The EFD Program

Addressing Environmental Issues and Increasing Environmental Awareness

Interstate Oil & Gas Compact Commission

Awarded October 5, 2009

CHAIRMAN'S STEWARDSHIP AWARDS

Shale Development 101

June 10, 2014

EFD

NETL
NATIONAL ENERGY TECHNOLOGY LABORATORY

RPSEA
Research Partnership to Secure Energy for America

Texas A&M University

MONTANA UNIVERSITY

HARC

Discussion

- Environmentally Friendly Drilling Systems Program (EFD: *www.efdsystems.org*)
- Shale?
- Well Construction
- Hydraulic Fracturing
- Gas Processing
- Environmental Concerns

EFD Program

A collaborative effort

Industry

Academia

Government

Environmental Organizations

Team Formed in 2005

Mission

Provide unbiased science to identify, develop and transfer critical, cost effective technologies that provide policy makers and industry with ability to develop reserves safely and environmentally friendly.

What We Do

Produce Enabling Data, Best Practices and Information to operators, regulators and stakeholders.

The EFD Team

Co-funded by RPSEA, US Fish and Wildlife, Industry, Environmental Organizations

Thank-you for your support!

All Areas are Environmentally Sensitive

- *The value of oil and gas resources are increasing.*
- *The value of protecting the environment is becoming more important.*
- *The public's interest in energy development is becoming more and more significant.*
- *The O&G Industry must engage the public in a more significant way.*

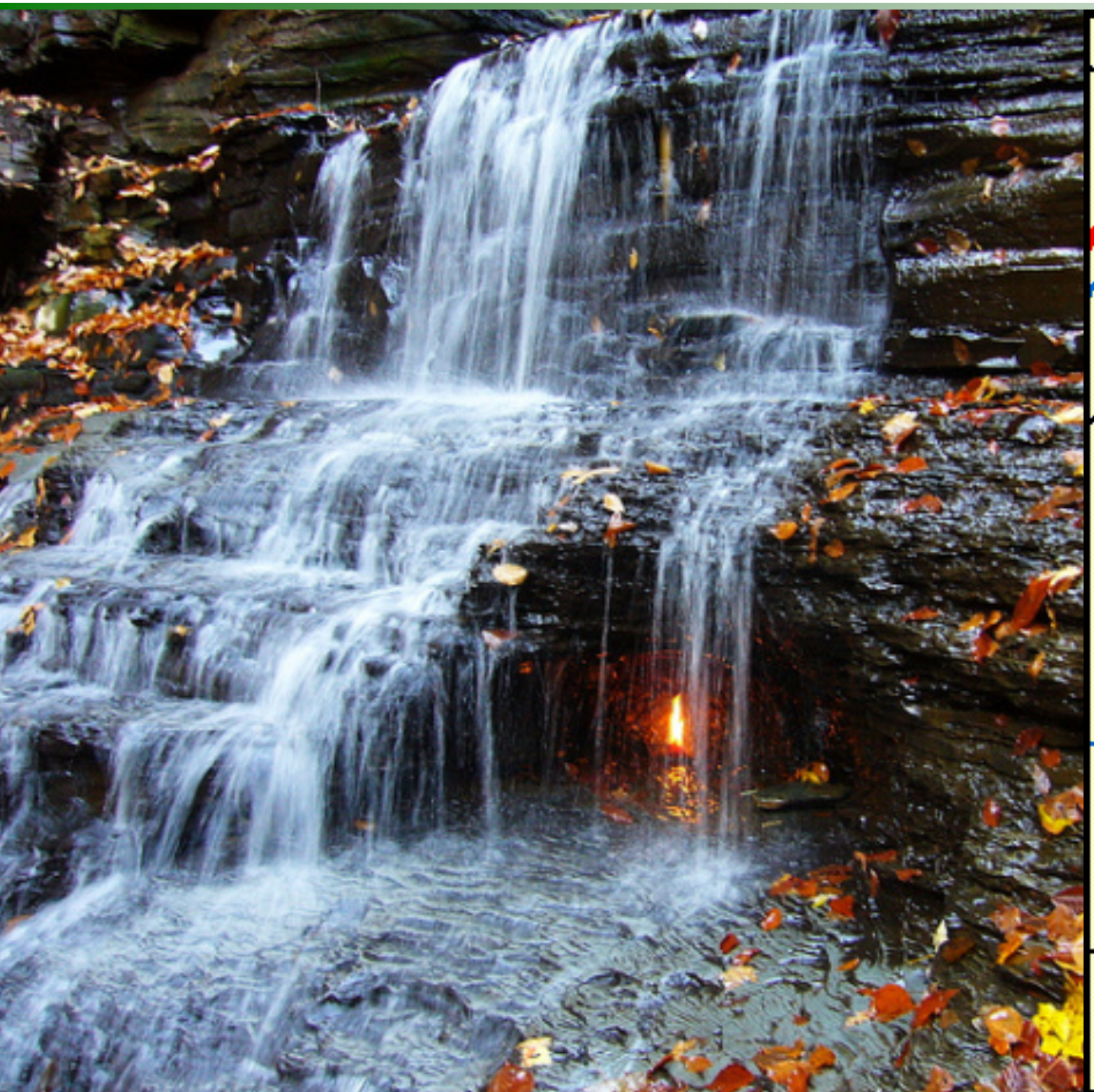
Identify and develop technologies to get access with minimal impact.

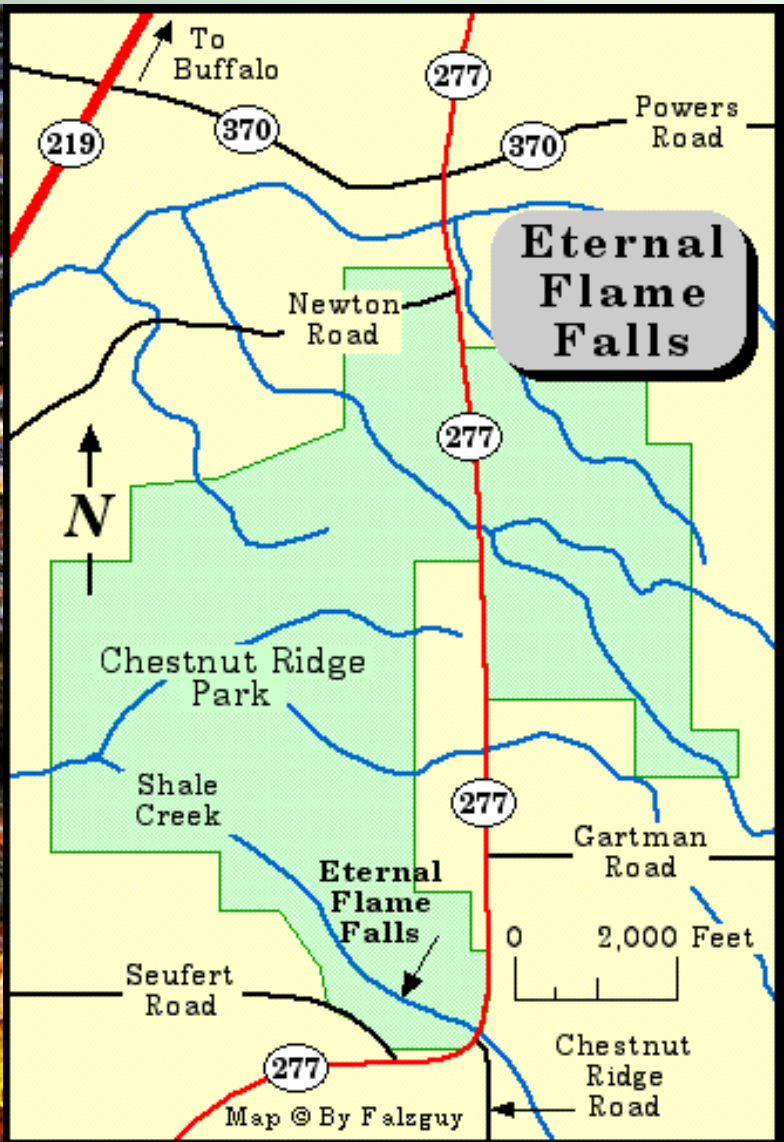
Determine how to measure the effect of low impact practices.


North American shale plays
(as of May 2011)
Muskwa-Otter Park, Evie-Klua
Lower Besa River
Muskwa-Otter Park
Montney
Doig Phosphate
Colorado Group
Niobrara*
Bakken ***
Cody
Heath**
Gammon
Mowry
Hilliard- Baxter-Mancos-Niobrara
Niobrara*
Mancos
Monterey-Temblor
Hermosa
Excello-Mulky
Lewis
Pierre-Niobrara
Woodford
Fayetteville
Monterey
Bend
Avalon
Barnett
Barnett-Woodford
Eagle Ford
Eagle Ford, La Casita
Haynesville-Bossier
Tuscaloosa
Floyd-Neal
Chattanooga
Conasauga
Eagle Ford, Tithonian
Pimienta
Pimienta,
Antrim
New Albany
Devonian (Ohio)
Marcellus
Utica
Utica
Frederick Brook
Horton Bluff
Current shale plays
Stacked plays
Shallowest / youngest
Intermediate depth / age
Deepest / oldest
* Mixed shale & chalk play
** Mixed shale & limestone play
*** Mixed shale & tight dolostone-siltstone-sandstone play
Prospective shale plays
Basins

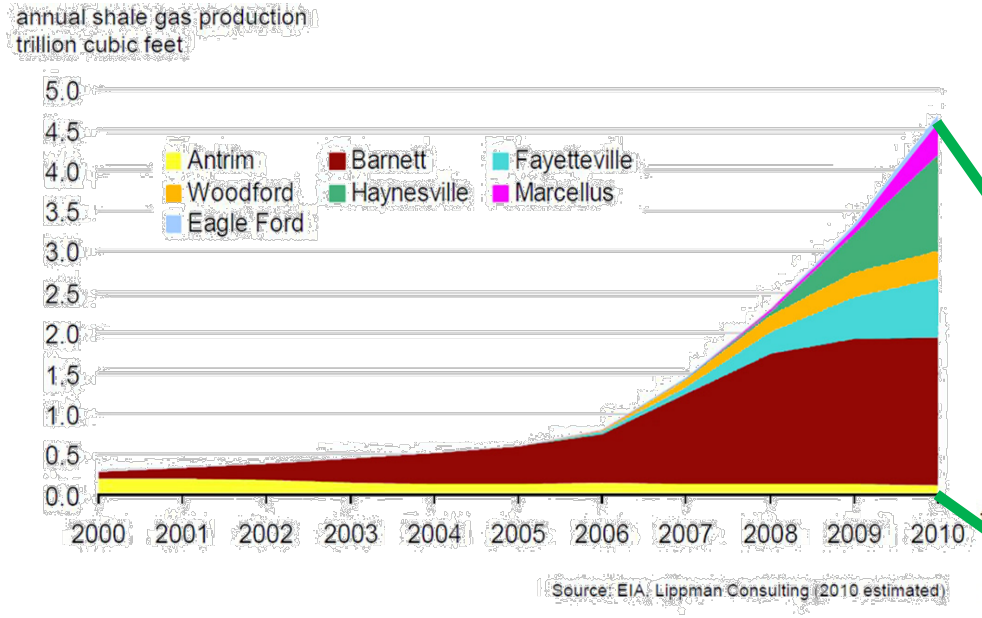
What is Shale?

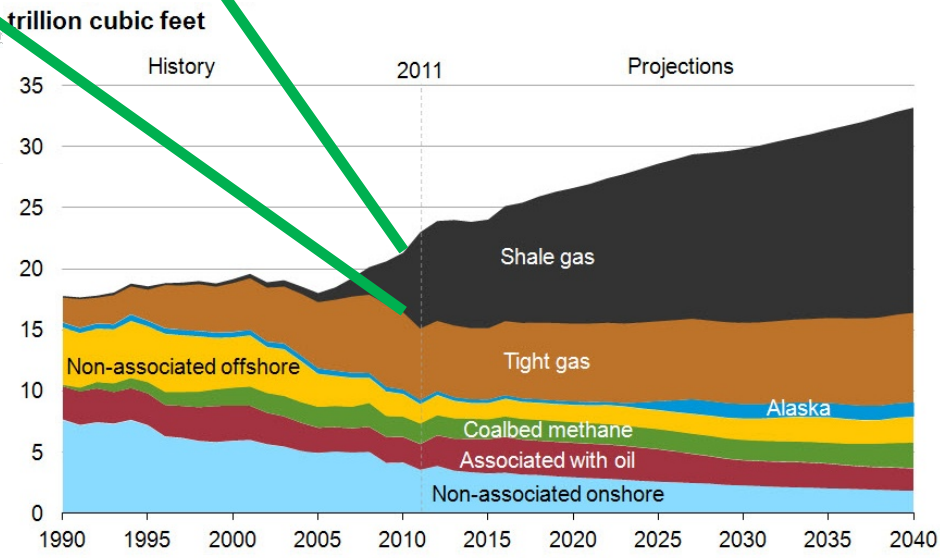
Shale Gas
Chestnut Ridge Park, NY





How Much Gas is There?





http://www.netl.doe.gov/technologies/oil-gas/publications/brochures/Shale_Gas_March_2011.pdf

Source: U.S. Energy Information Administration, *Annual Energy Outlook 2013 Early Release*

Environmental Issues

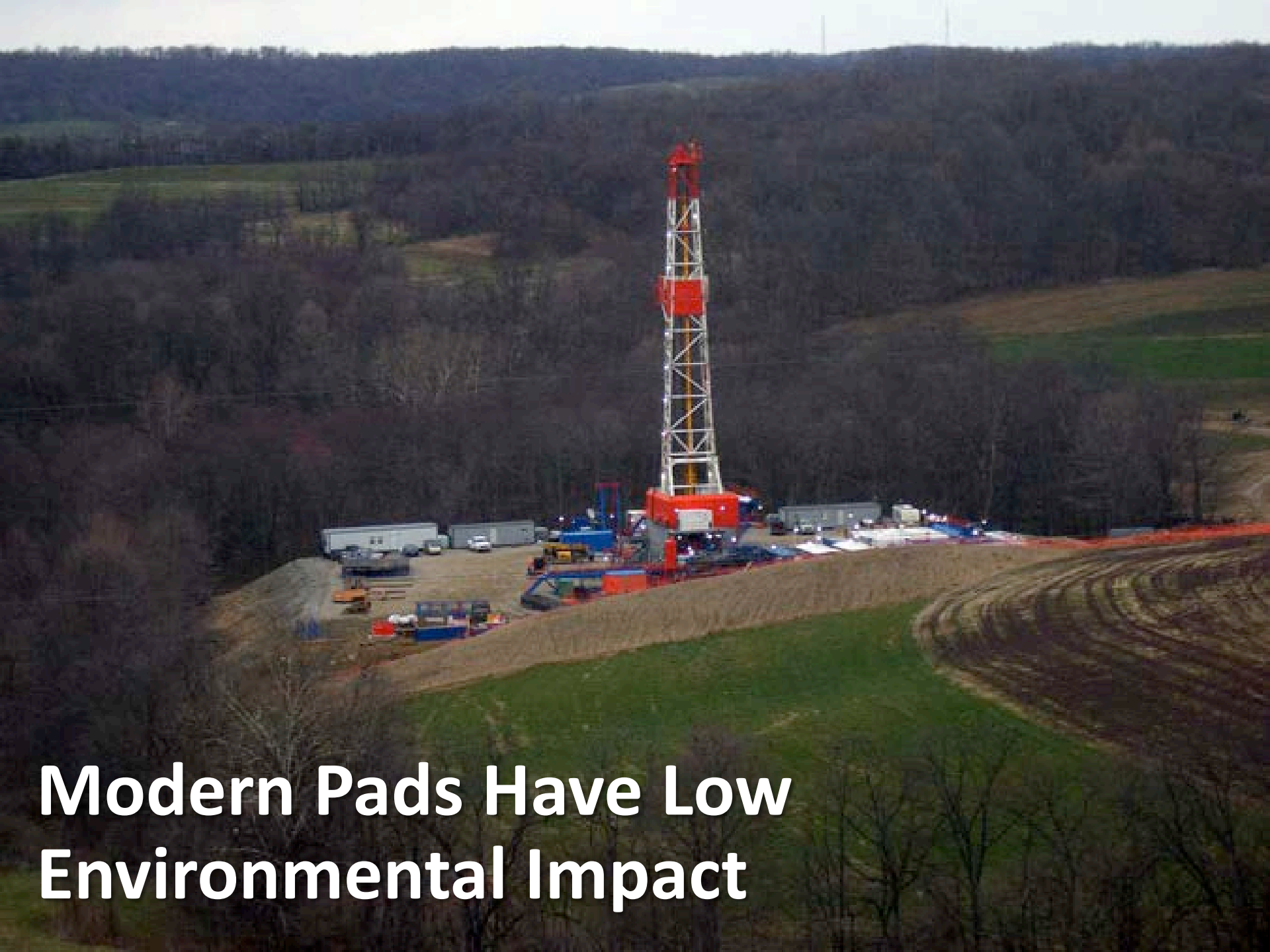
Fort Beeler Facility Next to a Drilling Location

(from www.marellus-shale.us/MARCELLUS)

Well Construction

From the Past
(single wells at multiple sites)

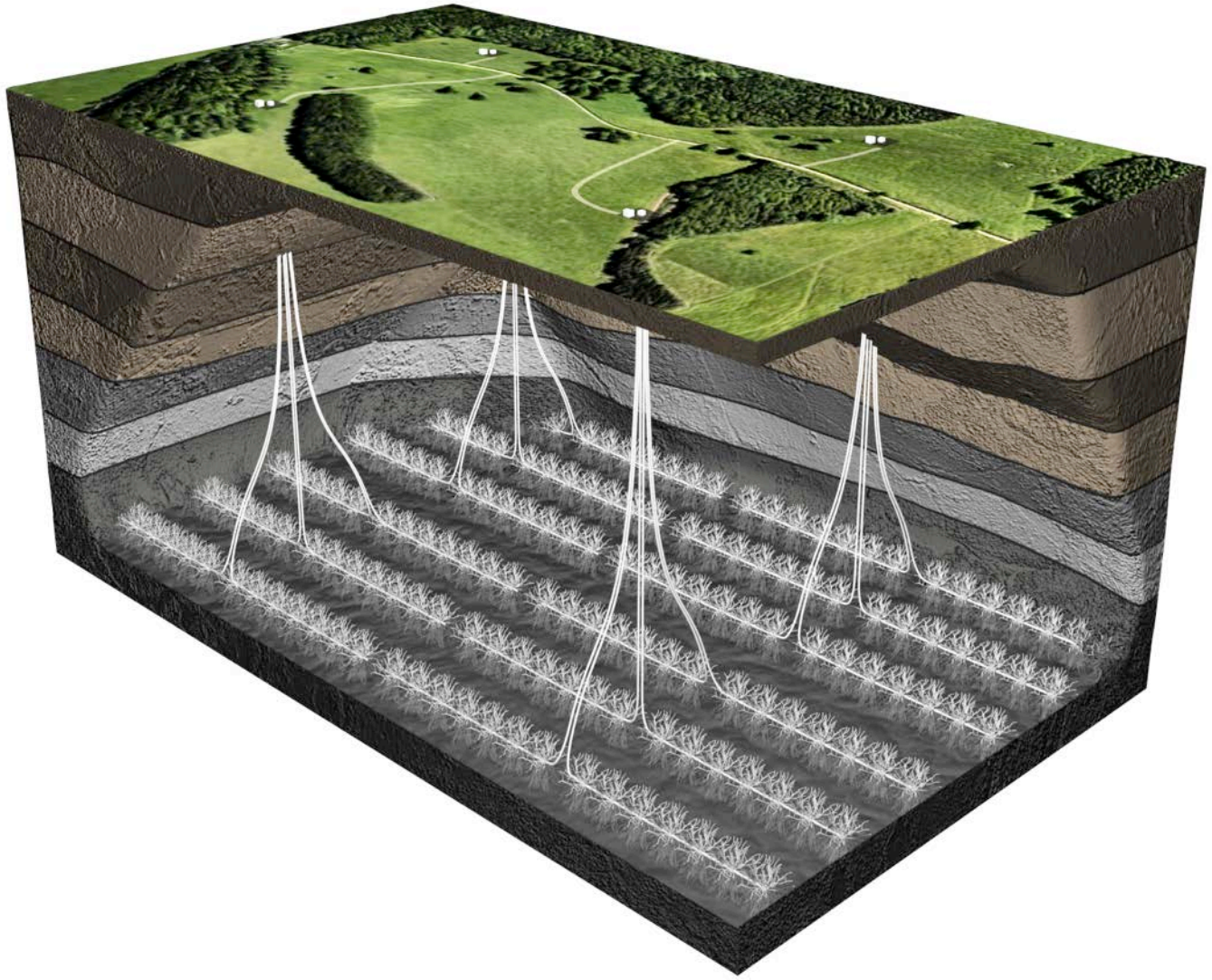
To the Present
(multiple wells at single sites)



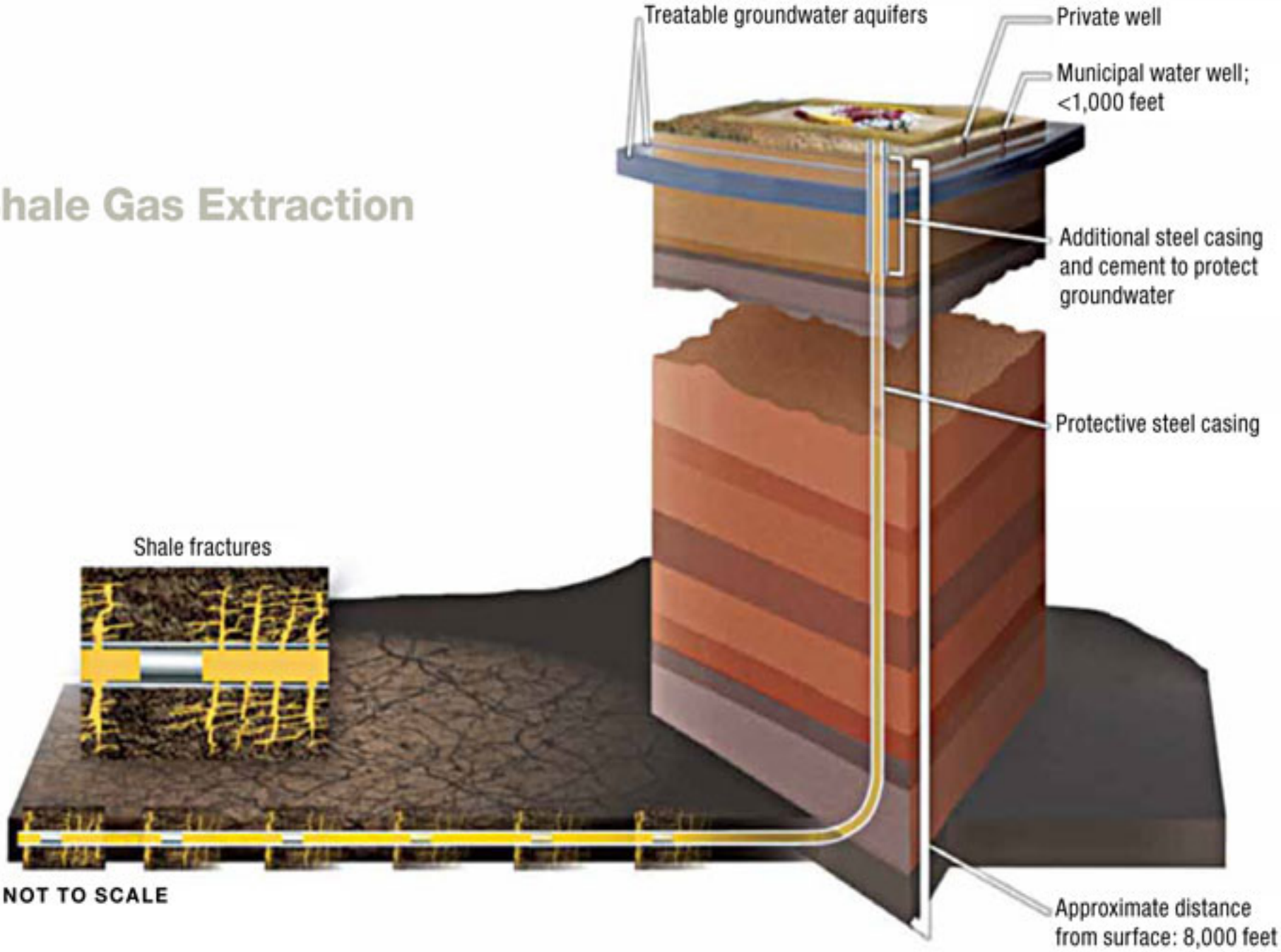
Modern Pads Have Low Environmental Impact

Drilling from Pads

Pad size about
2ha or
140 x 140 m



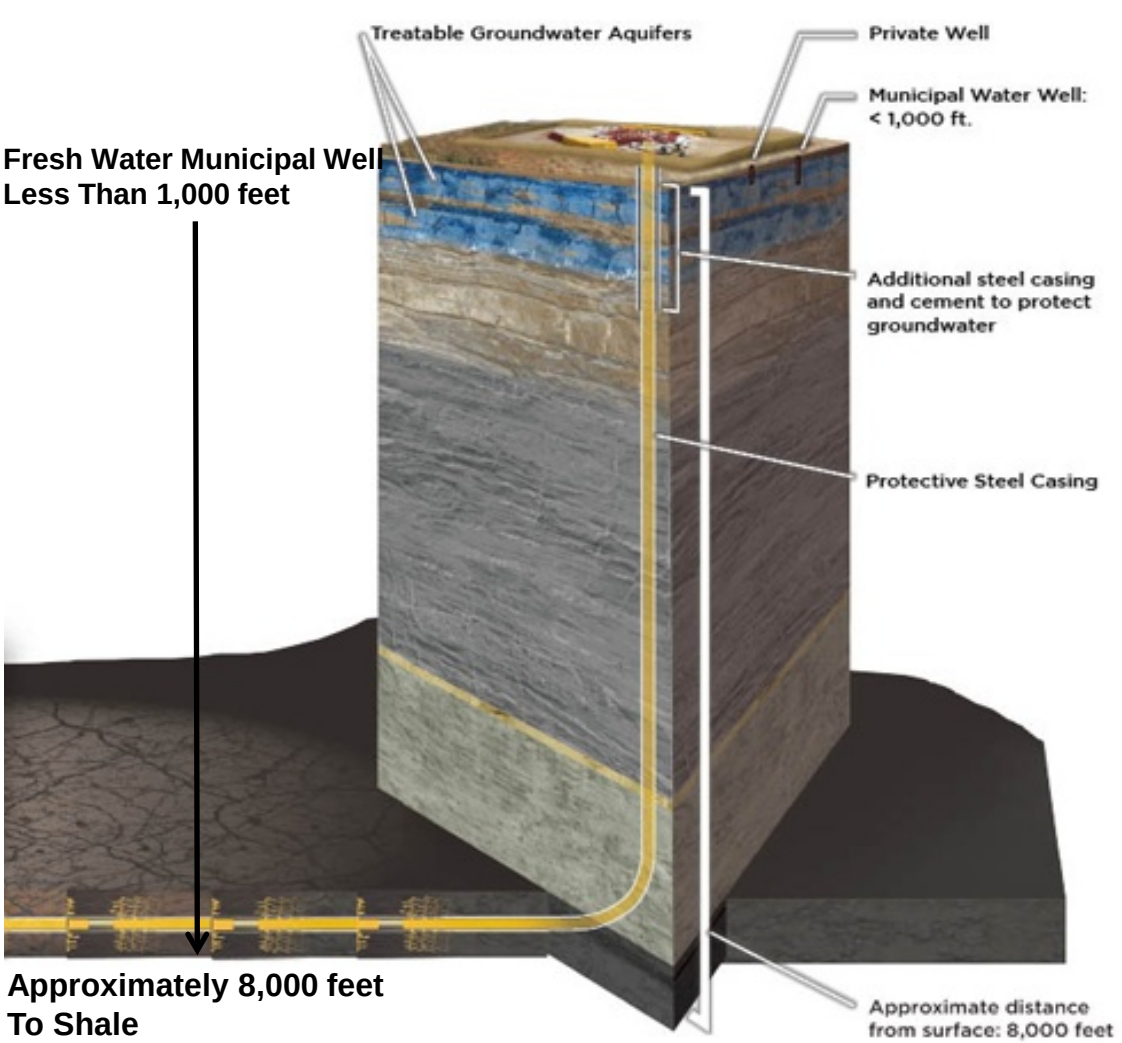
Shale Gas Extraction

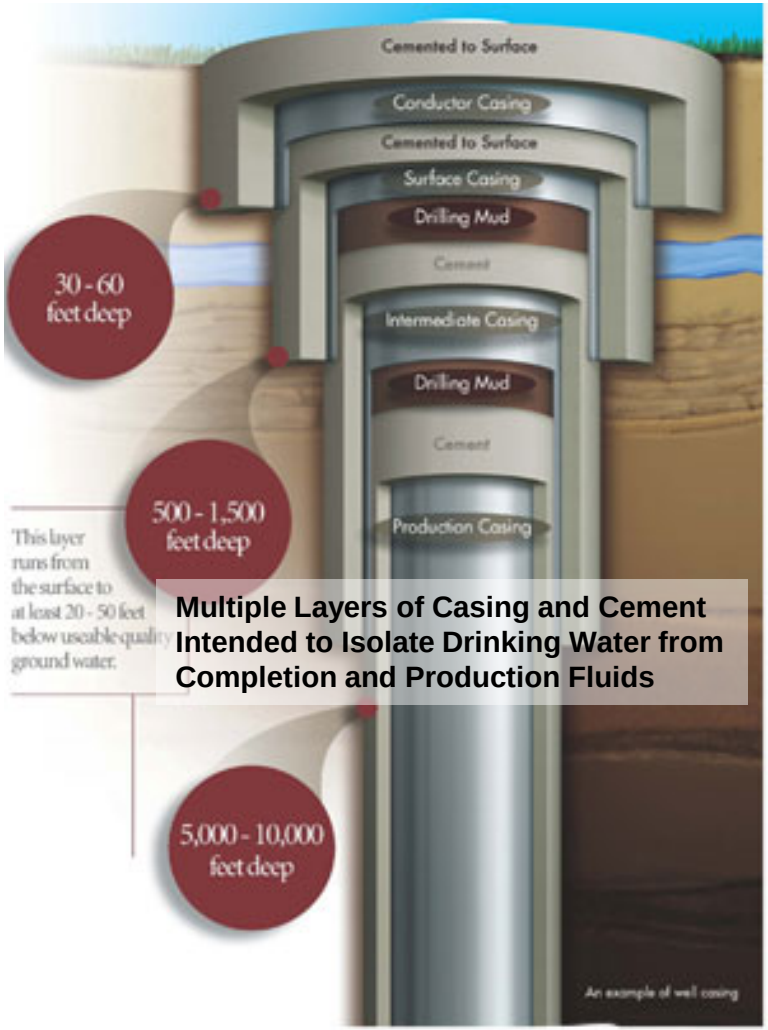


Graphic by Chesapeake Energy

Ground Water Protection

Required: Defining best practices in casing and cementing

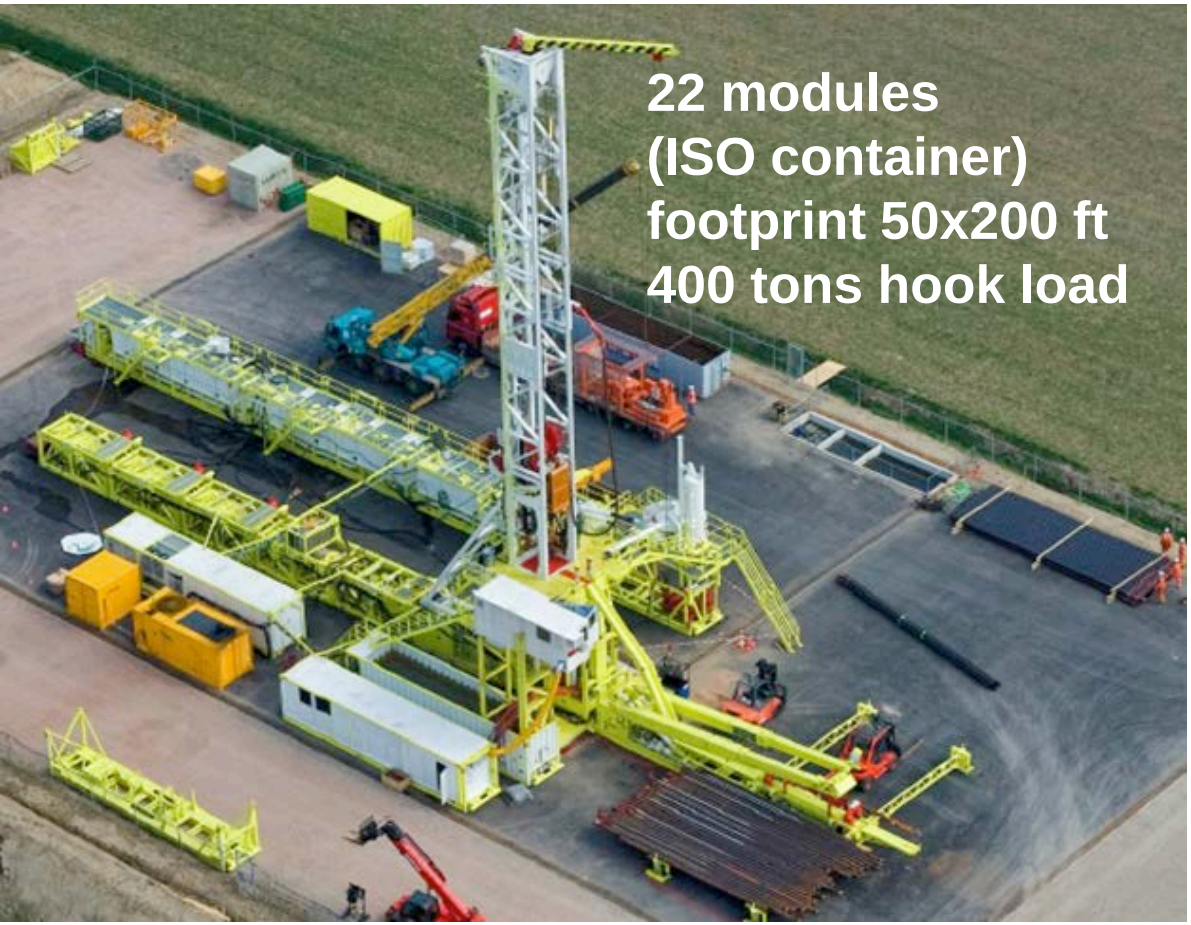




Multiple Layers of Casing and Cement Intended to Isolate Drinking Water from Completion and Production Fluids

Graphic Courtesy of Texas Oil and Gas Association

Environmental Friendly Drilling (EFD)
Zero Harmful Emissions –
Size Reduction



Rig concept (Source: AADE-11-NTCE-61)

EFD addresses:

- New low-impact technologies that reduce the footprint of drilling activities
- Light weight drilling rigs with reduced emission engine packages
- On-site waste management

Environmental Friendly Drilling Rig

“Green” drilling is more than drilling

- Get in, drill and get out as fast as possible with minimal disturbance to the land
- Protect surface and ground water
- Access roads
- Pad Drilling
- Reduce traffic, dust, noise, emissions, excessive lights that disturb nearby residences
- Aesthetics

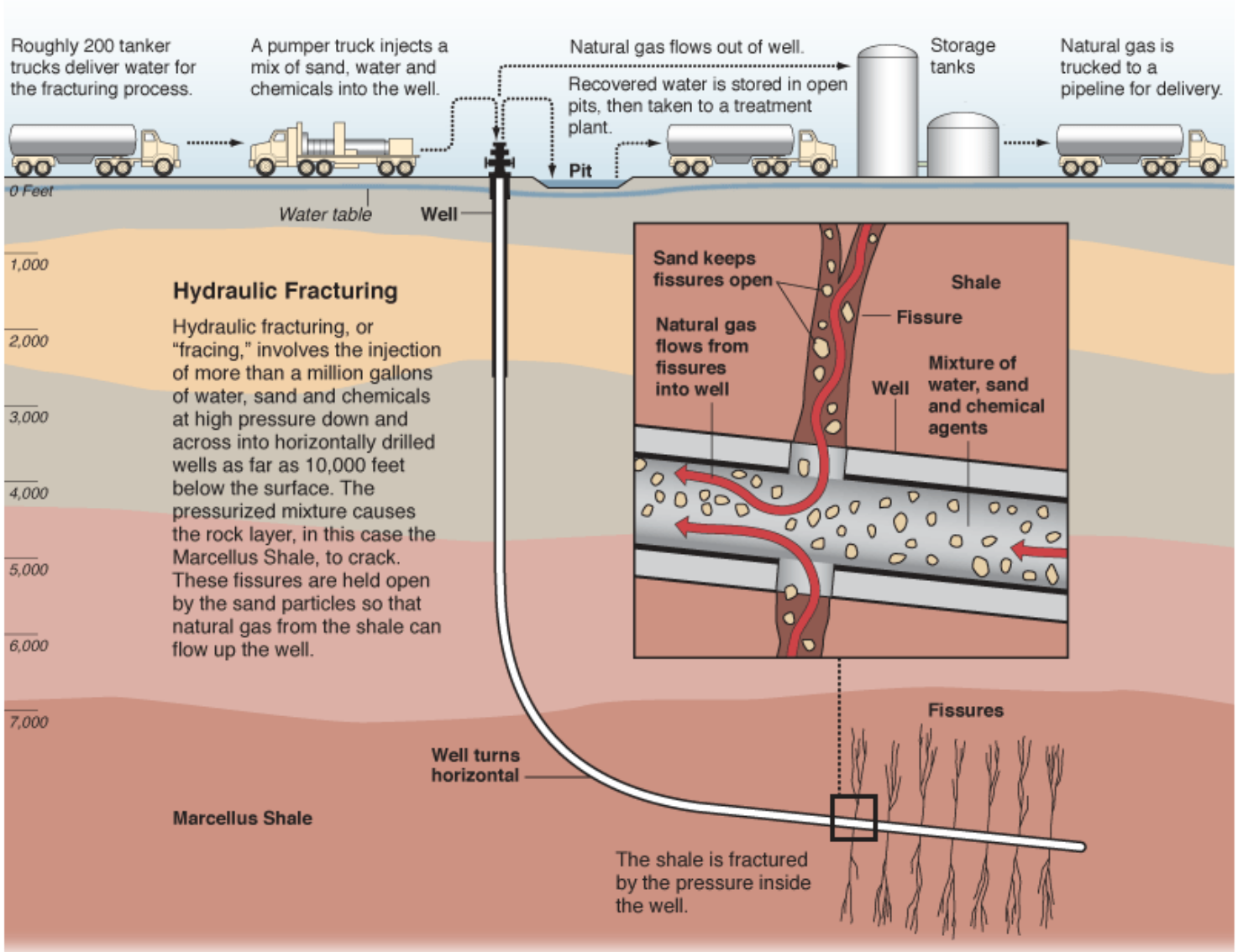
Hydraulic Fracturing

Hydraulic Fracturing History

More than 1 million wells hydraulically fractured

As shown in this historic photograph, the first hydraulic fracture treatment was performed by Halliburton under license to Stanolind Oil Company on March 17, 1949, east of Duncan, Ok. Hydraulic fracturing has since allowed commercial hydrocarbon recovery from more than 1 million wells that could not have produced economically, and that number grows by the day with nearly every U.S. gas well and the majority of all U.S. oil wells now being hydraulically fractured.

What is Hydraulic Fracturing?



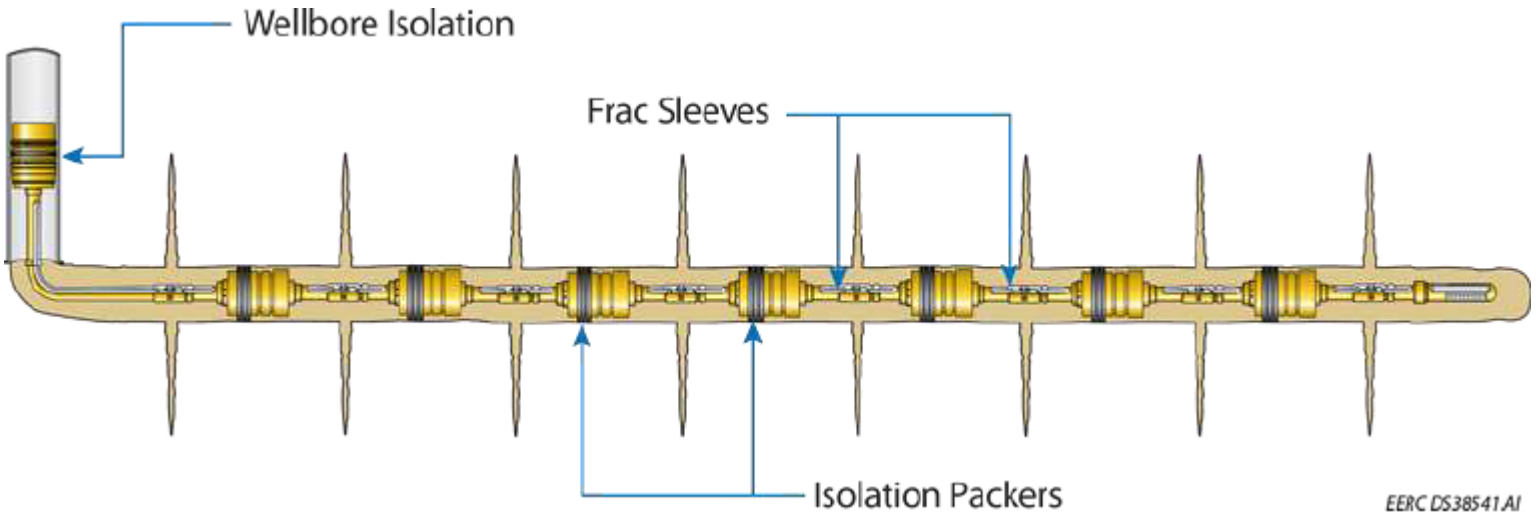
Hydraulic Fracturing in South Texas

A well head at a fracturing operation near Carrizo Springs, TX
Source: SA Express News

Chesapeake Energy
Hydraulic Fracturing Operation
Eagle Ford Shale near Carrizo Springs

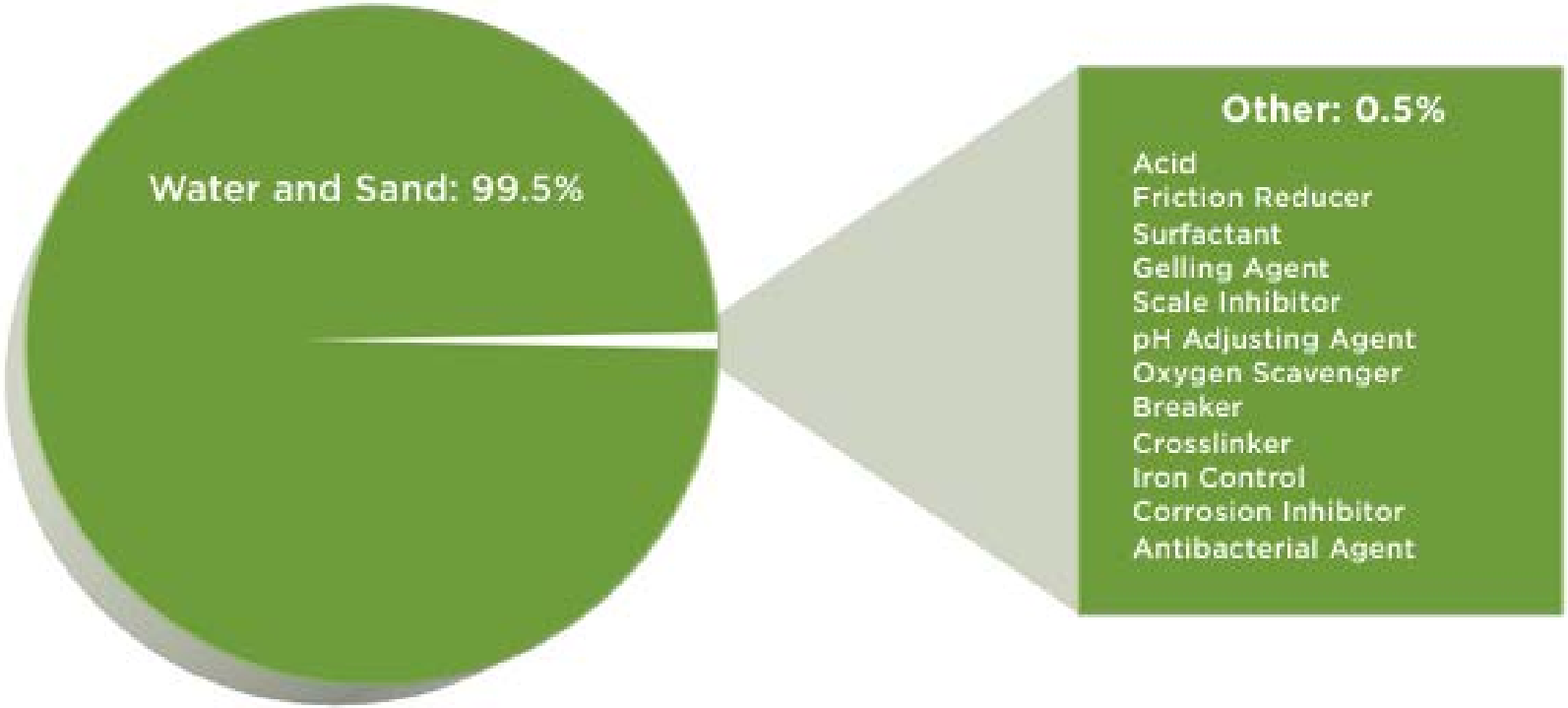
Source: San Antonio Express News

Downhole


Wellbore Isolation
Frac Sleeves
Isolation Packers
EERC DS38541.AI

The Controversy
Groundwater contamination from additives in fracture fluids

- ***Fracturing fluids contain 90% water, 9.5% sand or other particles, and less than 1% additives***
- ***All additives are used in common household products. Exposure not unique to fracturing chemicals***



e needed

What is Really Pumped?

Product Category	Main Ingredient	Purpose	Other Common Uses
Water	99.5% water & sand	Expand fracture and deliver sand	Landscaping and manufacturing
Sand		Allows the fractures to remain open so the gas can escape	Drinking water filtration, play sand, concrete and brick mortar
Other	**approximately 0.5%**		
Acid	Hydrochloric acid or muriatic acid	Helps dissolve minerals and initiate cracks in the rock	Swimming pool chemical and cleaner
Antibacterial agent	**Glutaraldehyde**	Eliminates bacteria in the water that produces corrosive by-products	Disinfectant; Sterilizer for medical and dental equipment
Breaker	**Ammonium persulfate**	Allows a delayed break down of the gel	Used in hair coloring, as a disinfectant, and in the manufacture of common household plastics
Corrosion inhibitor	**n,n-dimethyl formamide**	Prevents the corrosion of the pipe	Used in pharmaceuticals, acrylic fibers and plastics
Crosslinker	Borate salts	Maintains fluid viscosity as temperature increases	Used in laundry detergents, hand soaps and cosmetics
Friction reducer	Petroleum distillate	“Slicks” the water to minimize friction	Used in cosmetics including hair, make-up, nail and skin products
Gel	Guar gum or hydroxyethyl cellulose	Thickens the water in order to suspend the sand	Thickener used in cosmetics, baked goods, ice cream, toothpaste, sauces and salad dressings
Iron control	Citric acid	Prevents precipitation of metal oxides	Food additive; food and beverages; lemon juice ~7% citric acid
Clay stabilizer	Potassium chloride	Creates a brine carrier fluid	Used in low-sodium table salt substitute, medicines and IV fluids
pH adjusting agent	Sodium or potassium carbonate	Maintains the effectiveness of other components, such as crosslinkers	Used in laundry detergents, soap, water softener and dishwasher detergents
Scale inhibitor	Ethylene glycol	Prevents scale deposits in the pipe	Used in household cleansers, de-icer, paints and caulk
Surfactant	**Isopropanol**	Used to increase the viscosity of the fracture fluid	Used in glass cleaner, multi-surface cleansers, antiperspirant, deodorants and hair color

Green Hydraulic Fracturing Program

An employee of Chesapeake Energy pours a chemical mixture called cross linked gel that is mixed with sand and used in the hydraulic fracturing process

Source: SA Express News

- **Program instituted by Chesapeake Energy in 2009**
- **Researching additives to:**
  - **Find which are unnecessary**
  - **Find which are necessary, but harmful**
  - **Find more environmentally friendly replacements for harmful additives**

Hydraulic Fracturing Chemical Registry

www.fracfocus.org

- Developed/managed by GWPC
- Provide Transparency
- Protect Groundwater
- Engage Public
  - Explain hydraulic fracturing process
  - Provide well information

INTERSTATE Oil & Gas COMPACT COMMISSION

GROUNDWATER PROTECTION COUNCIL

Ground Water Protection Council
Report to the Nation . . . A Call to Action

How much water needed?

- A multi-stage fracturing of a single horizontal shale gas well can use several million gallons of water
- Most water used in hydraulic fracturing comes from surface water sources such as lakes, rivers and municipal supplies.

Water Sourcing

Source: ALL Consulting, 2008

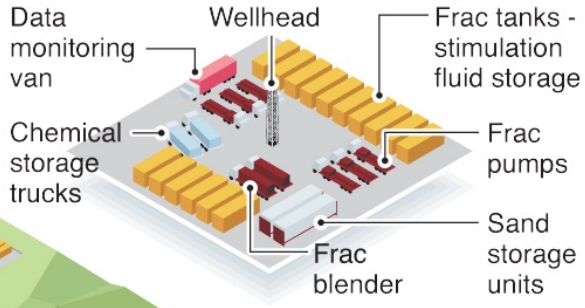
Lined Fresh Water Supply Pit from the Marcellus Shale Development in Pennsylvania

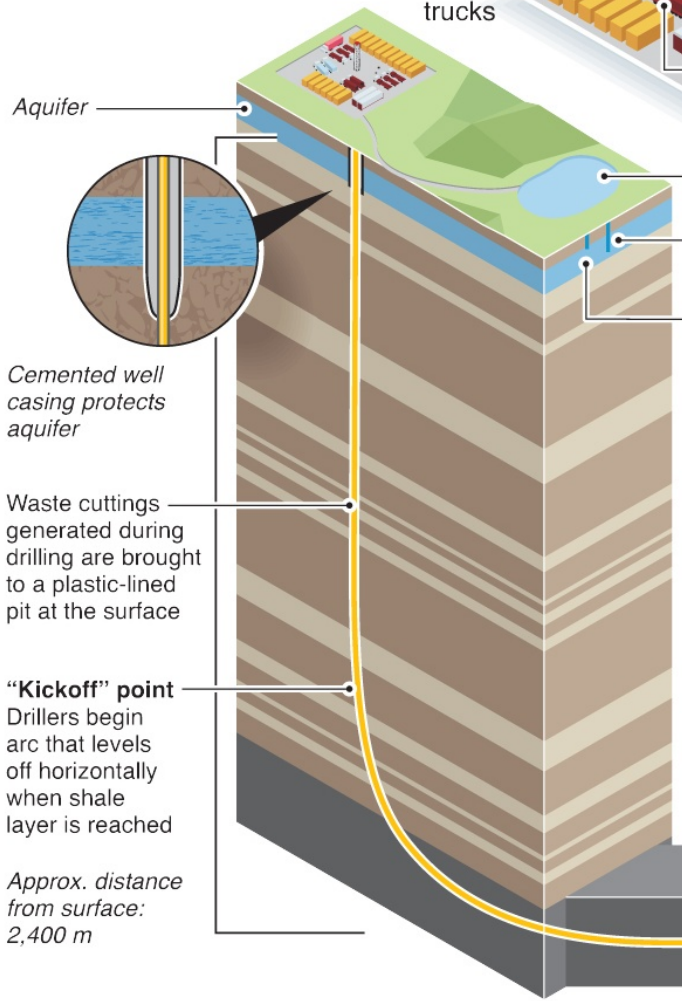
HYDRAULIC FRACTURING - ITS GROWTH AND RISKS

THE PROCESS

Hydraulic fracturing, is the creation of fractures in rock formations in the earth using pressurised fluid, generally for the purpose of extracting natural gas

Common Fracturing Equipment



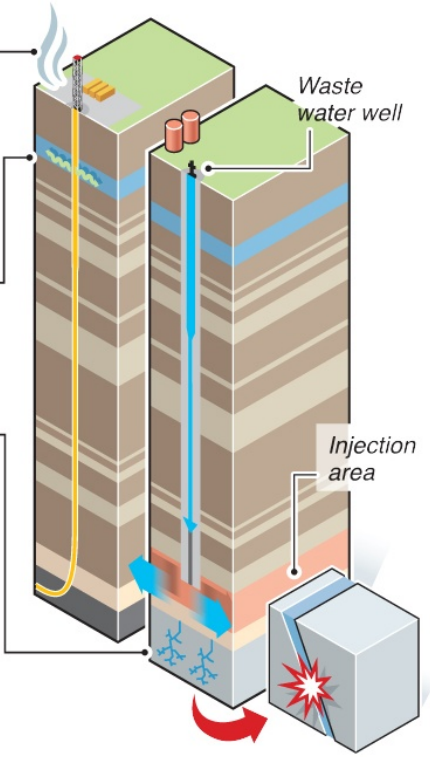


RISKS

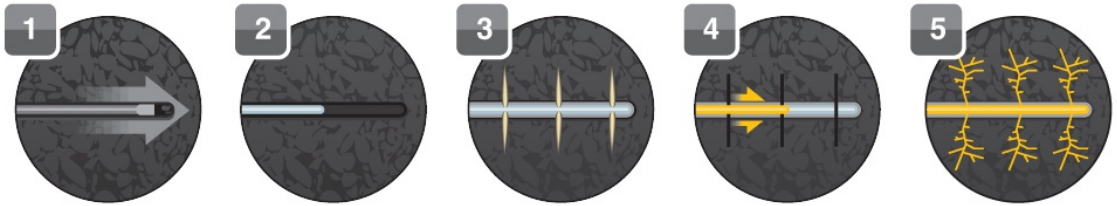
Air emissions
Methane gas associated with natural gas extraction can leak into air

Drinking water
Chemicals used in fracturing process have the potential to contaminate aquifers

Earthquakes
The disposal of waste fluid from the fracturing process is cited as a cause of earthquakes. Disposed fluids migrate below the injection area, destabilising the natural fractures in the rock formation



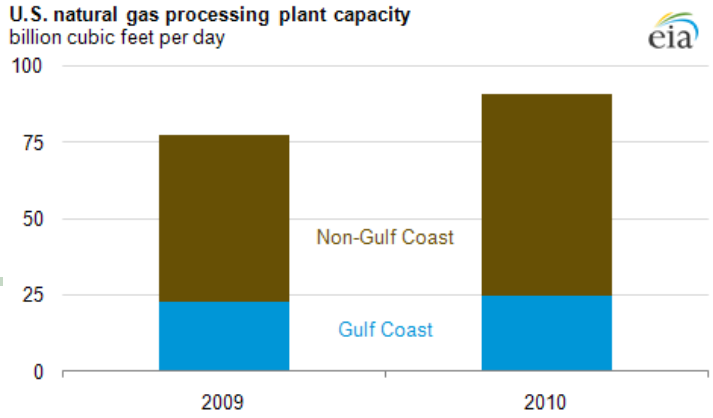
Horizontal Drilling



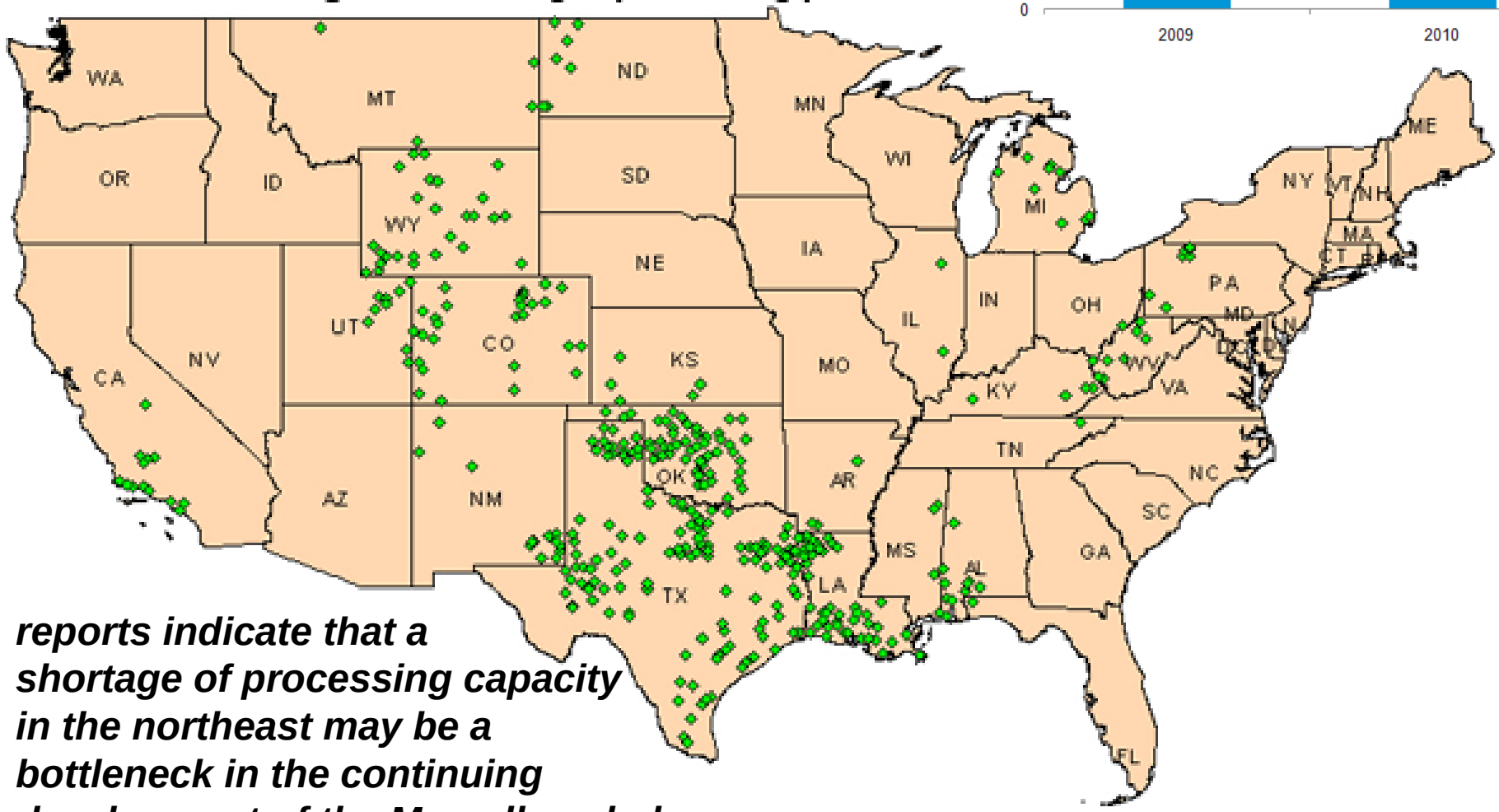
1. Well drilled horizontally at 914-1,524 m
2. Production casing inserted into borehole, then surrounded with cement
3. Charges then detonated inside a perforating gun, blasting small holes into the shale
4. Pressurised mixture of water, sand and chemicals then pumped into the well at 15,900 litres a minute
5. The fluid generates numerous small fissures in the shale, freeing trapped gas that flows to the surface

Illustration not to scale

Gas Processing

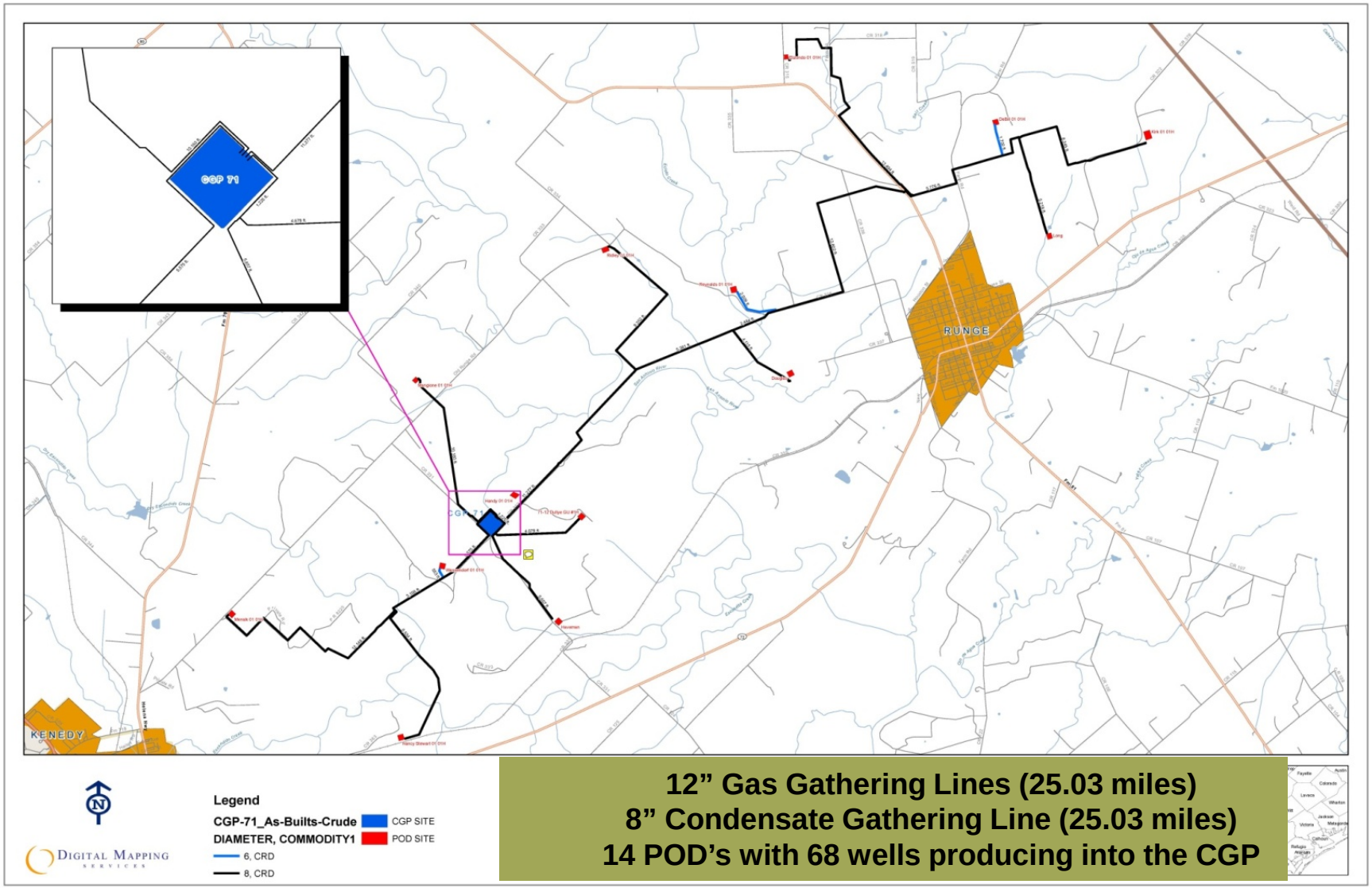


Locations of existing U.S. natural gas processing plants, 2010



reports indicate that a shortage of processing capacity in the northeast may be a bottleneck in the continuing development of the Marcellus shale.

Gas Gathering Lines



12” Gas Gathering Lines (25.03 miles)
8” Condensate Gathering Line (25.03 miles)
14 POD’s with 68 wells producing into the CGP

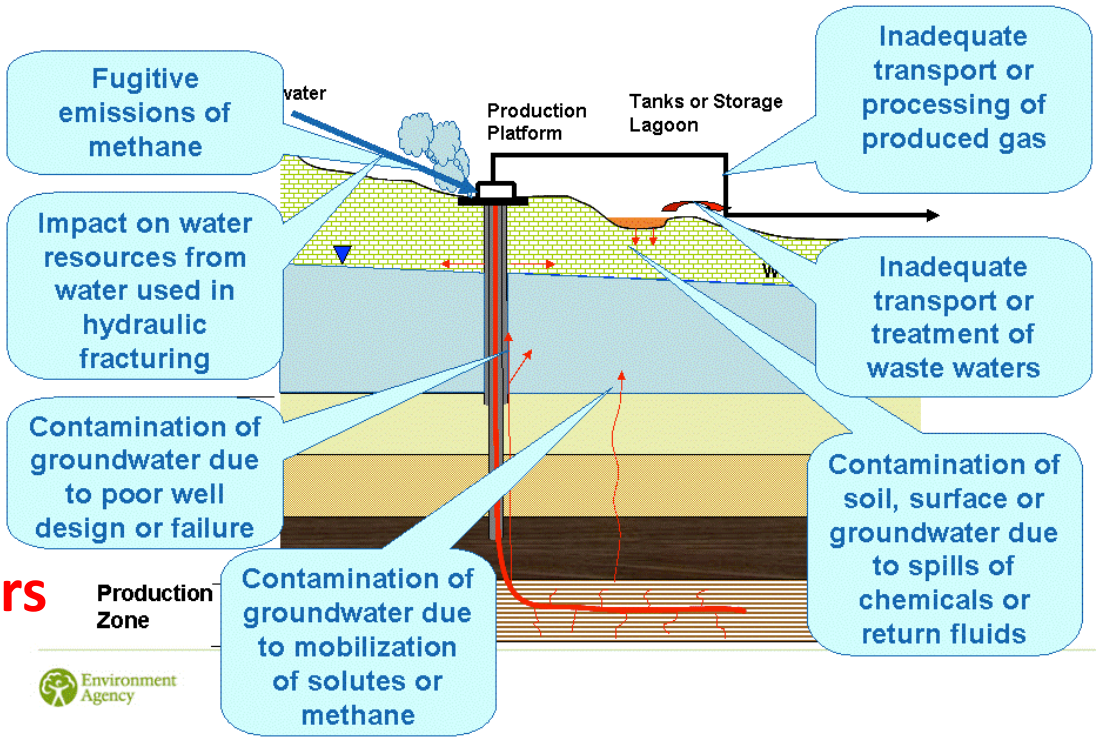
CGP 71


Commissioned
Gas Train November 17, 2010
Condensate Train December 18, 2010
CGP 71
April 20, 2013
customAerial
IMAGES

Environmental Risks

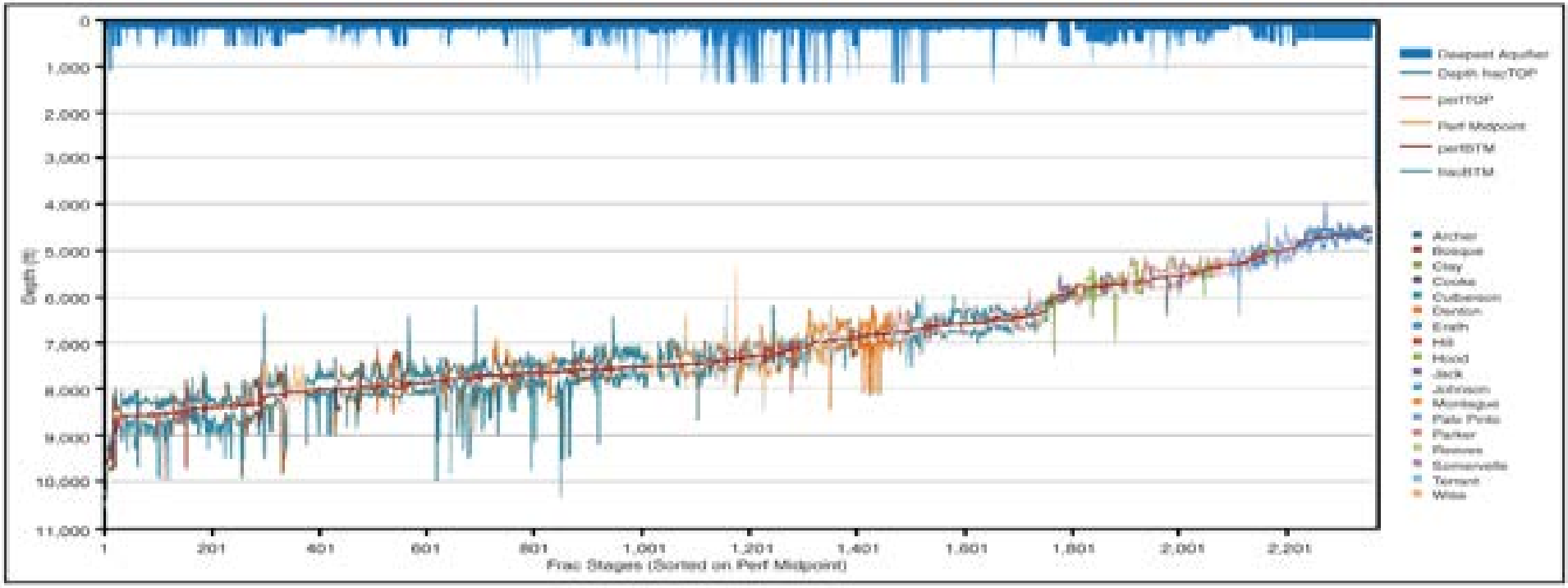
Potential Environmental Issues of Shale Gas Development

- Drill Pad Construction and Operation
- Groundwater Contamination *(most controversial issue)*
- Hydraulic Fracturing and Flowback Water Management *(another controversial issue)*
- Blowouts/Explosions
- Water Consumption and Supply
- Spill Management and Surface Water Protection
- Small earthquakes from injecting wastewaters in deep underground reservoirs



Water Table Safety – Facts

- ***Fractures are necessary for hydrocarbons to flow from the tight shale formations***
- ***Fractures are typically thousands of feet below water table***
- ***They extend only hundreds of feet at most in any given direction***



Risks to Groundwater

- Primary risk for contamination of groundwater is compromise of mechanical integrity of well

- Contamination of ground water with flow back water resulting from well design ***very unlikely*** due to long distances and natural barriers between the reservoirs and the ground water zones.

- Contamination of ground water with shale gas resulting from well design or leaking faults is more likely to happen.

Mitigating Risks to Groundwater

- Leaky well design can be repaired, the risk for leaking faults can be minimized by fracture monitoring during the job and by designing a proper job based on best knowledge about the subsurface geology.

- Monitoring ground water quality is required prior and after a fracturing job.

MIT Study (2011) on Shale Gas Accidents in the US

All reported US cases from 2000-2010

Source 1

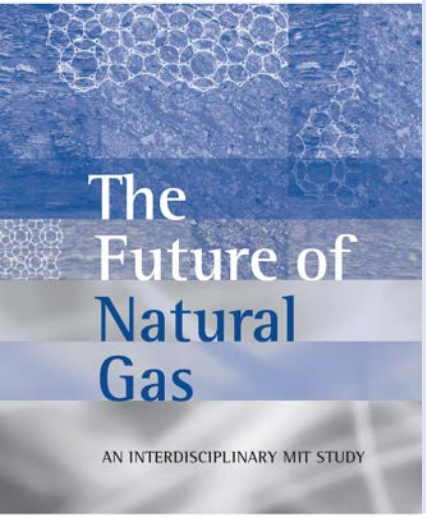
Frac Attack: Risk, Hype and Financial Reality of Hydraulic Fracturing in the Shale Plays; July 8, 2010; A Special Report by Reservoir Research Partners and Tudor Pickering & Holt

Source 2

Hydraulic Fracturing: Preliminary Analysis of Recently Reported Contamination; September 2009; Prepared for: Drinking Water Protection Division (DWPD) Office of Ground Water and Drinking Water (OGWDW) U.S. Environmental Protection Agency (EPA); Prepared by The Cadmus Group Inc.

Source 3

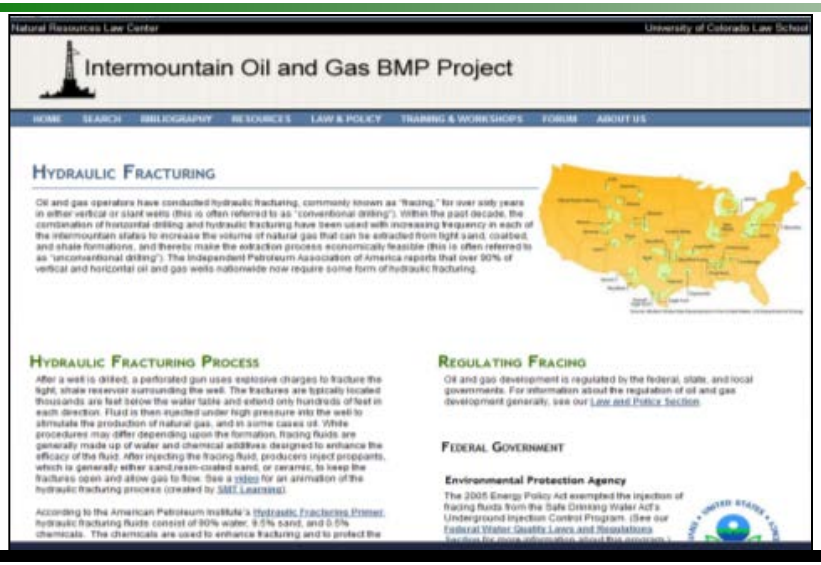
Fractured Communities — Case Studies of the Environmental Impacts of Industrial Gas Drilling; September 2010; Craig Michaels, Program Director; James L. Simpson, Senior Attorney; William Wegner, Staff Scientist; Watershed



Type of incident	Number reported	Fraction of Total
Groundwater contamination by natural gas	20	47%
On-site surface spills	14	33%
Off-site disposal issues	4	9%
Water withdrawal issues	2	4%
Air quality	1	2%
Blowouts	2	4%

40,000+ shale gas wells drilled in the US during this period

Working to Reduce Impacts



For more Info see:

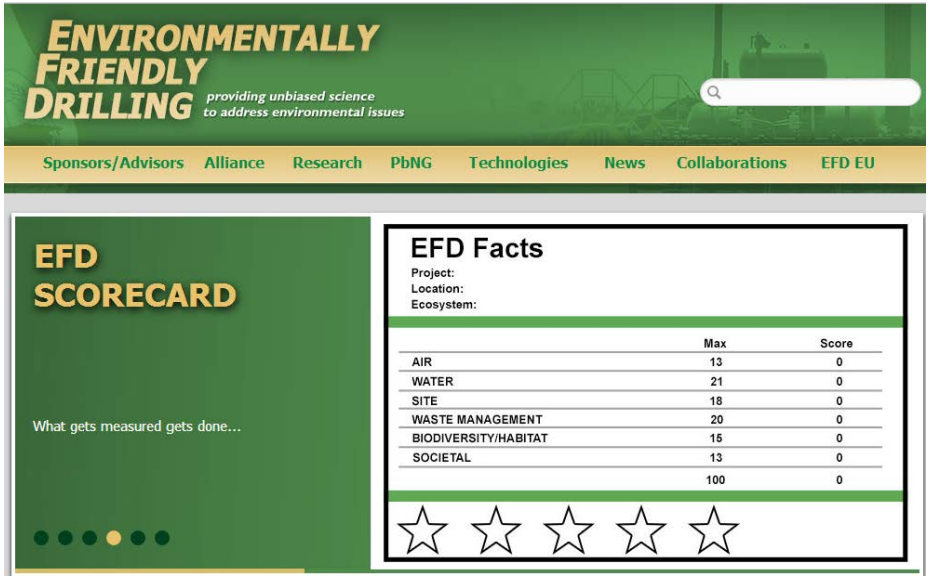
www.oilandgasbmps.org

www.strongerinc.org/p

www.efdsystems.org

www.fracfocus.org

www.lawatlas.org/oilandgas



What to take home

- **The USA has an abundant supply of natural gas.**
- **Gas shales are ubiquitous across the USA.**
- **Hydraulic fracturing is required to produce the gas from shales and other low permeability rock.**
- **Safety & environmental awareness are important.**

It’s not so hard to be green

Thank you

www.efdsystems.org
www.efdvirtualsite.org
www.facebook.com/EFDSystems