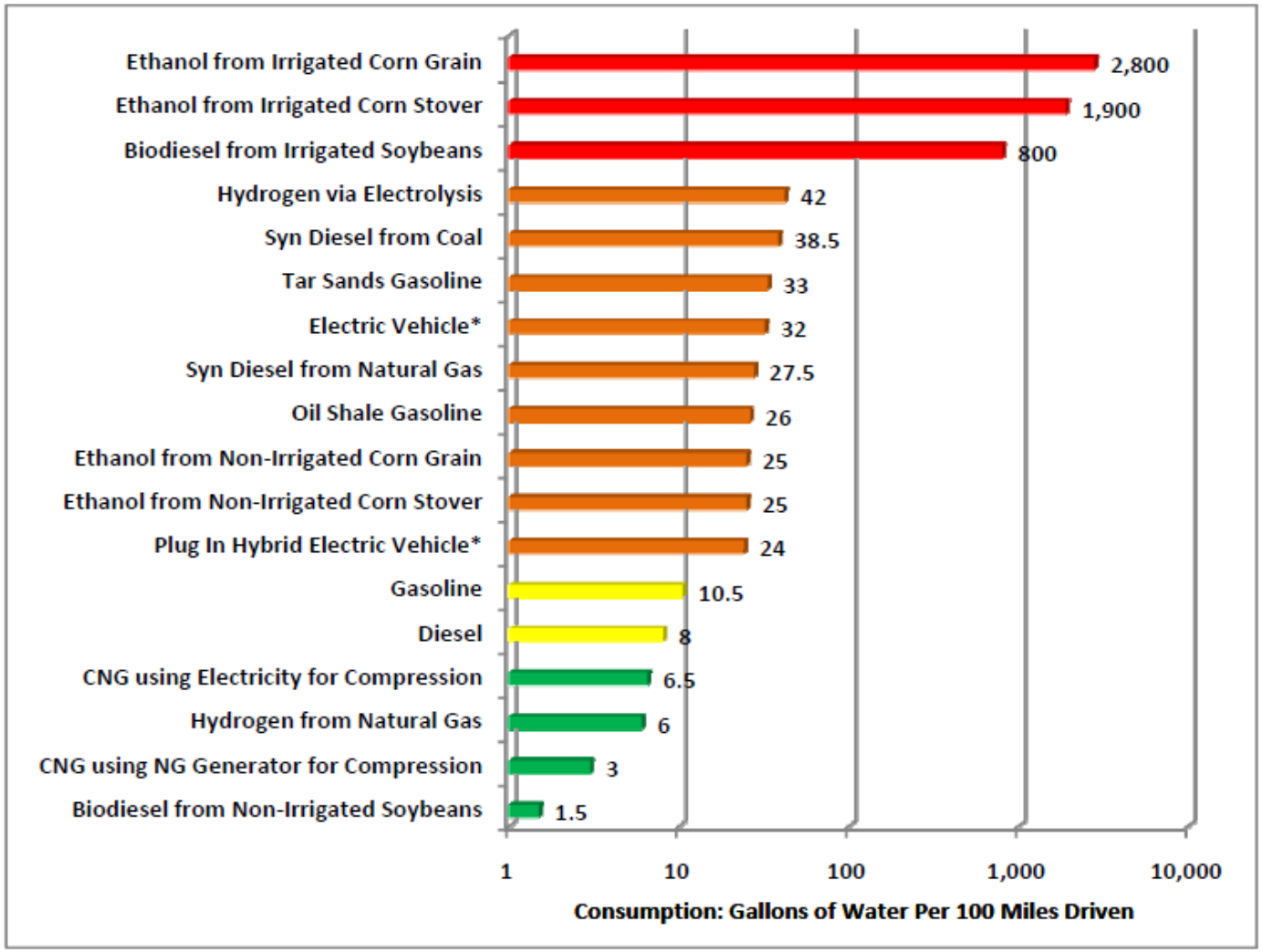
Water Concerns: Usage

Figure 6: Water Intensity of Transportation Fuels



*Source: Adapted from King and Webber 2008a; *Adapted from King and Webber 2008b*

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Water Concerns: Usage

- What's being done to conserve?
  - Recycle nearly 100% of flow-back frac water
    - 20% - 40% Recovered
    - Reduced usage
    - Minimal disposal
  - Unconventional sources
    - Brackish or formation water
    - Mine drainage water
      - 13.4 billion gals/day in PA alone

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Water Concerns: Protection

- Ground water protection
  - The only documented cases of ground water contamination occurred when the casing or cement integrity were compromised
  - Well integrity
    - Quality casing
    - Cement is the #1 Controllable Factor
    - Testing, modeling, quality source
    - Proper technique

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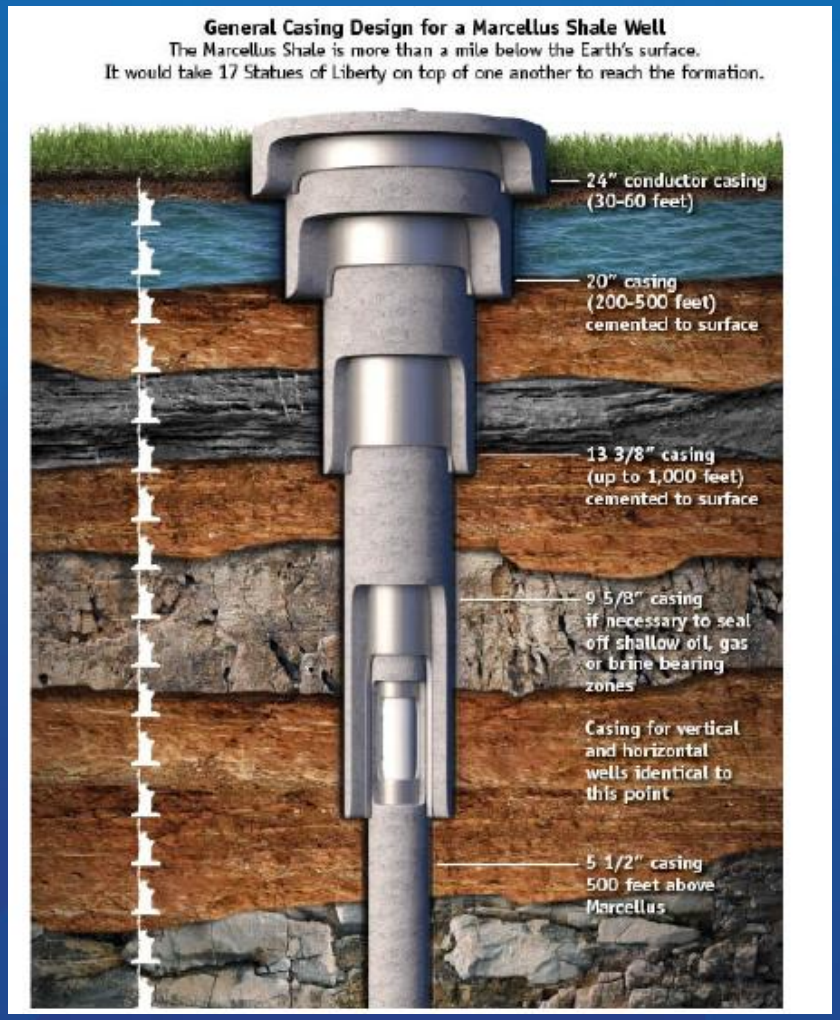
Water Concerns: Protection



- Multiple seals
  - Casing pipe
  - Cement overlap
  - Overburden rock
  - Extreme depth below water table 7000'+

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Water Concerns: Protection

- "Just a note about fracking: First of all, it's standard operating procedure in Pennsylvania. And it's important to point out that we've never seen an impact to fresh groundwater directly from fracking." (Scott Perry, Director of PA DEP's bureau of oil and gas management, May 2010)

- The statistical chance of a fracture extending to the surface from even shallow wells is 1: 2,000,000

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Water Concerns: Protection

- Chemical composition of frac water
  - Mostly food grade and biodegradable components
  - Small percentage of over-all volume
  - Moving toward a CAS (Chemical Abstract Service #) system rating industry wide
  - Transparency
    - Frac chemicals published on-line

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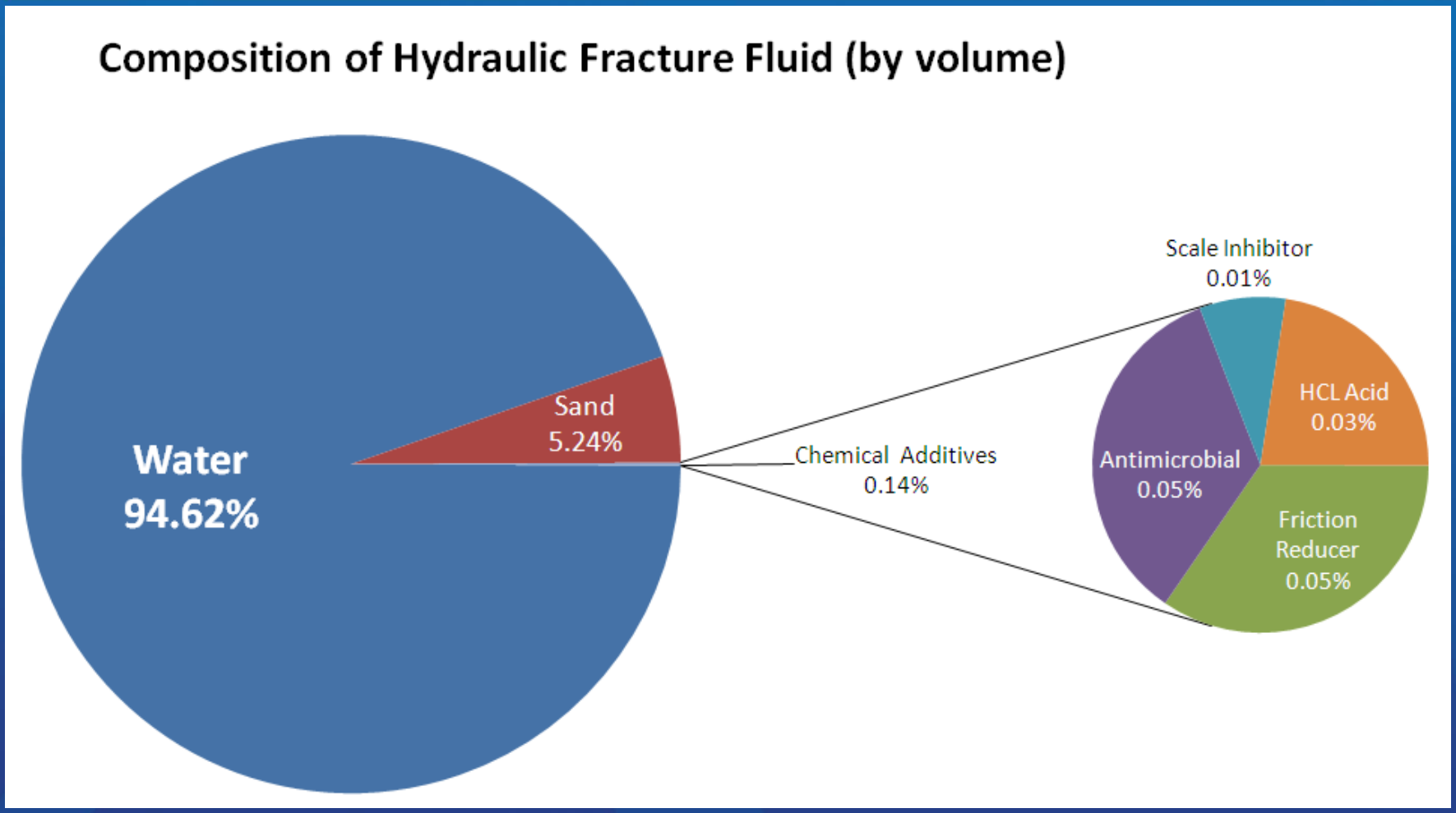
Water Concerns: Protection



Public Image

- *Frack Attack, The Movie:*
  - Hydraulic fracturing turns community into zombies
  - Seen on-line, coffee shops
  - Can't separate fact from fiction
- Truth: The Energy Industry can safely, and responsibly develop the "Gift" of the Marcellus Shale without converting an entire population into Zombies
- Truth: We too, are "environmentalists"

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Public Image

- *Gaslands, The Movie:*
  - Slanted, anti-industry documentary about fracturing
  - Debunked by www.energyindepth.org
- Truth:
  - Our-industry and technology is complex
  - Misinformation leads to fear and misunderstanding

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Public Image

- Recent news sources: “High pressure fluid blasts the rock with chemicals”
- Truth: Hydraulic pressure cracks and opens the rock while the sand is placed to prop the fracture open
- Truth: High pressure is due to fluid friction in the pipe at high pump rates
- Truth: The chemicals are used solely to condition the fluid, not change the composition of the rock

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Public Image

- Marcellus Shale Coalition, 1/27/11: “The Philadelphia City Council endorsed an outright ban on responsible shale gas development along the Delaware River Basin, based on a joint council committee ‘report’. As part of today’s misguided vote, the council also directed the Philadelphia Gas Works to abstain from purchasing affordable, clean-burning natural gas from the Marcellus Shale, despite the fact that the municipal utility provider indirectly already receives Marcellus natural gas.”
- Truth: It may get very cold and costly in Philly next winter

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Public Image

- Eyes On Drilling: The EPA Region03 has posted a reporting site called “Eyes On Drilling” that gives instructions and an e-mail address for citizens to anonymously report “suspicious or apparent illegal” activity related to oil and gas development operations.
- Truth: Although all of our well site operations are conducted totally within the realm of environmental regulations, the activity could look suspicious to someone unfamiliar with our industry.

What's In The Future

- The "Industry" has come a long way

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What's In The Future

- The "Future" is here now
  - Food grade chemicals
  - No-spill locations
  - Closed loop recovery systems
  - Noise, light, dust, and visual controls

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What's In The Future

- Drilling
  - Multilateral bores in single wells
  - Two or more zones per well
  - Additional deeper shale production, "Utica"

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What's In The Future

- Fracturing fluid usage
  - Low fluid treatments
  - Visco-elastic polymers (Hi-tech surfactants)
  - Very light weight proppants
  - More gas and foam fracturing
  - Conditioning and using "grey" water
    - Power plant waste
    - Mine drainage
    - Brines and formation water
    - Industrial waste
    - Municipal waste

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What's In The Future

- Long term stable gas prices
  - Clean power generation
  - CNG fleet vehicles
- Domestic shale oil production
  - Energy stability and independence
- "Cost Effective" environmental solutions
  - Most likely to be accepted and followed
  - Must be able to maintain economic viability of shale development

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Conclusions

- Hydraulic Fracturing is a PROVEN and SAFE technology that is the key to unlocking our nation's growing 100-year supply of clean burning natural gas
- Fracturing can be managed properly to conserve and protect valuable resources
- Use and removal of undesirable water sources can result in positive net environmental impact
- Regulation must be "Cost Effective" to ensure positive economic development of shale plays

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Active Reclaimed Shale Well

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Questions?