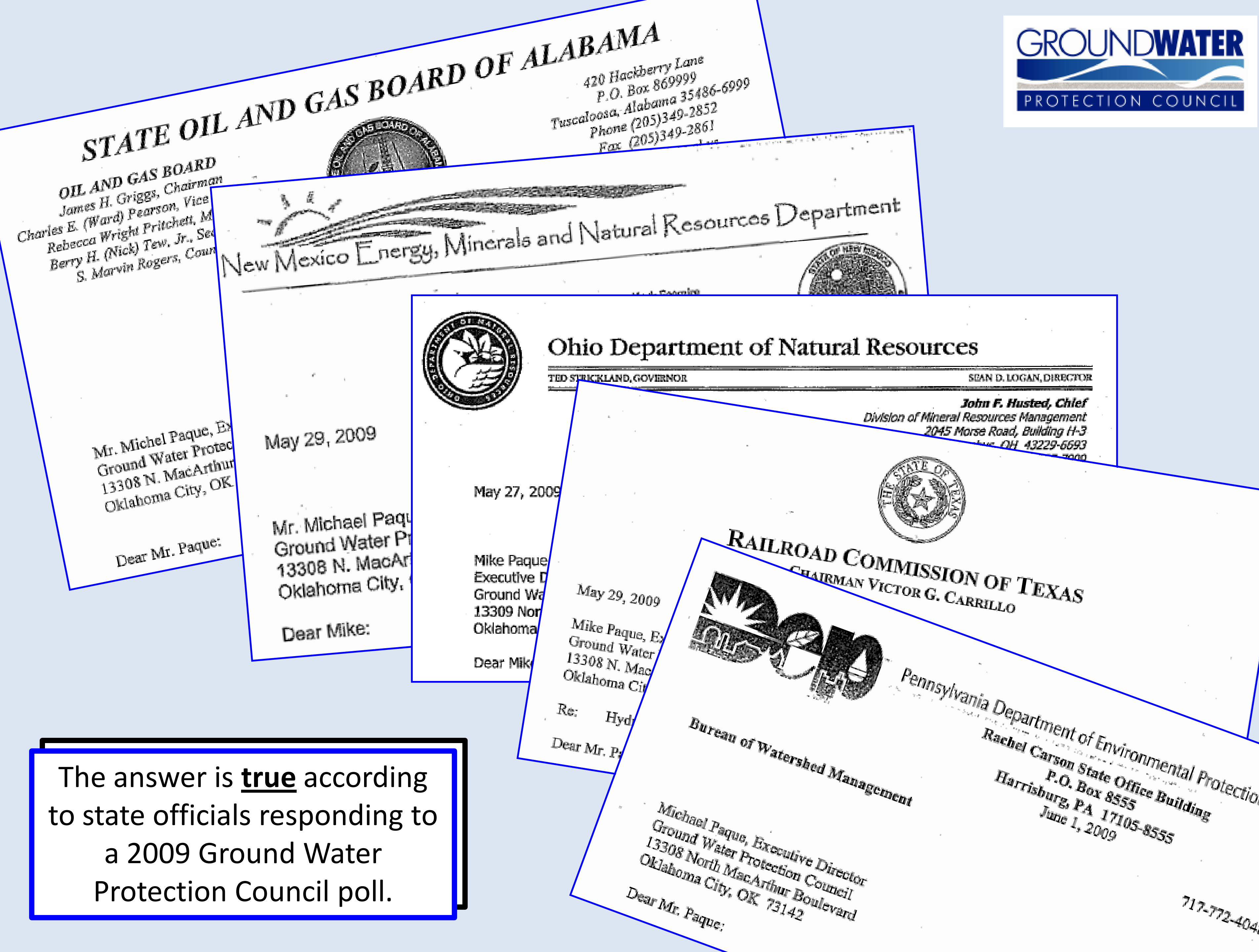
Over 1,000,000 hydraulic fracturing stimulations within the USA without compromising fresh groundwater: True or False?

GROUNDWATER PROTECTION COUNCIL

Terry Engelder
Department of Geosciences
The Pennsylvania State University
University Park, PA 16802


STATE OIL AND GAS BOARD OF ALABAMA
420 Hackberry Lane
P.O. Box 869999
Tuscaloosa, Alabama 35486-6999
Phone (205)349-2852
Fax (205)349-2861

OIL AND GAS BOARD
James H. Griggs, Chairman
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Berry H. (Nick) Tew, Jr., Se
S. Marvin Rogers, Coun

Mr. Michel Paque, Ex
Ground Water Protec
13308 N. MacArthur
Oklahoma City, OK

Dear Mr. Paque:

New Mexico Energy, Minerals and Natural Resources Department

May 29, 2009

Mr. Michael Paqu
Ground Water Pr
13308 N. MacAr
Oklahoma City,

Dear Mike:

Ohio Department of Natural Resources
TED STRICKLAND, GOVERNOR
SEAN D. LOGAN, DIRECTOR
John F. Husted, Chief
Division of Mineral Resources Management
2045 Morse Road, Building H-3

May 27, 2009

Mike Paque
Executive D
Ground Wa
13309 Nor
Oklahoma

Dear Mik

RAILROAD COMMISSION OF TEXAS
CHAIRMAN VICTOR G. CARRILLO

May 29, 2009

Mike Paque, Ex
Ground Water
13308 N. Mac
Oklahoma Cit

Re: Hyd

Dear Mr. P

Pennsylvania Department of Environmental Protection
Rachel Carson State Office Building
P.O. Box 8555
Harrisburg, PA 17105-8555
June 1, 2009

Bureau of Watershed Management

Michael Paque, Executive Director
Ground Water Protection Council
13308 North MacArthur Boulevard
Oklahoma City, OK 73142

Dear Mr. Paque:

717-772-4048

GROUNDWATER PROTECTION COUNCIL

The answer is **true** according to state officials responding to a 2009 Ground Water Protection Council poll.

If true, why is there such a disconnect between state officials and the public?

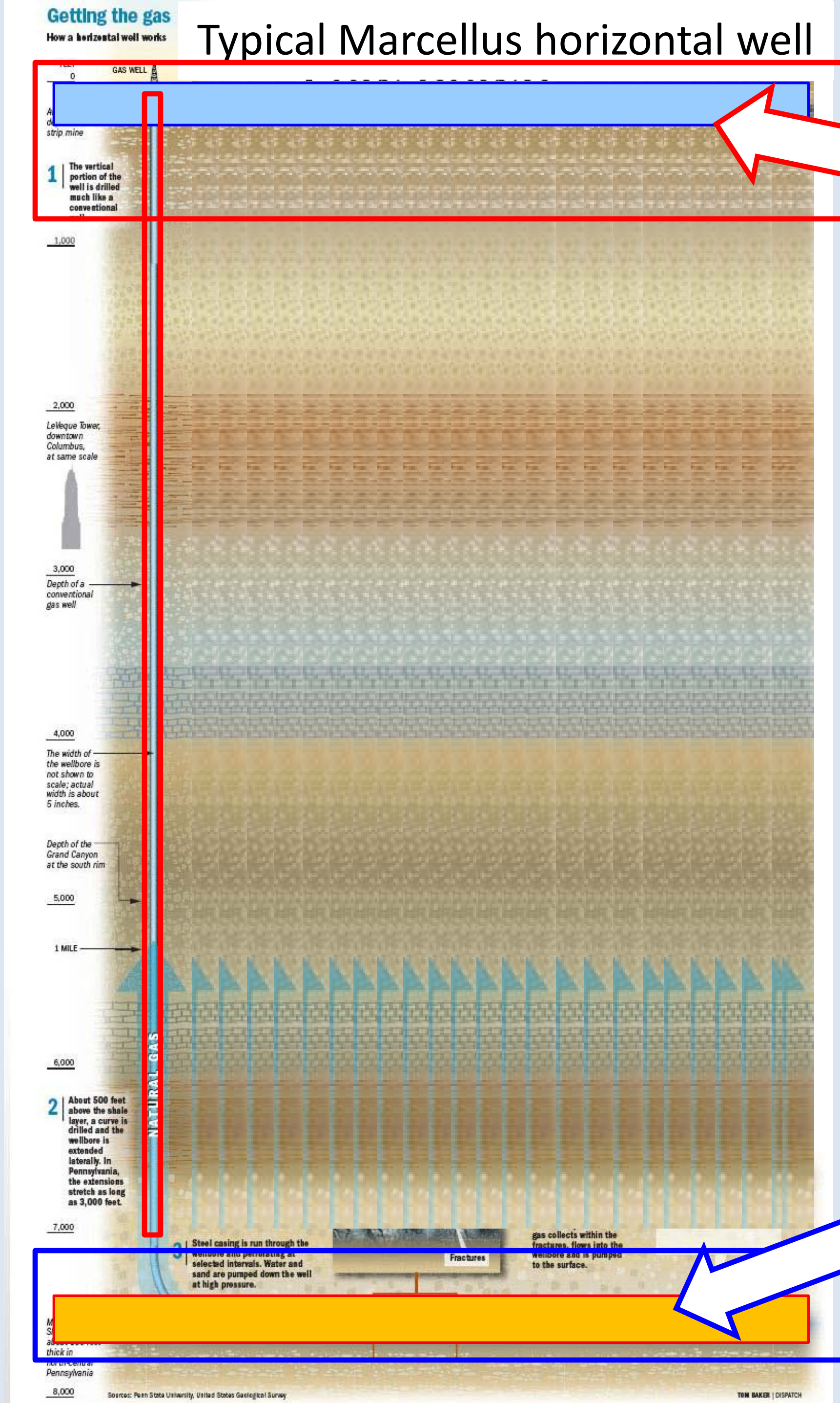
- People simply do not understand the mechanics of groundwater flow, recharge, contaminant transport, or the fact that most of what they need to worry about in their well comes in from **above**, not **below**.

E-mail: A hydrologist working for the federal government to T.E. (September 2, 2010)

Ground water (drinking)

8000 feet

Frac Fluid



Above

Sources of "serious environmental impact":
muddy water,
poor cement jobs,
stray gas,
surface spills

Below

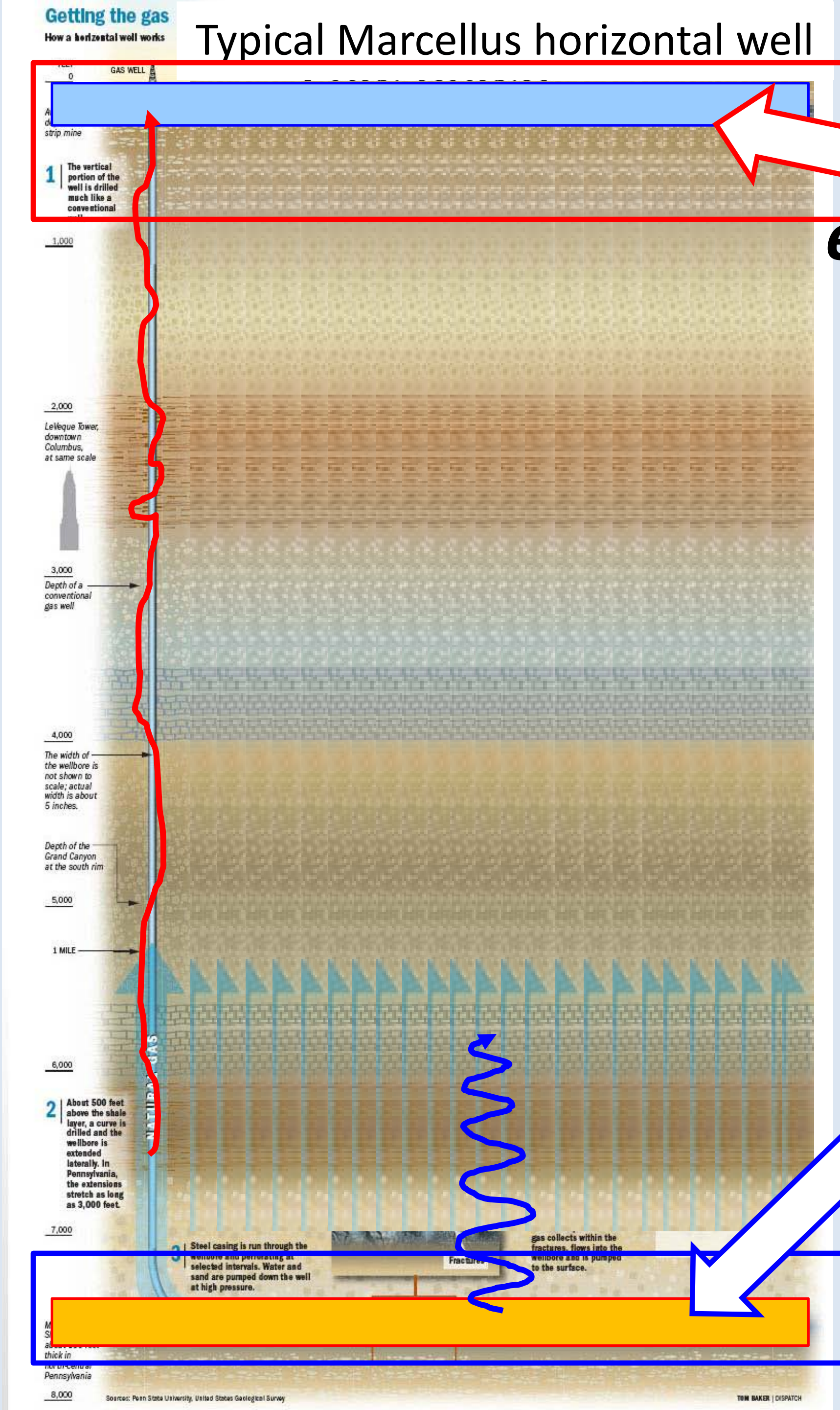
frac fluid left behind in the Marcellus

Typical Marcellus horizontal well

Ground water (drinking)

8000 feet

Frac Fluid



Above

engineered pathways to ground water

with these society can discover what went wrong and how to corrected it.

Below

natural pathways to groundwater

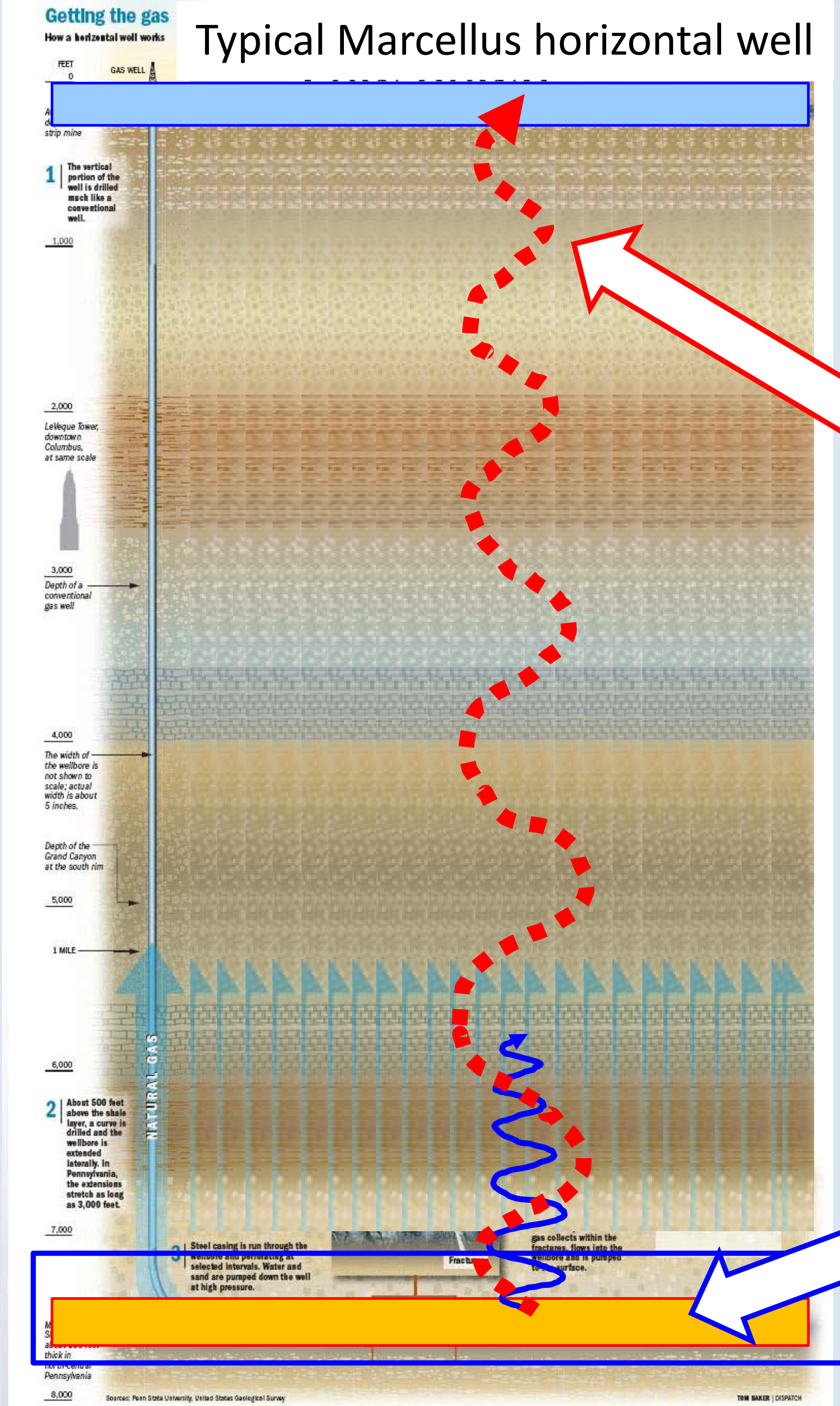
with these remediation is impossible!

Ground water (drinking)

8000 feet

Frac Fluid

Typical Marcellus horizontal well



If the state regulators are wrong, the genie is already out of the bottle!

Frack, the Genie

Below

(*natural pathways*)

If the state regulators are correct, nature keeps the genie in the bottle!

E-mail: A hydrologist working for the federal government to T.E. (September 2, 2010)

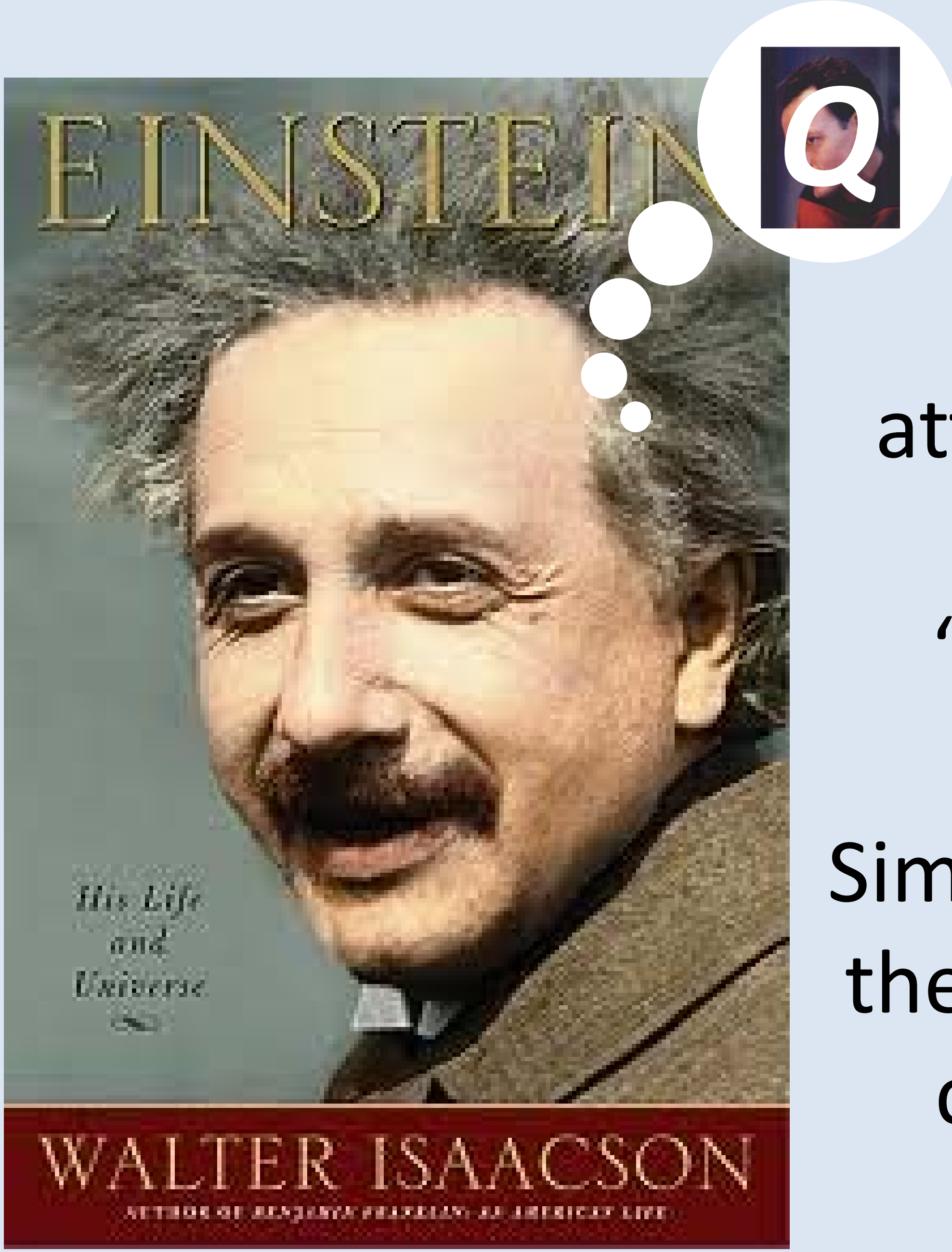
- People simply do not understand

Darcy's Law

And the extent to which the Earth is capable of keeping Frack, the Genie, in its bottle!

<u>Objectives of Today's Talk:</u>

To show how a better understanding of <u>Darcy's Law</u> might assure a public searching for peace of mind regarding nature's ability to protect ground water from frac fluid, , buried deep within the Marcellus and other gas shales ('below').



When bringing **<u>Darcy's Law</u>** to the attention of the public, geologists face the "*Einstein challenge*"

******

Simplifying a complicated theory so that the public can understand and embraced it.

Who was Darcy?

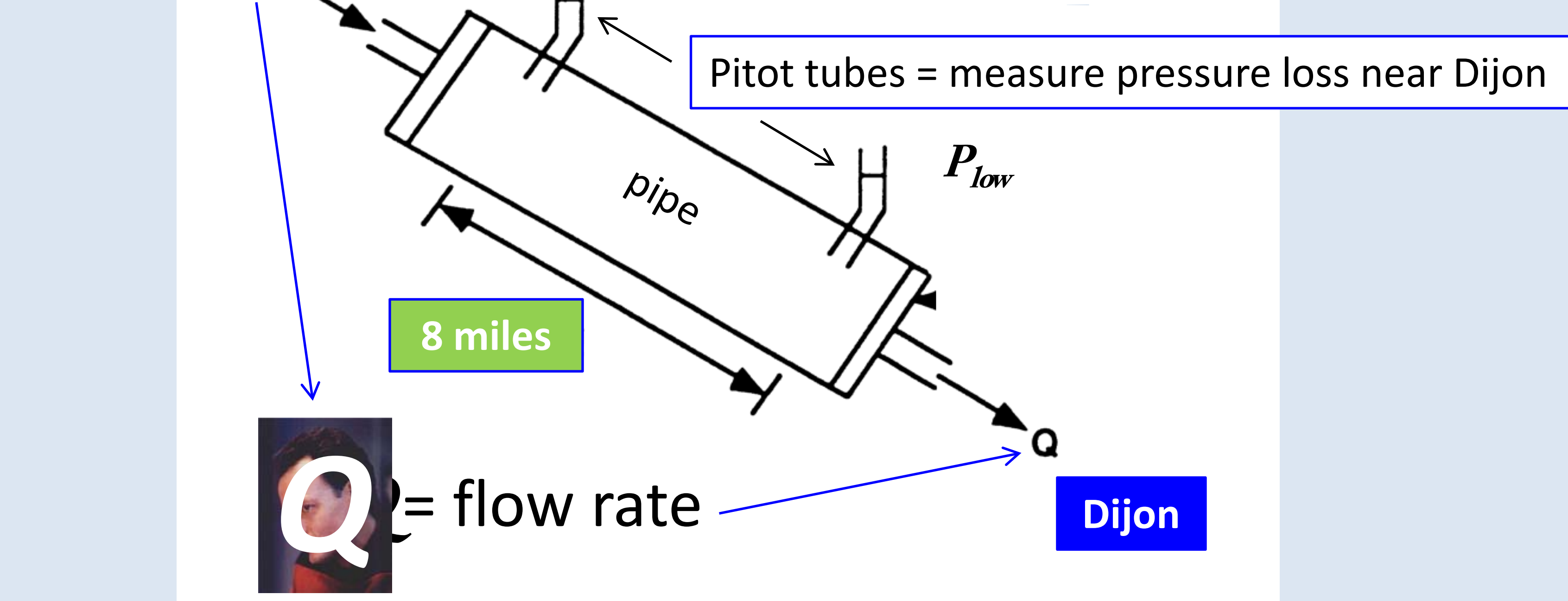
Henry Darcy

Born	June 10, 1803
Died	January 3, 1858

Darcy built a water distribution system that was pressurized by gravity and delivered water to much of Dijon, a French city.

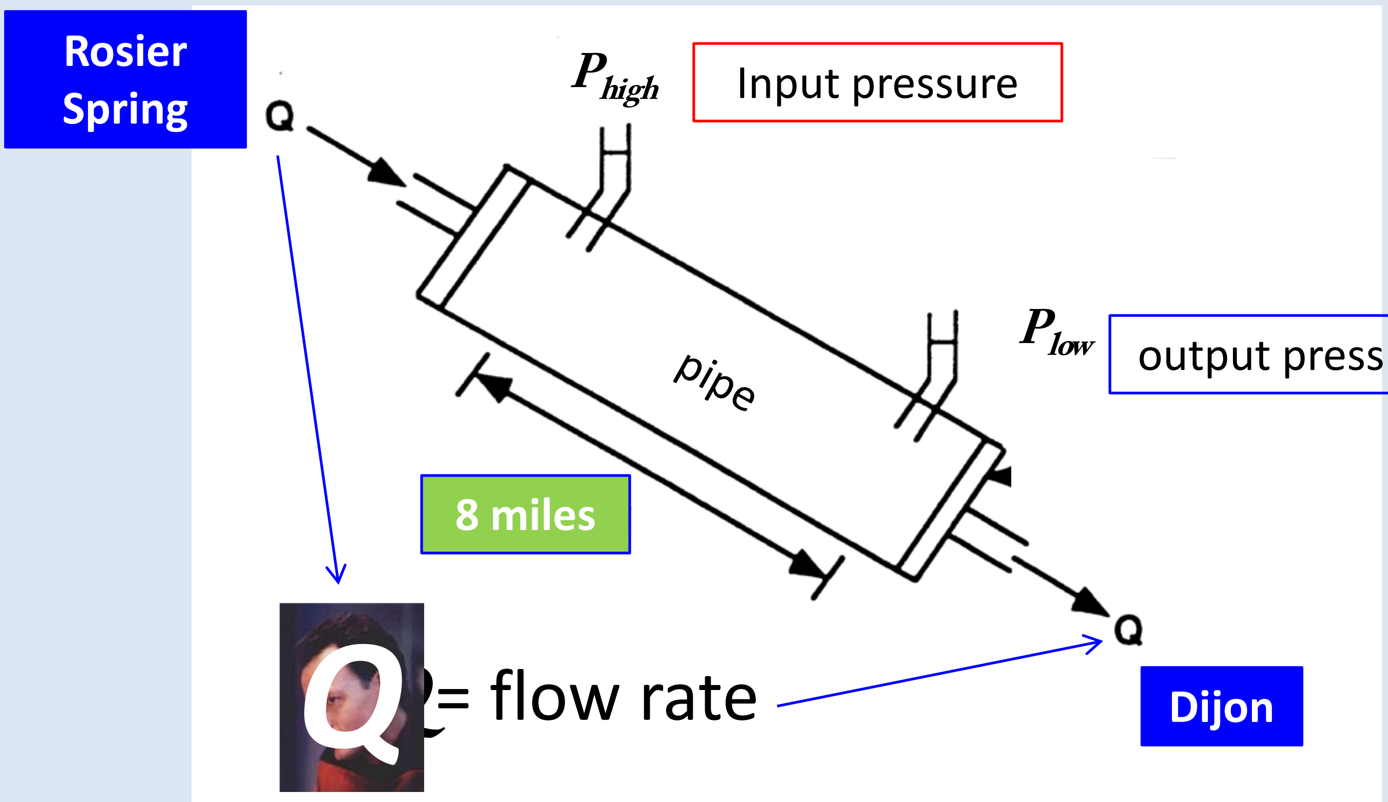
Model for Darcy's Water System

(gravity drives water downhill)



Model for flow through a pipe

(gravity drives water downhill)

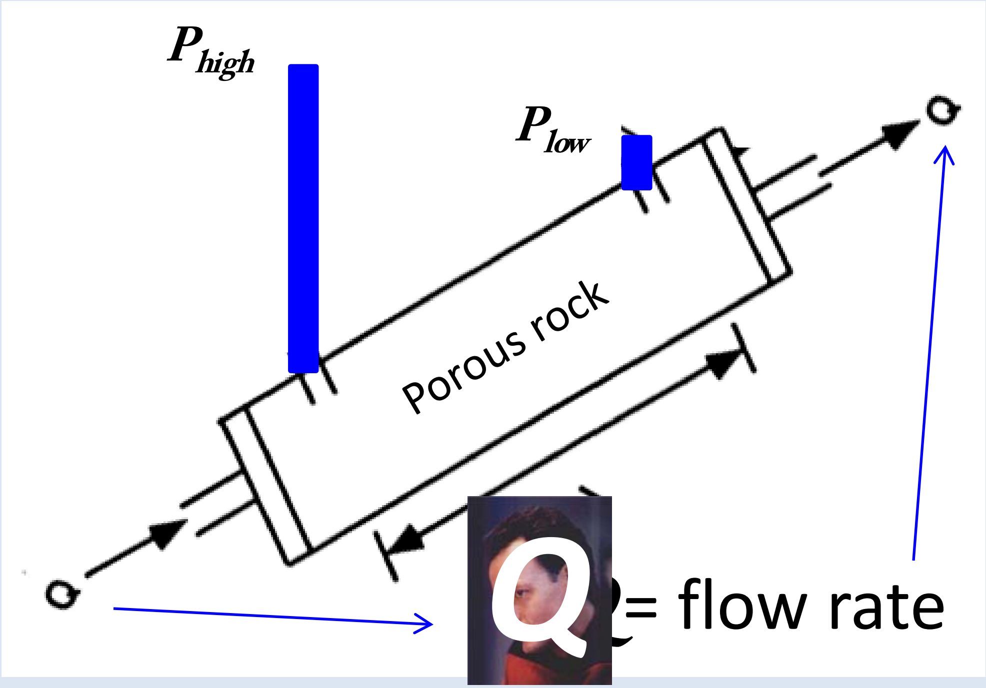


An early lesson that applies to the Marcellus:

1. Water flows only when input pressure exceeds output pressure

Rotate model for flow through a pipe

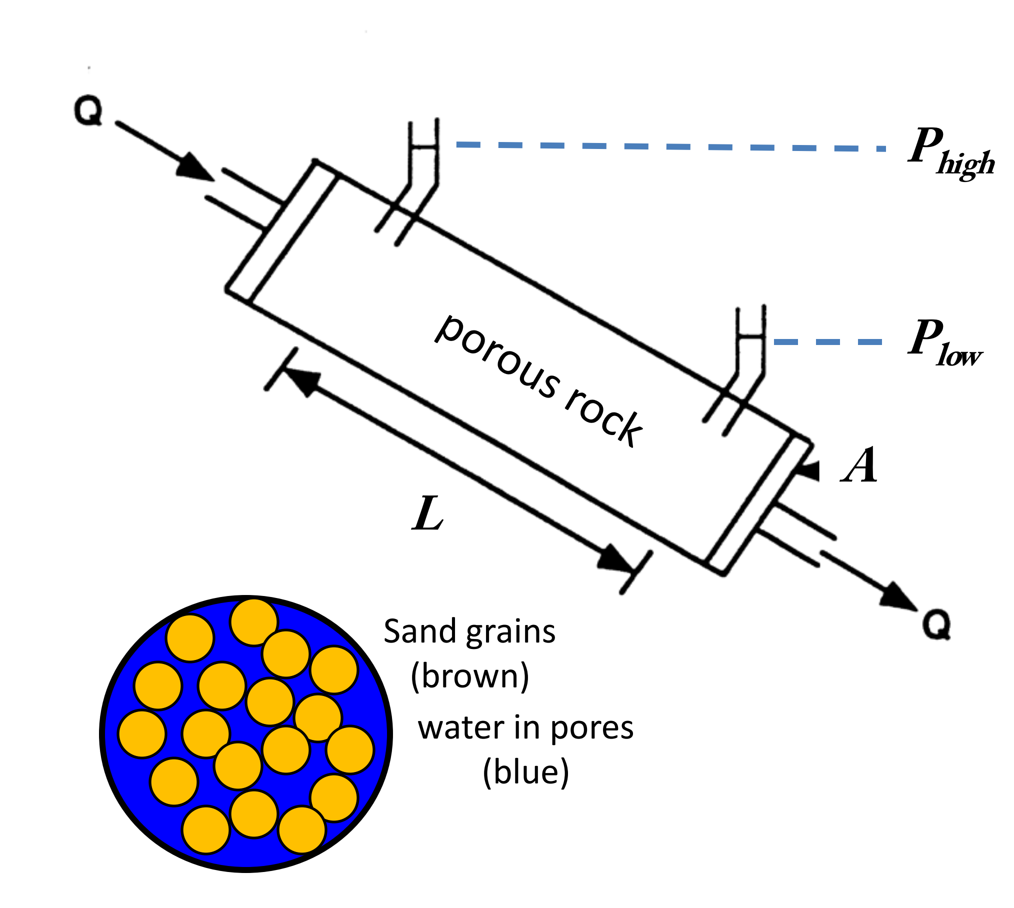
(high pressure is required to drive water uphill)



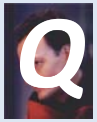
Another lesson that applies to the Marcellus:

2. input pressure must be relatively higher than output pressure if water is to flow against gravity!

The Earth is like Darcy's water system but filled with marbles (sand grains)



A third lesson that applies to the Marcellus

3. Marbles (sand grains) get in the way of flow. This makes  smaller than flow in an open pipe.

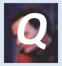
Large & Weak

Like Jean-Luc Pecard's ***Q***,

the GWPC's ***Q*** has omnipotent powers

(when small like humans)

It's all about ***Q***



Small & Powerful

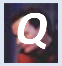
Large & Weak

has omnipotent powers

- ***Q*** keeps Frac, the Genie, locked in his bottle!

Q says, “Frac the Genie!”

- A smaller ***Q***, a stronger lock!



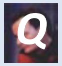
Small & Powerful

Large & Weak

With the advent of fracking, the GWPC needs a new slogan:

GROUNDWATER PROTECTION is small ***Q***

So what about the Earth makes ***Q*** small?



Small & Powerful

Q's  power over Frac, the Genie, is expressed in **<u>Darcy's Law</u>**, an algebraic equation that describes flow through a porous rock

A = cross section of flow (area)

L = length of flow

P_{high} = high pressure

P_{low} = low pressure

μ = viscosity (property of fluid)

κ = permeability (property of the rock)

$$Q = \frac{\kappa A}{\mu L}\left(P_{high} - P_{low}\right)$$

Q = flow rate

Over 1,000,000 hydraulic fracturing stimulations within the USA without compromising fresh groundwater

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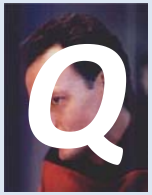
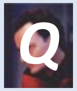
The response of the States to the GWPC poll means that flow rate, · , for frac fluid along <u>natural pathways</u> must be very small.

GROUNDWATER
PROTECTION COUNCIL

The algebra to make 

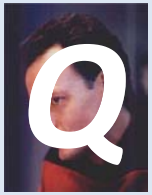
small?



$$= \frac{(small)(small)}{(large)(large)}(small)$$

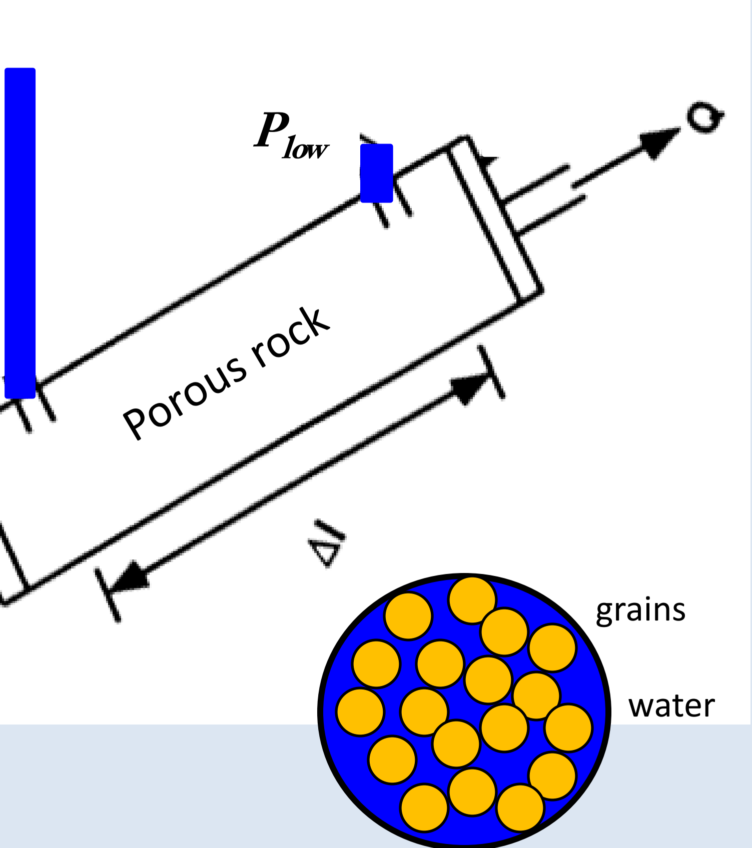
Q= flow rate

The algebra to make Q small?



$$Q = \frac{\kappa A}{\mu L}\left(P_{high} - P_{low}\right)$$

Q = flow rate

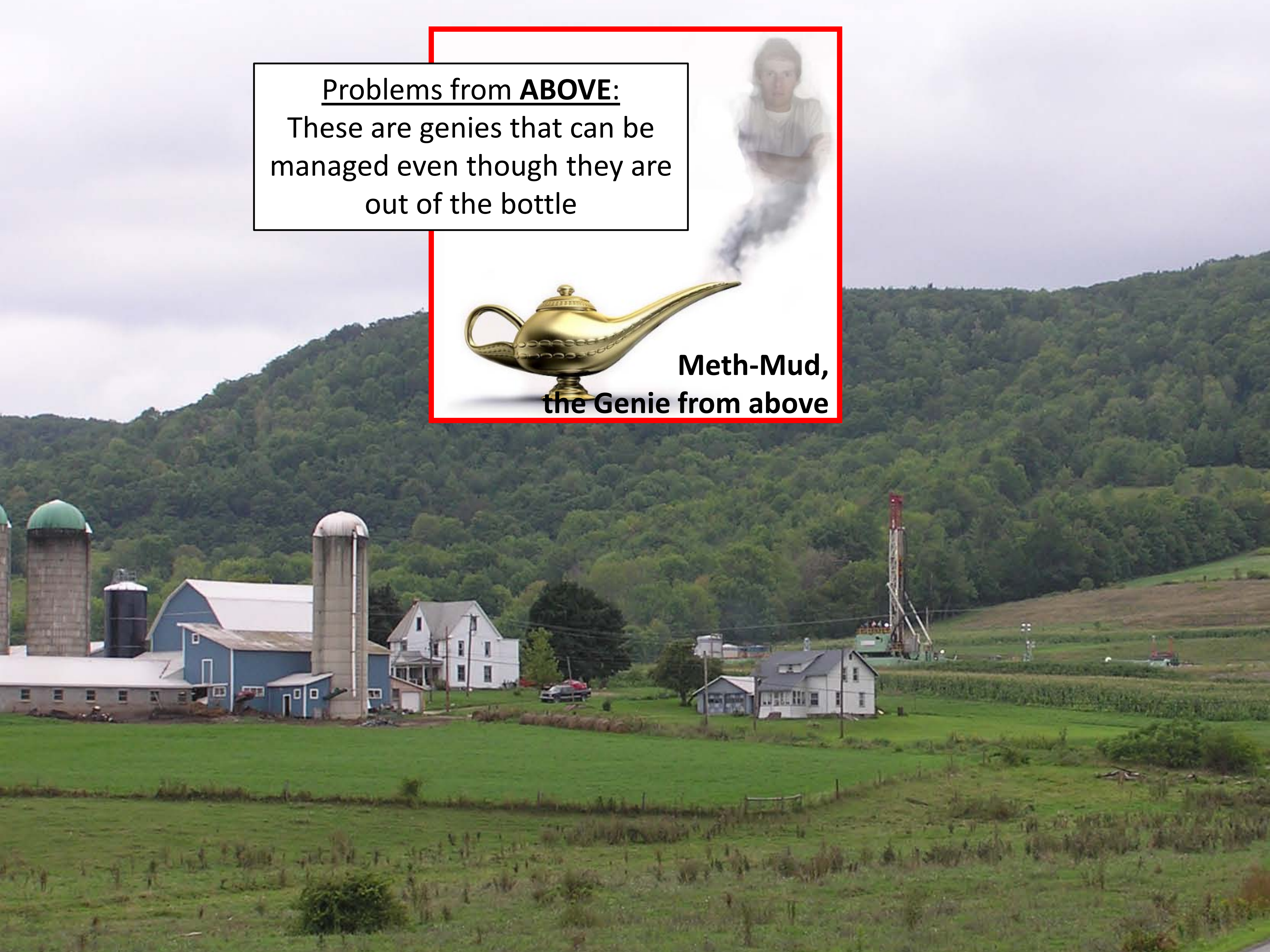


	Number Size
A = cross section of flow (area)	small
L = length of flow	large
$P_{high} - P_{low}$ = pressure difference	small
μ = viscosity of fluid	large
κ = permeability of the rock	small

Always remember

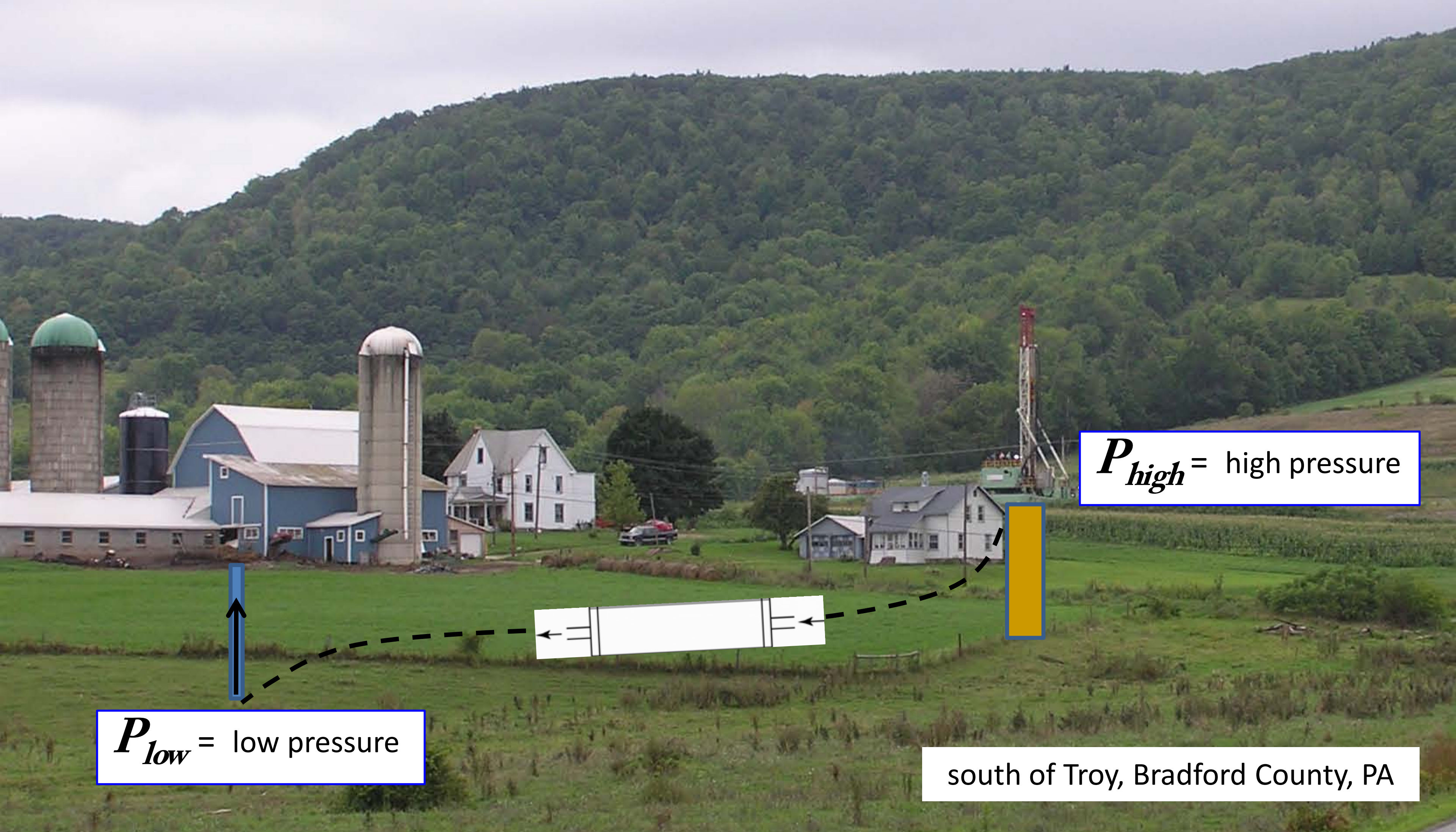
- When $P_{high} - P_{low} = 0$ (pressure difference),
- Q ⇨ zero and there can be no flow!

Zero pressure difference = GROUNDWATER PROTECTION


Problems from **ABOVE**:
These are genies that can be managed even though they are out of the bottle
Meth-Mud, the Genie from above

Problem #1 from **ABOVE**:

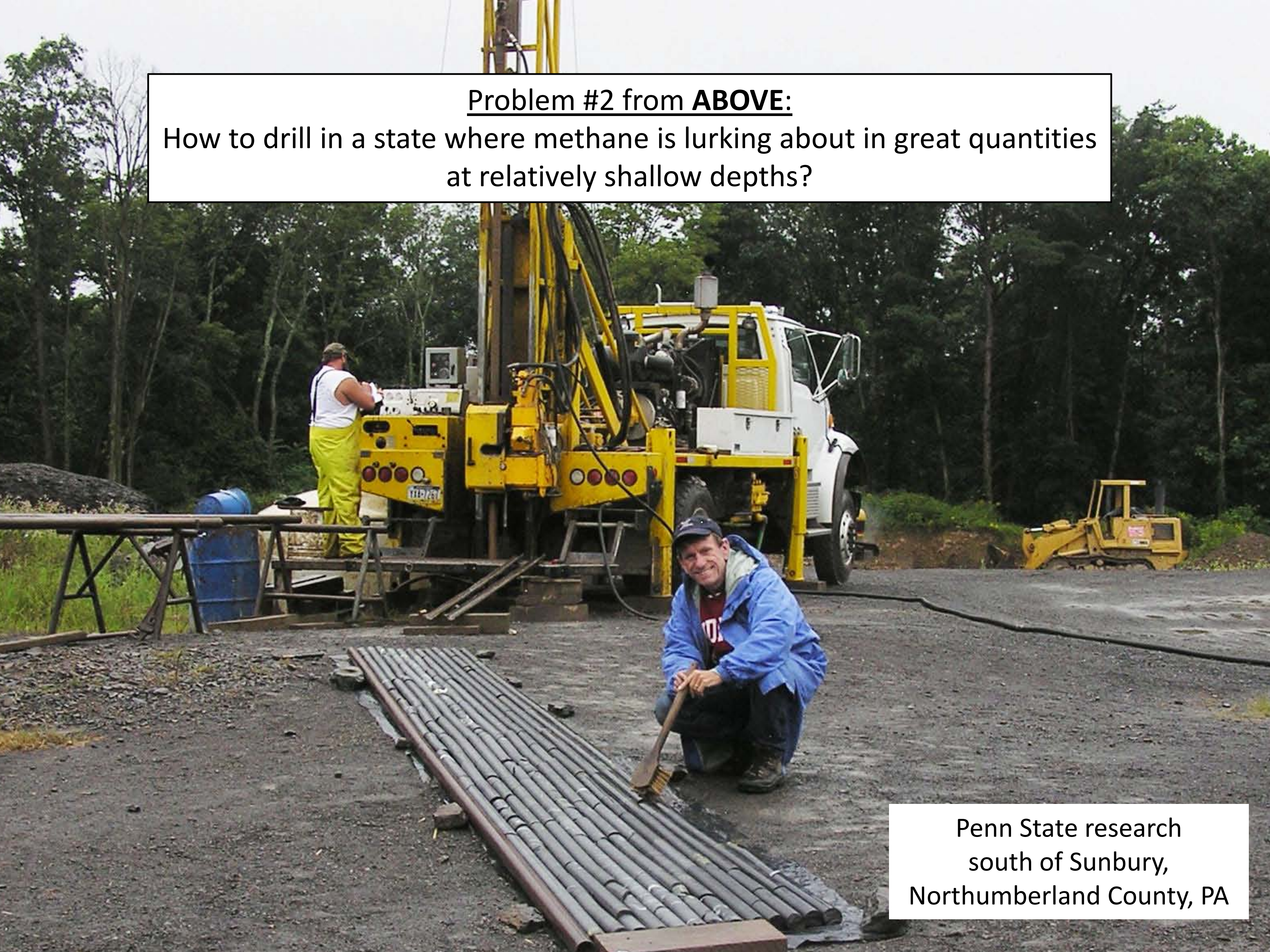
How to drill a series 17.5 inch pilot holes through soil without muddying the local groundwater for weeks if not months?




Q
If Q is large, its power is weak!
Meth-Mud,
the Genie from above
Q says, “Mankind, you are on your own with Meth-Mud. I can’t help!”

<u>Problem #2 from **ABOVE**:</u>

How to drill in a state where methane is lurking about in great quantities at relatively shallow depths?



Penn State research
south of Sunbury,
Northumberland County, PA

methane blowing up from 972 feet

fresh water

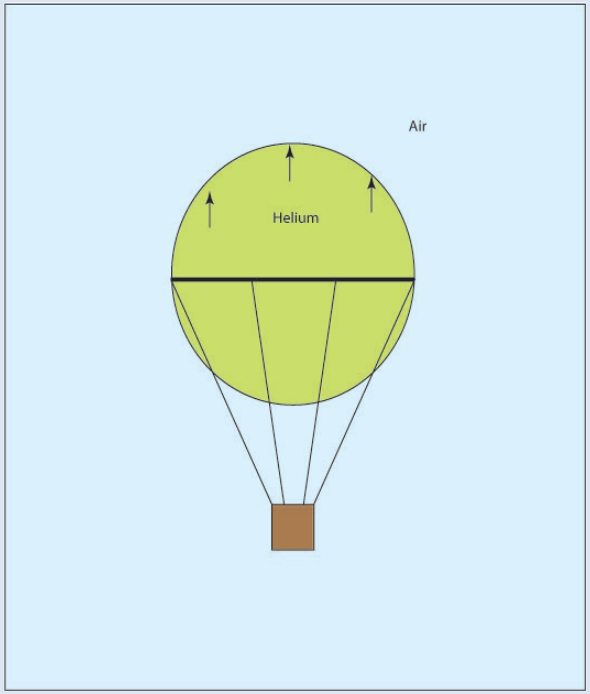
Q says, "If Prof. Engelder can hit pockets of shallow methane in PA, anyone can!"

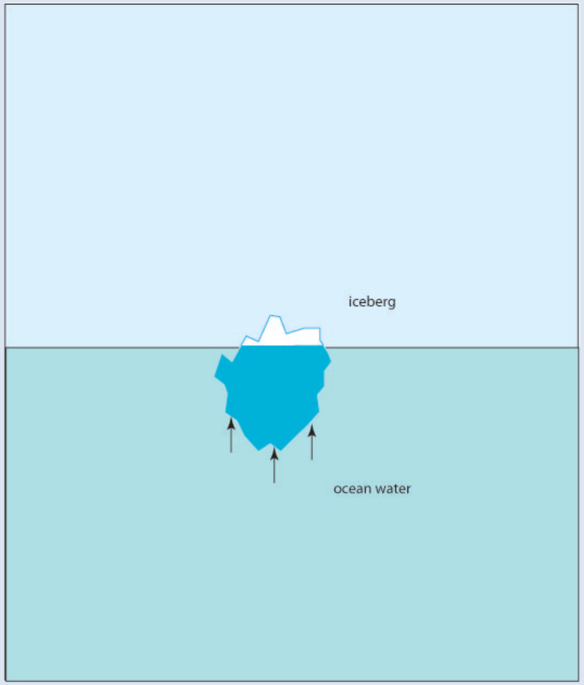

FRACK

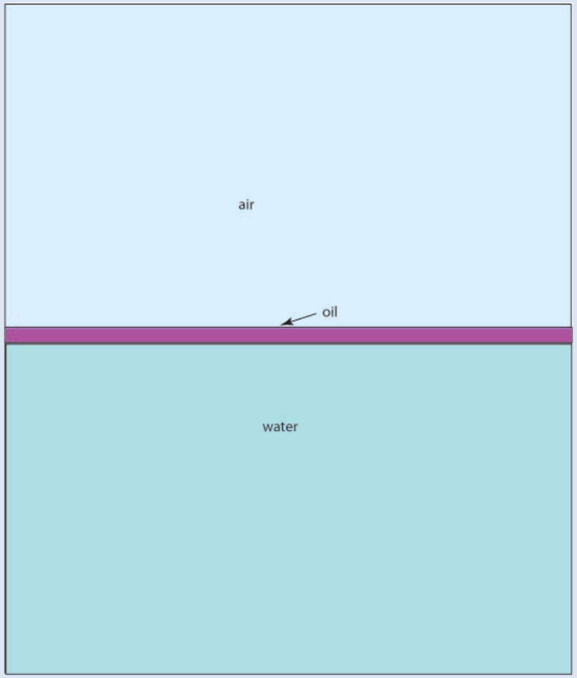
The Principle of Buoyancy

Fluids stack by density with less dense fluids rising to the top.

Lesson: the force of buoyancy sets up a pressure difference when fluids are NOT stacked by density!







Darcy's equation during Penn State's coring operation

methane blowing up from 972 feet

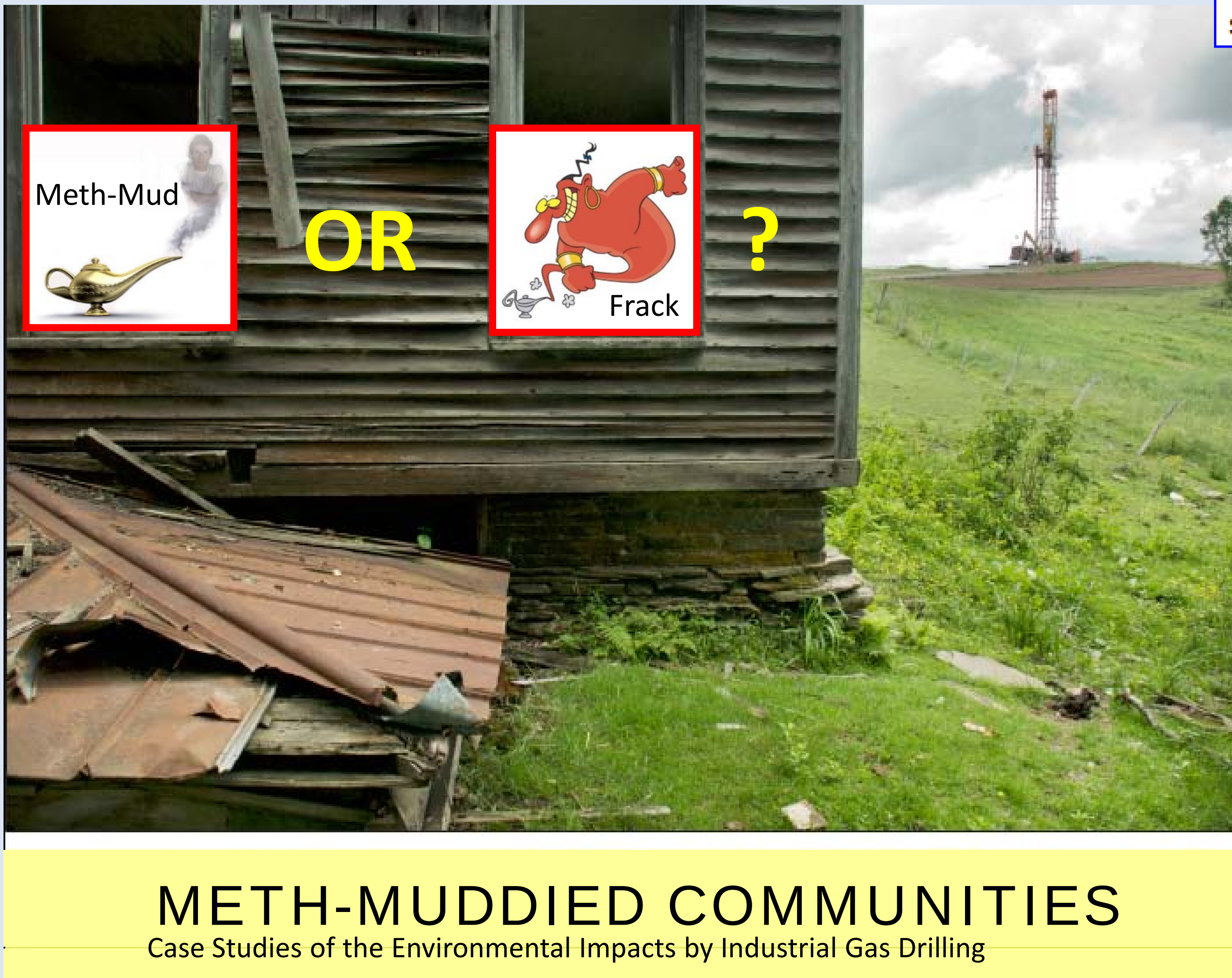
Before drilling **low** rock permeability (κ) keeps methane in place much like gas in a glass jar or a genie in a bottle!

$$Q = \frac{\kappa A}{\mu L}\left(P_{high} - P_{low}\right)$$

After drilling the force of buoyancy blows (i.e., drives) gas to the surface!

2010 Report to EPA

RIVERKEEPER
NY's clean water advocate
SEPTEMBER 2010



RIVERKEEPER
NY's clean water advocate
SEPTEMBER 2010

According to "Fractured Communities", **Meth-Mud** had a significant "environmental impact" about **once*** for every 150** Marcellus wells between 1/2008 and 8/2010.

(excluding the Dimock cluster)!

* counting only Marcellus wells

** # DEP violations about 1:1

Some would say that this is a really good record for a very complex and difficult industry!

RIVERKEEPER
NY's clean water advocate
SEPTEMBER 2010

...unities", **Meth-Mud** had a
sig... ...bout <u>**once**</u>* for every
150 ... ...08 and 8/2010.

* counting only
...llus wells

...ns

But one mission of PA DEP is to provide the leadership that allows this complex and difficult industry to develop even better practices in keeping Meth-Mud at bay!

The challenge for industry to make this ONE significant environmental impact per, say, 300 wells by 2011 and better yet, why not ONE per 500 wells by 2012!

Some would say that this is a really goo... very complex and difficult industry

If industry can learn to keep Meth-Mud in its bottle in the next couple of years, then a future environmental activist report might look like this!

Future Report to EPA

SEPTEMBER 2012

GENIE-FREE COMMUNITIES

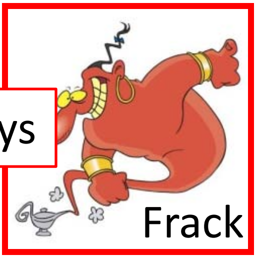
Case Studies of the Good Practices by Industrial Gas Drilling

RIVERKEEPER NY's clean water advocate Testimony to U.S. Environmental Protection Agency

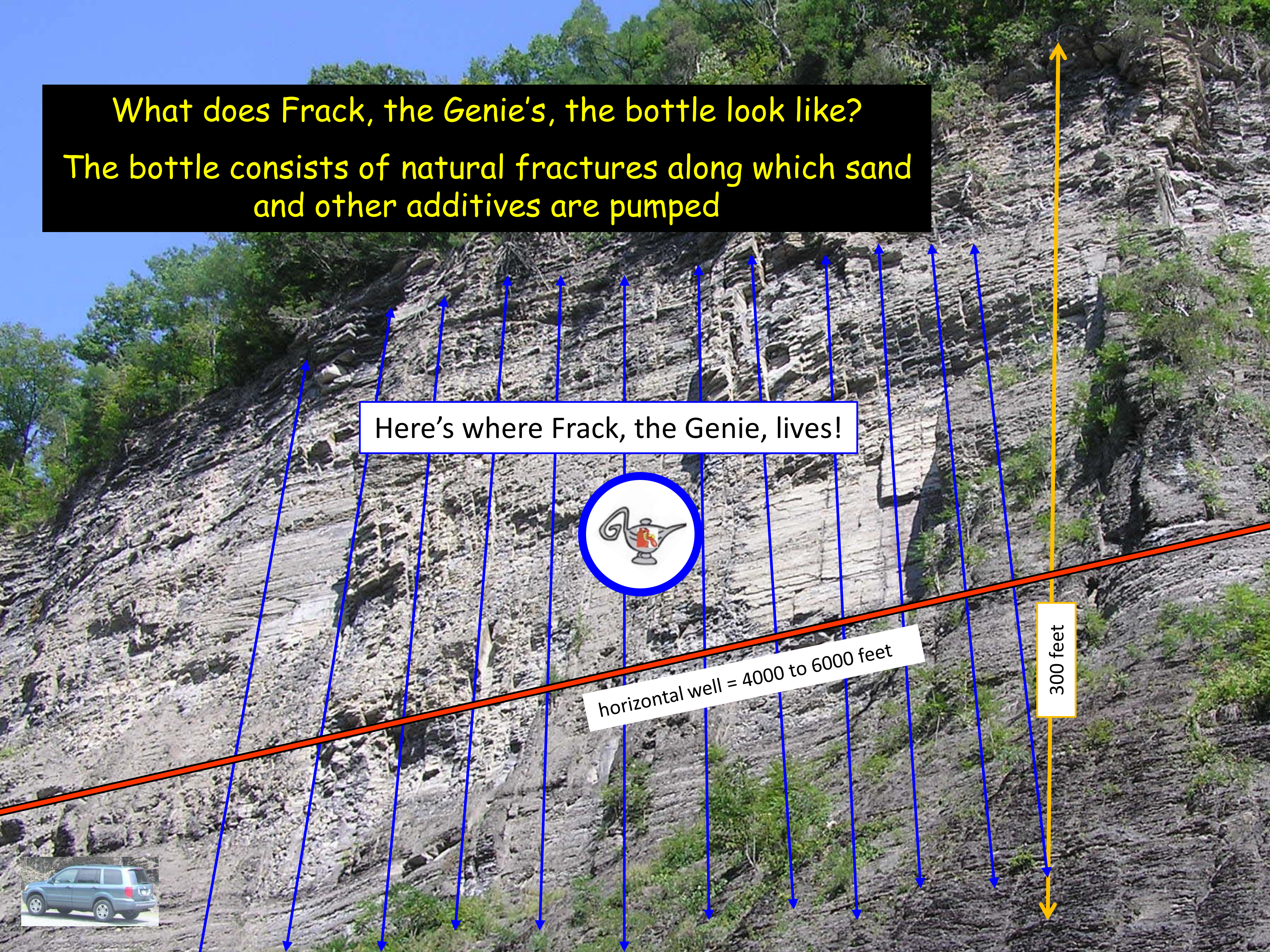
(September 13, 2010)

- We propose the following topics for Science Advisory Board consideration during advisory process:
  - The adverse impacts to groundwater supplies associated with hydraulic fracturing; including but not limited to potential contamination through existing geological faults and fractures!

These are natural pathways



What does Darcy's Law have to say about flow along natural pathways?


What does Frack, the Genie's, the bottle look like?
The bottle consists of natural fractures along which sand and other additives are pumped
Here's where Frack, the Genie, lives!
horizontal well = 4000 to 6000 feet
300 feet

Getting the gas

How a horizontal well works

FEET 0 — GAS WELL

Average depth of a strip mine

1 | The vertical portion of the well is drilled much like a conventional well.

1,000

2,000

LeVeque Tower, downtown Columbus, at same scale

3,000

Depth of a conventional gas well

4,000

The width of the wellbore is not shown to scale; actual width is about 5 inches.

Depth of the Grand Canyon at the south rim

5,000

1 MILE

NATURAL GAS

6,000

2 | About 500 feet above the shale layer, a curve is drilled and the wellbore is extended laterally. In Pennsylvania, the extensions stretch as long as 3,000 feet.

7,000

3 | Steel casing is run through the wellbore and perforating at selected intervals. Water and sand are pumped down the well at high pressure.

Natural gas

Fractures

4 | The water causes the shale to fracture. Sand flows in to keep the fractures open. Natural gas collects within the fractures, flows into the wellbore and is pumped to the surface.

Marcellus Shale averages about 100 feet thick in north-central Pennsylvania

MARCELLUS SHALE

8,000

Sources: Penn State University, United States Geological Survey

TOM BAKER | DISPATCH

The Columbus Dispatch
dispatch.com

Low down, rich and stingy

Energy companies just figuring out how to coax natural gas from deepest Appalachian shale deposits

By Kevin Mayhood
THE COLUMBUS DISPATCH

For a time, Ohio was located just south of the equator and areas of the state were covered by a warm, shallow sea filled with ancient algae, plankton, fishes and sharks.

Over eons, the Earth's plates and equator shifted, the plants and animals died, the sea dried up, layers of sediment formed and the rich mud at the bottom of the geologic pile became compressed by time and incredible pressure.

Fast-forward to today, and that shale, buried deep beneath eastern Ohio, West Virginia, upstate New York and parts of Pennsylvania, contains something energy companies are dying to reach — natural gas.

Companies have drilled in these states with modest results for decades, but news of an untapped reservoir has energy companies talking. So does a method for getting it out of the ground, in some places 8,000 feet deep.

"It's just getting started," said Terry Engelder, a Penn State geologist who has studied the shale for 30 years.

In January, he and Gary Lash, a geologist at the State University of New York at Fredonia, announced that the reservoir could contain 50 trillion cubic feet of natural gas worth $400 billion.

See SHALE Page B5

PHOTO COURTESY OF TERRY ENGELDER

Penn State geologist Terry Engelder says there is about $400 billion worth of natural gas waiting to be tapped in parts of four states.

Down — way down — then sideways

HORIZONTAL DRILLING could capture vast natural gas resources trapped in shale deposits.

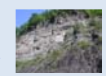
NEW YORK
Buffalo
Dimock
LAKE ERIE
MARCELLUS SHALE
PENNSYLVANIA
OHIO
Cleveland
Pittsburgh
Columbus
Wheeling
WEST VIRGINIA
Charleston
APPALACHIAN MOUNTAINS
VIRGINIA
N
50 MILES

Untapped energy

- **What's there:** Marcellus Shale underlies much of northern Appalachia, 6,000 to 8,000 feet below the ground. Tiny pores in the shale contain large amounts of natural gas. The layer becomes thicker from west to east, beginning at about 50 feet thick in eastern Ohio to more than 100 feet in north-central Pennsylvania.
- **How much:** An estimated 50 trillion cubic feet of natural gas is trapped in the tiny pores in the shale. Not all of it is recoverable. The U.S. uses 23 trillion cubic feet of natural gas each year.
- **Getting it:** Horizontal drilling could tap the natural gas in the shale. The technology takes advantage of shale's tendency to fracture easily under pressure, forming cracks that run perpendicular to horizontal wells.

http://www.dispatch.com/live/content/science/stories/2008/03/11/Sci_shale.ART_ART_03-11-08_B4_A99I7HO.html?print=yes

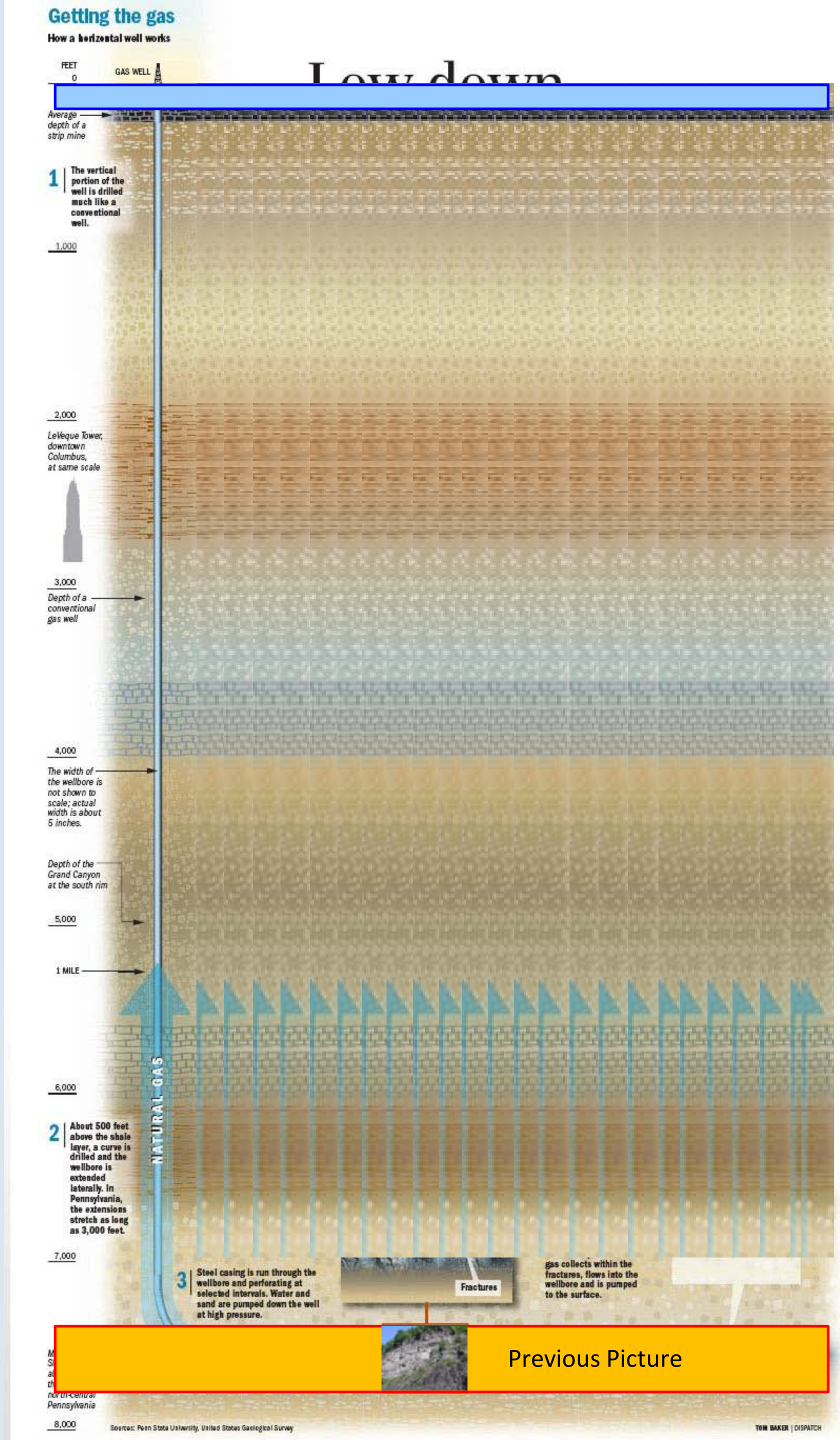
What's the true scale of Frack, the Genie's, bottle?



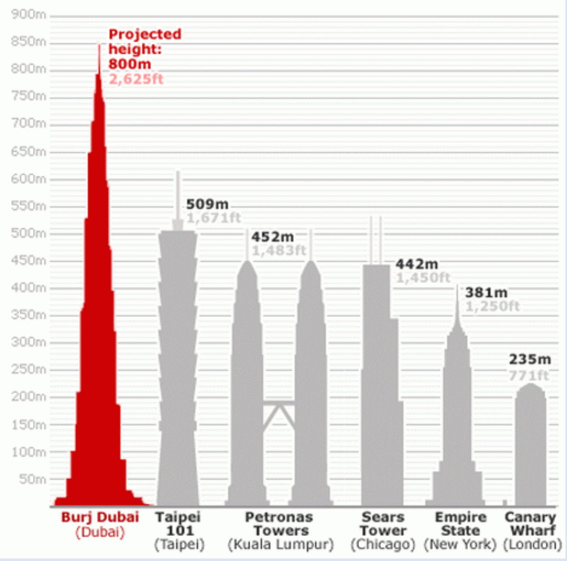
Previous Picture

Configuration of a Marcellus Well

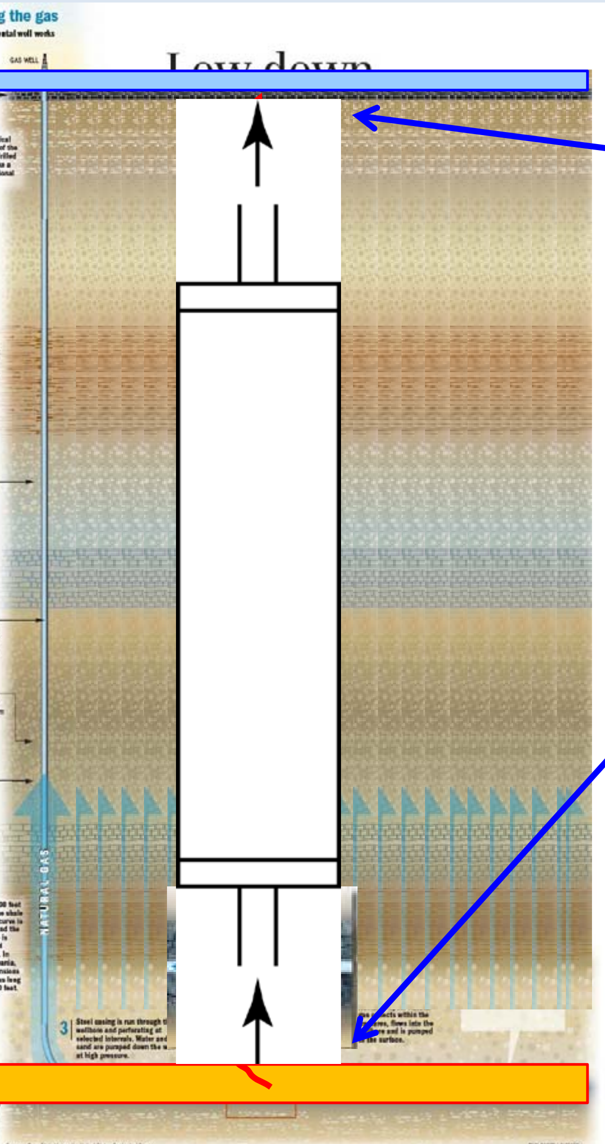
Ground Water (drinking)

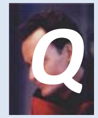


Frac Fluid



Darcy's Law



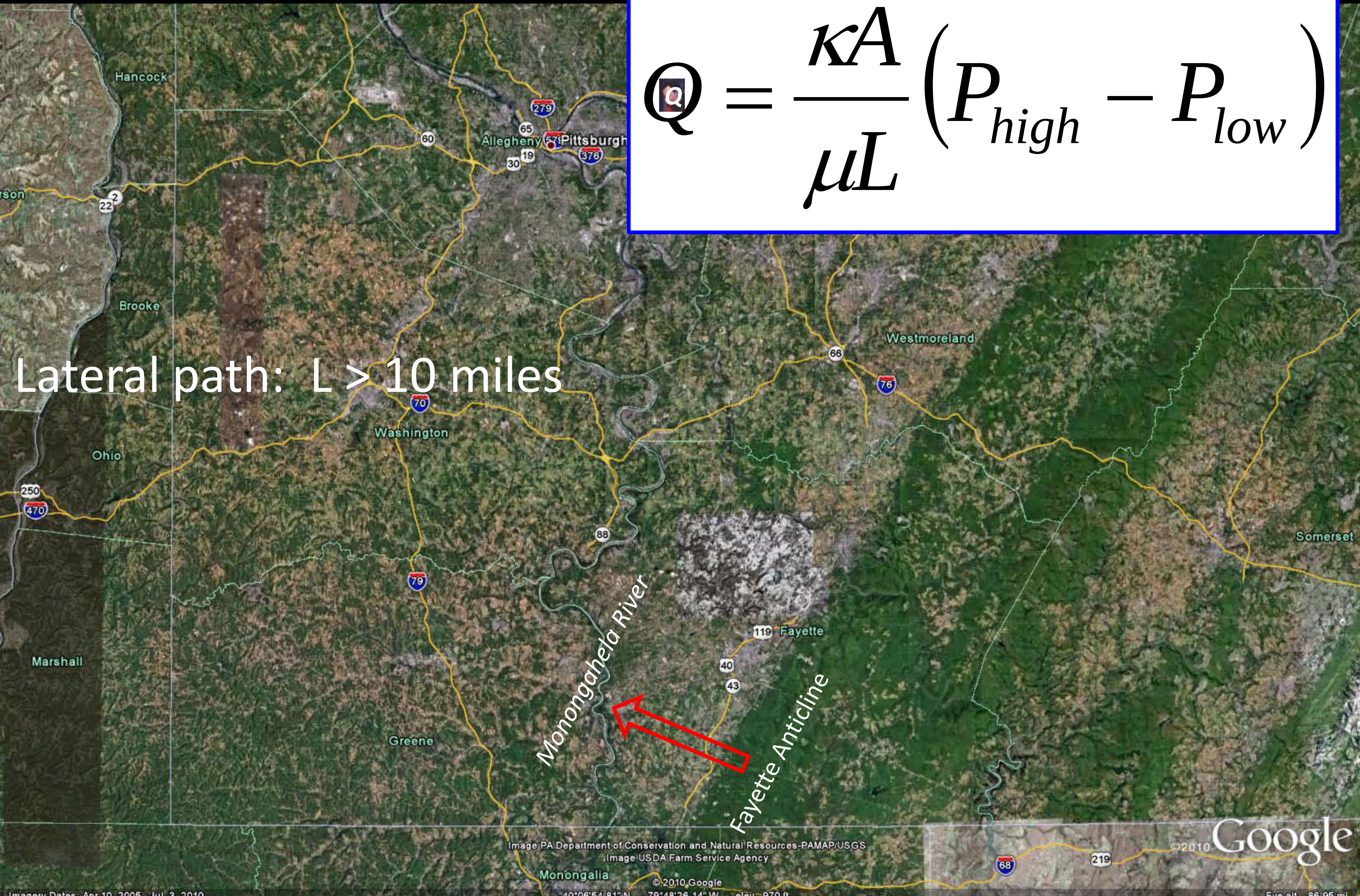


$$Q = \frac{\kappa A}{\mu L}\left(P_{high} - P_{low}\right)$$

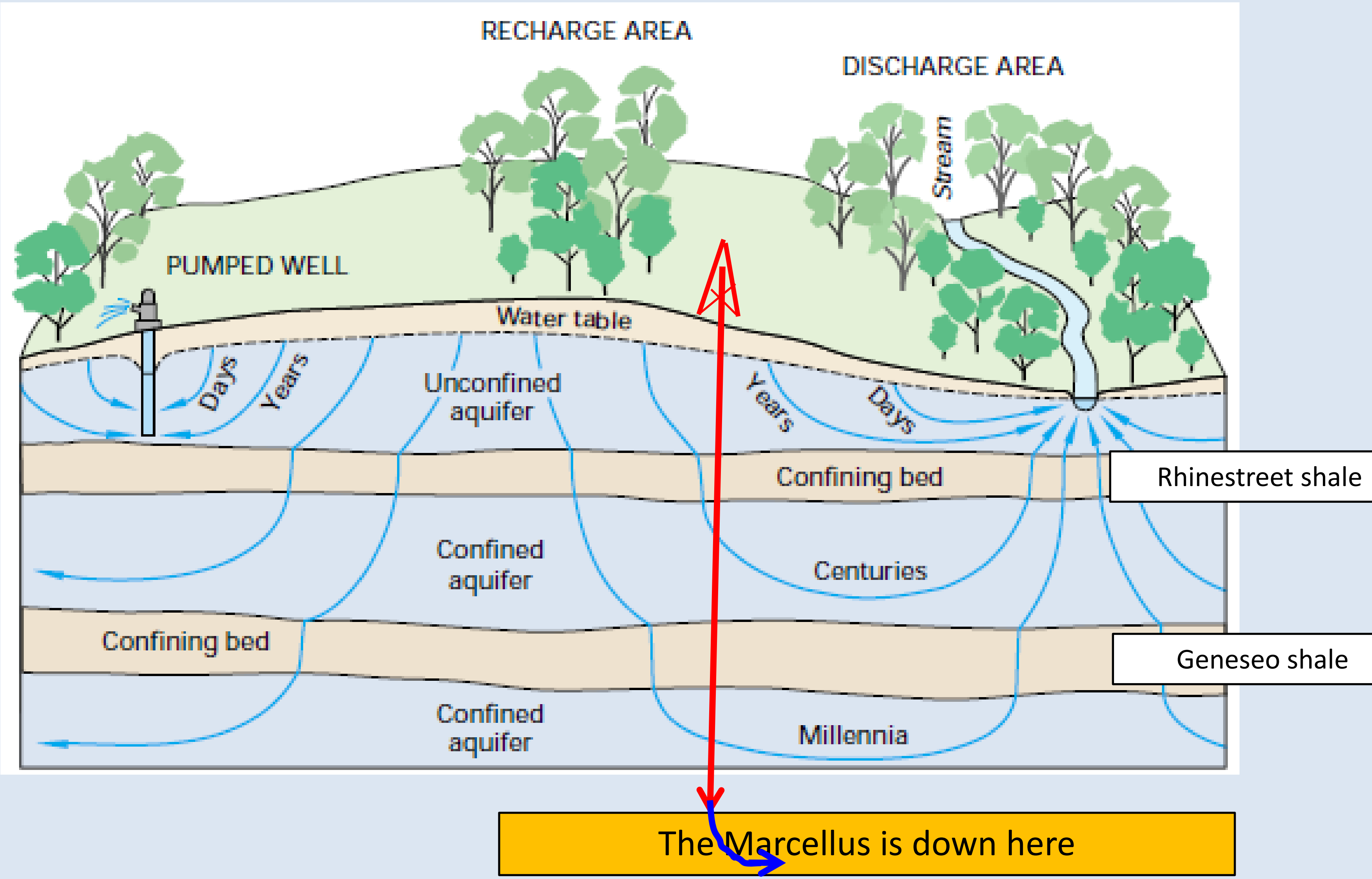
- Dimensions of the flow
- L – Distance the fluid might flow.
  - *minimum = 6000 - 7000 ft*.
  - Maximum = 10s to 100s of miles.

Big numbers in the denominator make for small *Qs!*

$$Q = \frac{\kappa A}{\mu L}\left(P_{high} - P_{low}\right)$$



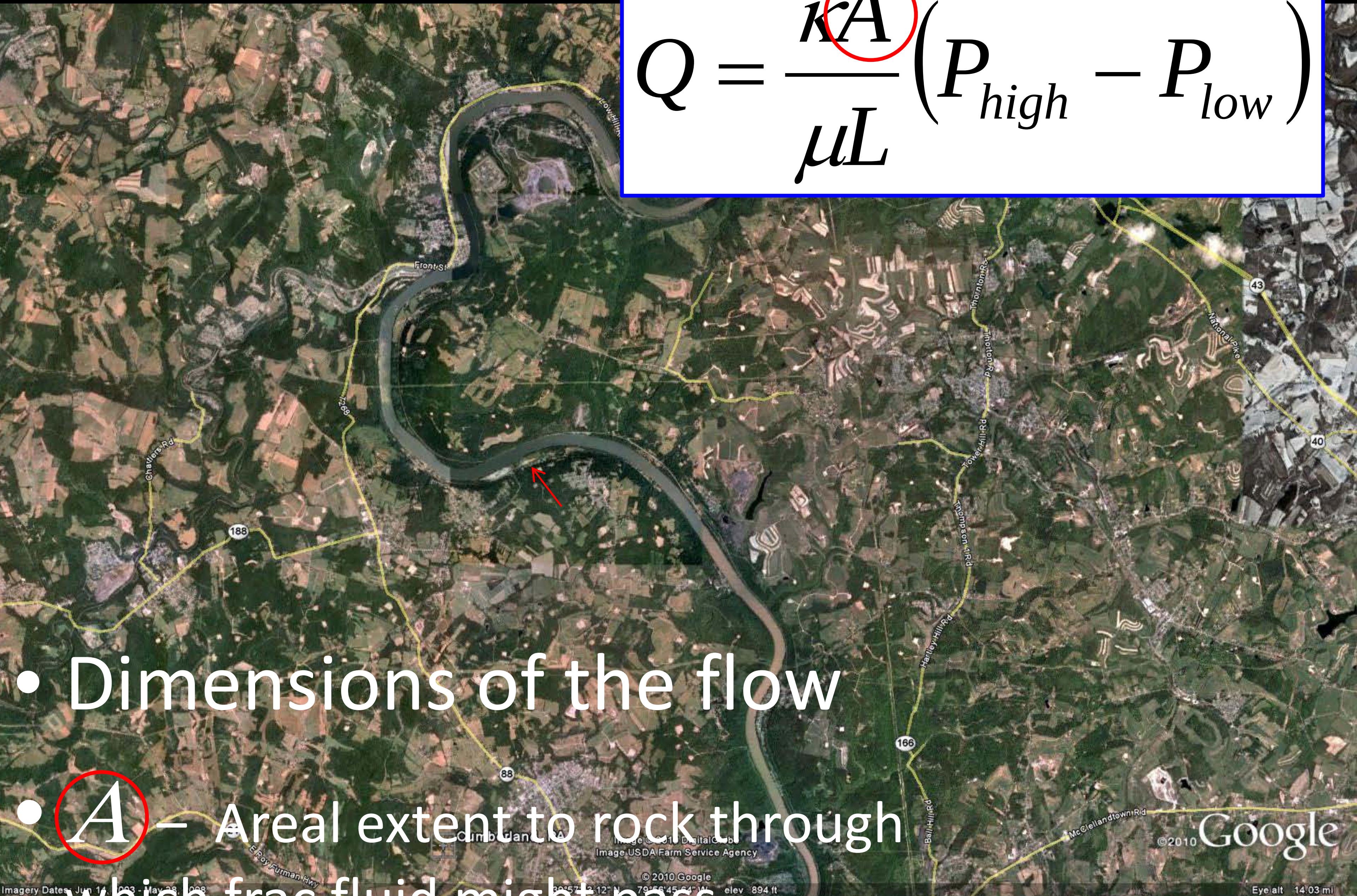
Fayette Anticline *Monongahela River*



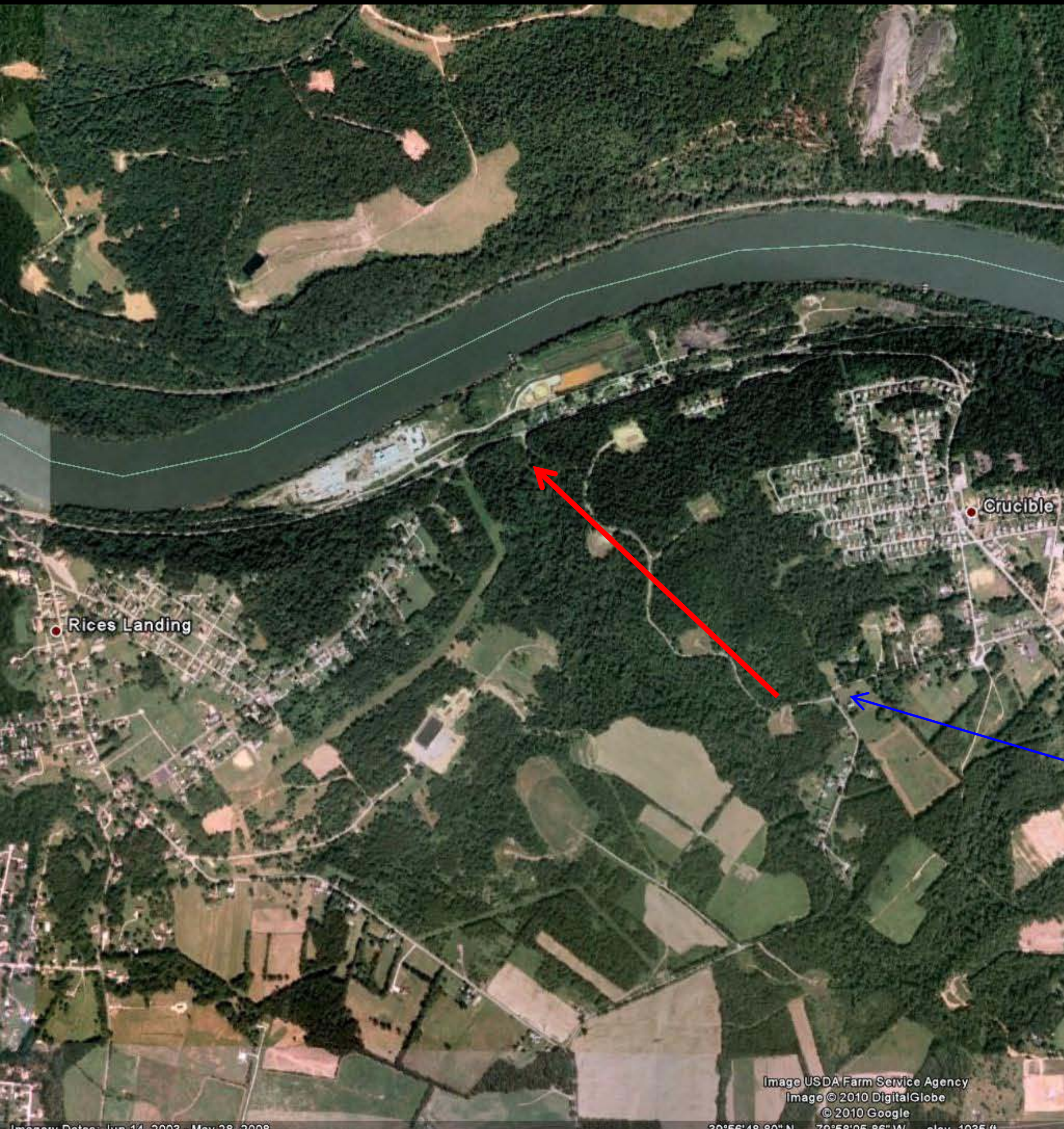
Looking South
Vertical Exaggeration > 10:1

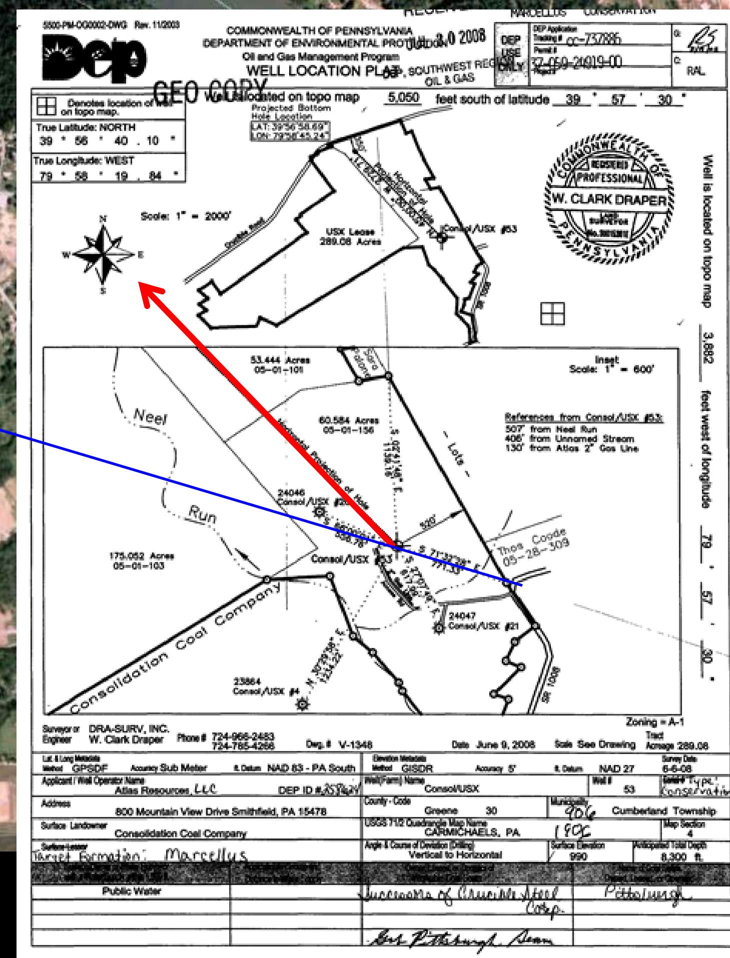
http://pubs.usgs.gov/circ/circ1139/pdf/circ1139.pdf

$$Q = \frac{\kappa A}{\mu L}\left(P_{high} - P_{low}\right)$$



- Dimensions of the flow
- A – Areal extent to rock through which frac fluid might pass.





5500-PM-OG0002-DWG Rev. 11/2003

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Oil and Gas Management Program
WELL LOCATION PLAT

JUL 30 2008
DEP, SOUTHWEST REGION OIL & GAS
GEO COPY
MARCELLUS CONSERVATION

DEP USE ONLY	DEP Application Tracking # cc-737886
	Permit # 37-059-24919-00

Denotes location of well on topo map.

True Latitude: NORTH 39 ° 56 ' 40 . 10 "

True Longitude: WEST 79 ° 58 ' 19 . 84 "

Well is located on topo map 5,050 feet south of latitude 39 ° 57 ' 30 "

Well is located on topo map 3,882 feet west of longitude 79 ° 57 ' 30 "

Projected Bottom Hole Location
LAT: 39°56'58.69"
LON: 79°58'45.24"

Scale: 1" = 2000'

USX Lease 289.08 Acres

Consol/USX #53

COMMONWEALTH OF PENNSYLVANIA REGISTERED PROFESSIONAL W. CLARK DRAPER LAND SURVEYOR PENNSYLVANIA

Inset Scale: 1" = 600'

53.444 Acres 05-01-101

60.584 Acres 05-01-156

175.052 Acres 05-01-103

References from Consol/USX #53:
507' from Neel Run
406' from Unnamed Stream
130' from Atlas 2" Gas Line

Neel Run

Horizontal Projection of Hole

Thos. Coode 05-28-309

Consolidation Coal Company

24046 Consol/USX #20

24047 Consol/USX #21

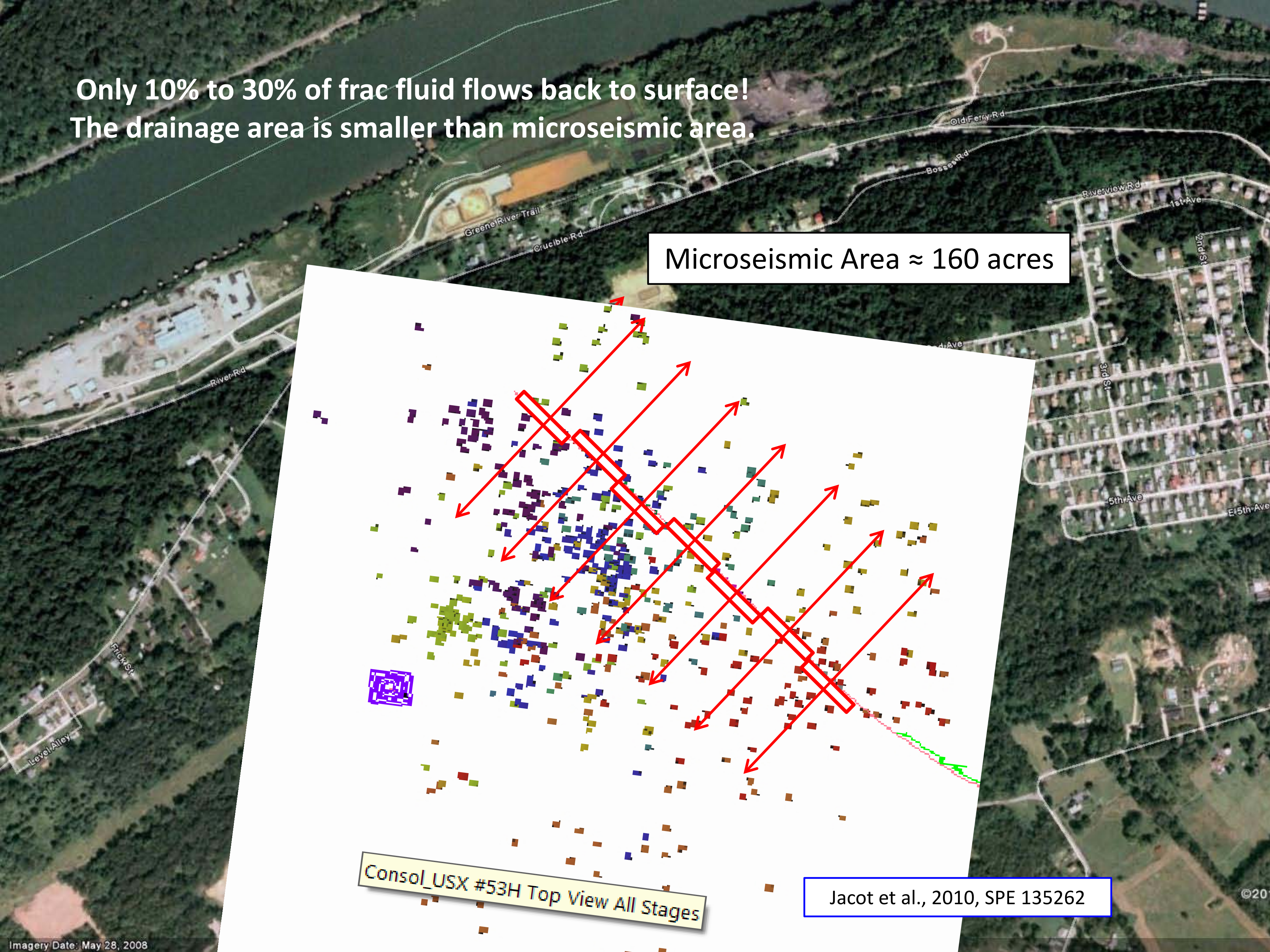
23864 Consol/USX #4

Zoning = A-1

Surveyor or Engineer: DRA-SURV, INC. W. Clark Draper
Phone # 724-966-2483 724-785-4266
Dwg. # V-1348
Date June 9, 2008
Scale See Drawing
Tract Acreage 289.08

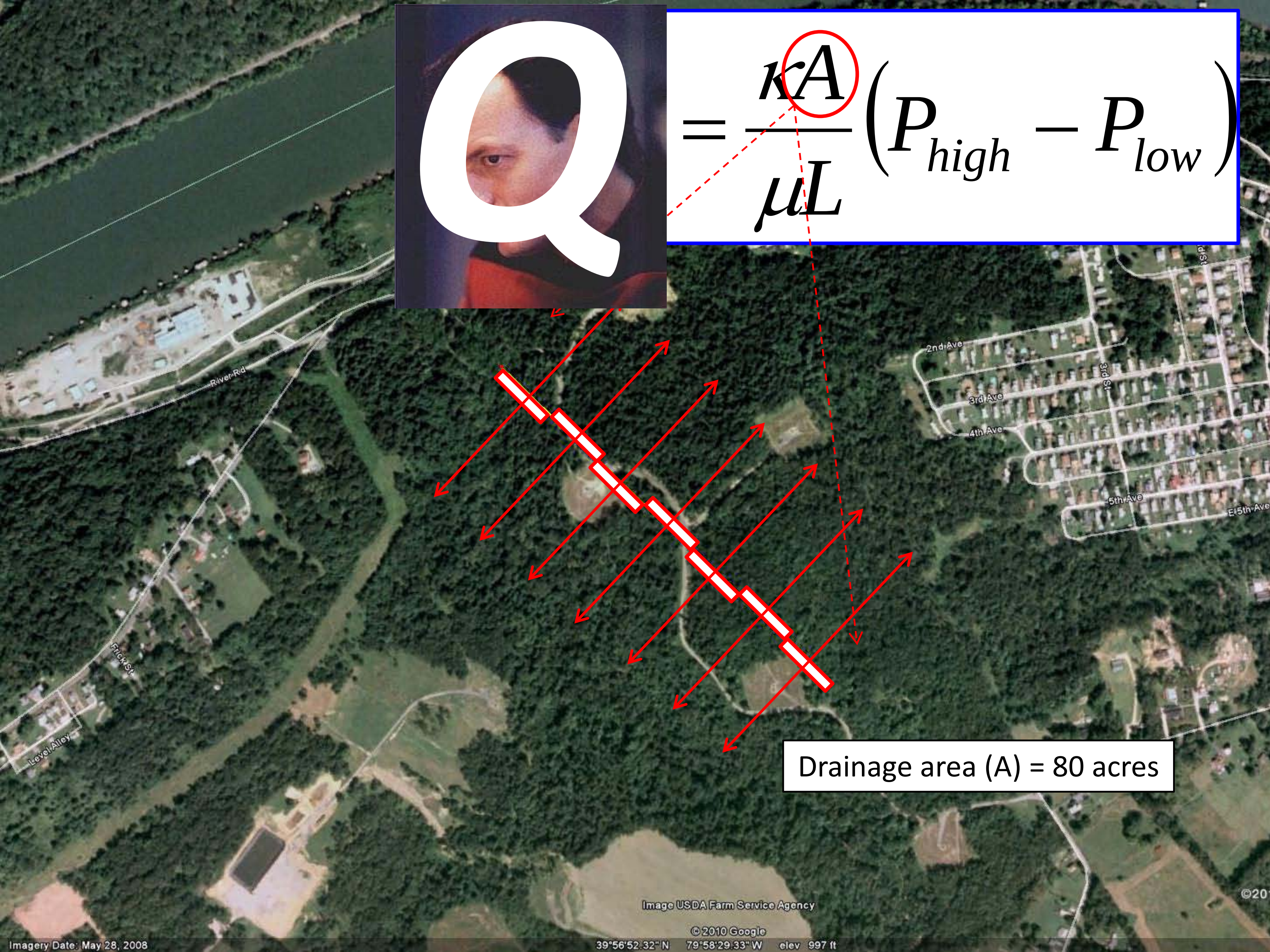
Lat & Long Metadata: Method GPSDF; Accuracy Sub Meter; Datum NAD 83 - PA South	Elevation Metadata: Method GISDR; Accuracy 5'; Datum NAD 27; Survey Date 6-6-08
Applicant / Well Operator Name: Atlas Resources, LLC; DEP ID #	Well (Farm) Name: Consol/USX; Well # 53; Type: Conservation
Address: 800 Mountain View Drive Smithfield, PA 15478	County - Code: Greene 30; Municipality: 906 Cumberland Township
Surface Landowner: Consolidation Coal Company	USGS 7 1/2 Quadrangle Map Name: CARMICHAELS, PA 190C; Map Section 4
Target Formation: Marcellus	Angle & Course of Deviation (Drilling): Vertical to Horizontal; Surface Elevation 990; Anticipated Total Depth 8,300 ft.

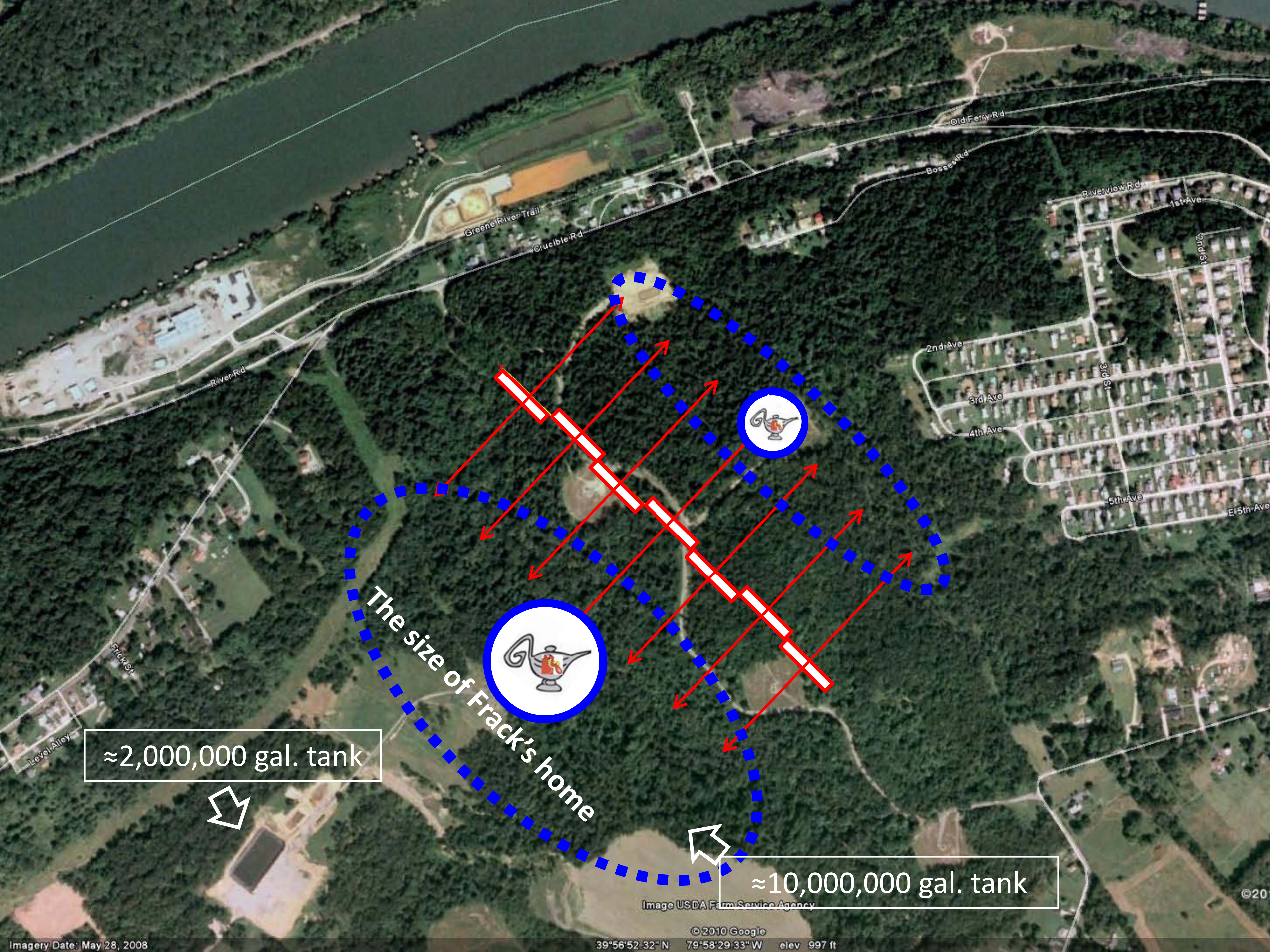
Public Water		Successors of Crucible Steel Corp.	Pittsburgh
		Gob Pittsburgh Seam	



Only 10% to 30% of frac fluid flows back to surface!
The drainage area is smaller than microseismic area.
Microseismic Area ≈ 160 acres
Consol_USX #53H Top View All Stages
Jacot et al., 2010, SPE 135262
Old Ferry Rd
Bosses Rd
Riverview Rd
1st Ave
Greene River Trail
Crucible Rd
2nd St
River Rd
3rd St
5th Ave
E 5th Ave
Frick St
Level Alley
Imagery Date: May 28, 2008

$$Q = \frac{\kappa A}{\mu L}\left(P_{high} - P_{low}\right)$$



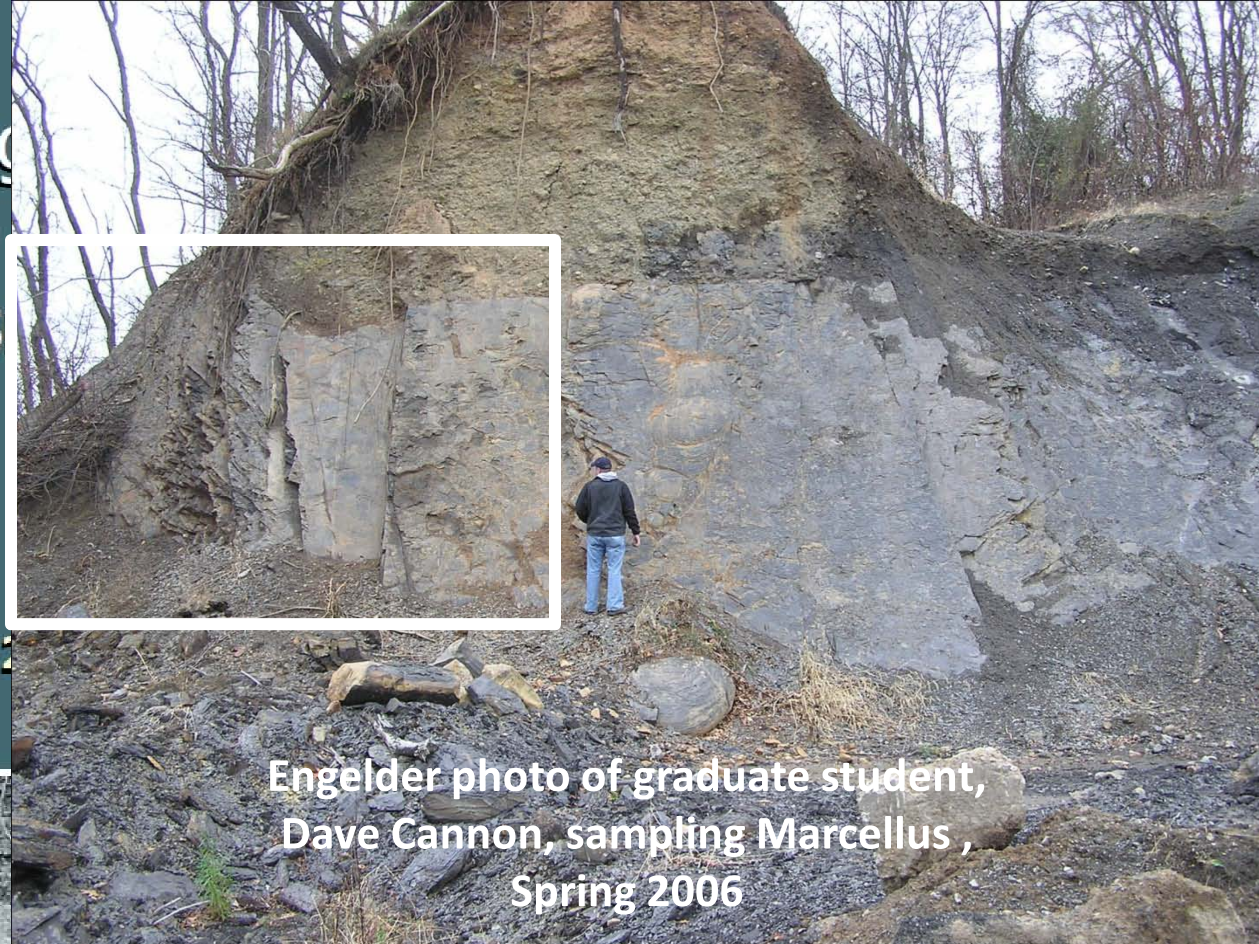


The size of Frack's home
≈2,000,000 gal. tank
≈10,000,000 gal. tank
Old Ferry Rd
Bosses Rd
Riverview Rd
1st Ave
2nd St
2nd Ave
3rd Ave
4th Ave
5th Ave
E 5th Ave
3rd St
Greene River Trail
Crucible Rd
River Rd
Frick St
Level Alley
Image USDA Farm Service Agency
© 2010 Google
Imagery Date: May 28, 2008
39°56'52.32" N 79°58'29.33" W elev 997 ft

New York City Department of Environmental Protection
www.nyc.gov/dep

Briefing
on the
Assess

December



Engelder photo of graduate student, Dave Cannon, sampling Marcellus , Spring 2006

Environmental Engineers & Scientists

Impact Assessment of Natural Gas Production in the New York City Water Supply Watershed

The essential quality of the

HAZEN AND SAWYER
Environmental Engineers & Scientists
A joint venture

FINAL IMPACT ASSESSMENT REPORT,

Impact Assessment of Natural Gas Production in the New York City Water Supply Watershed

December 2009

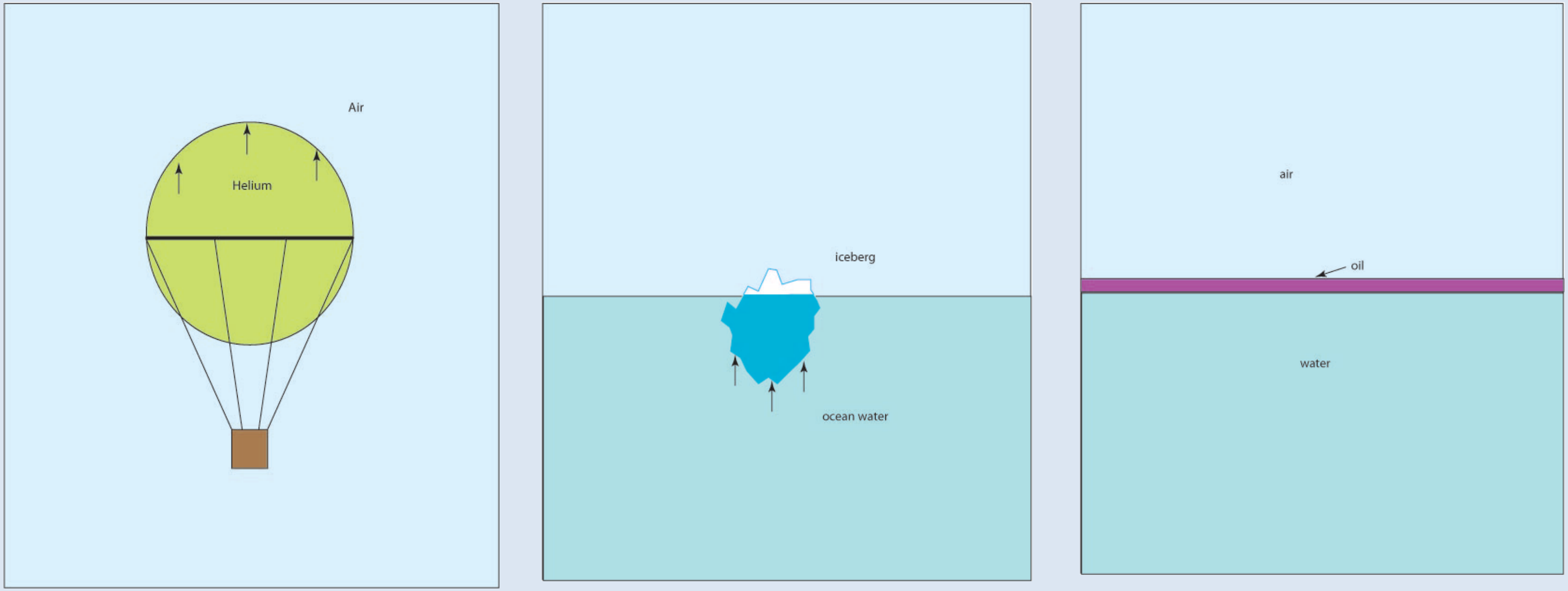
is captured in figure 4-1 on page 42.

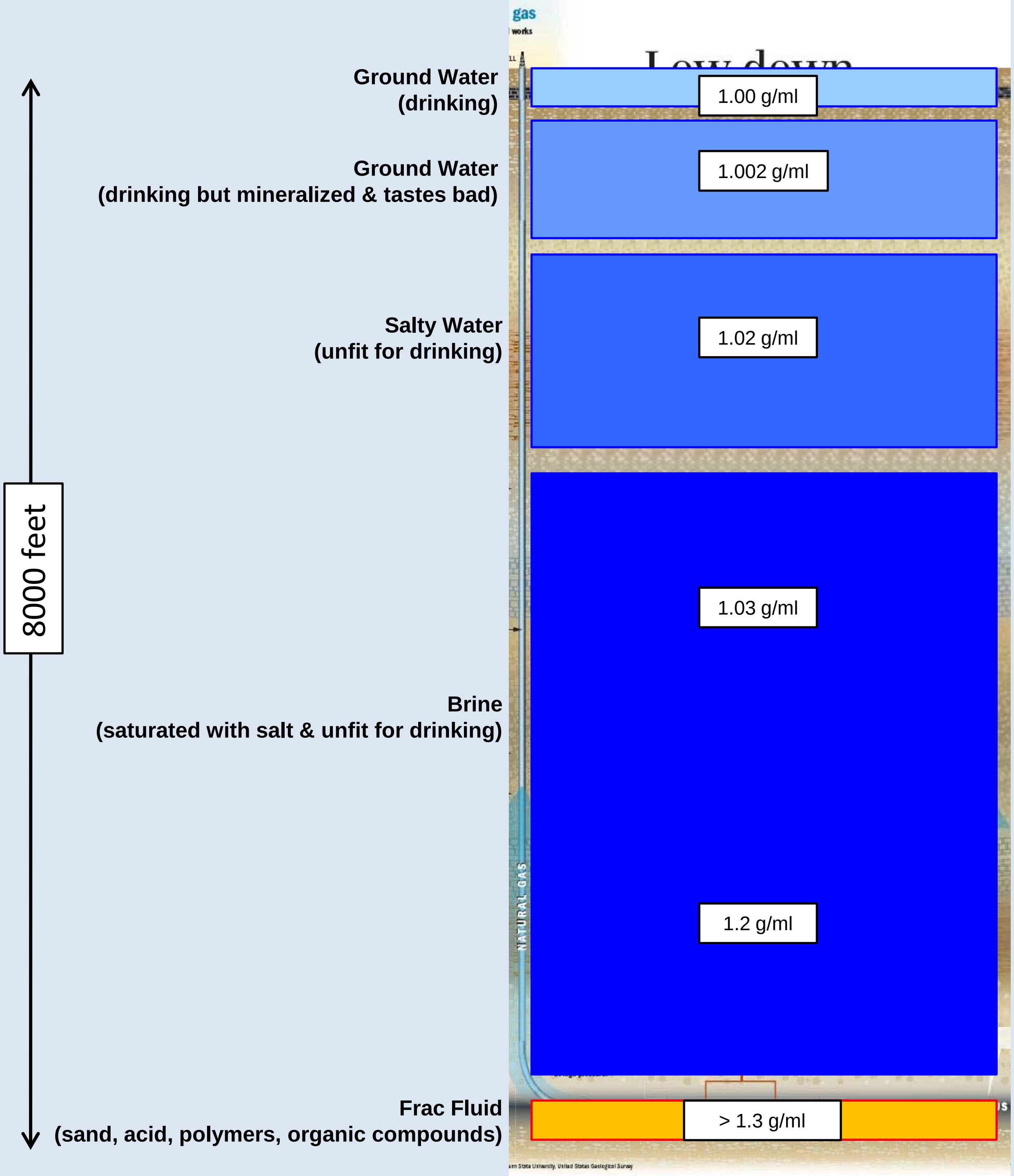
the TOP Ten!

Background for understanding Fig. 4-1:
Water within the earth is stratified by buoyancy

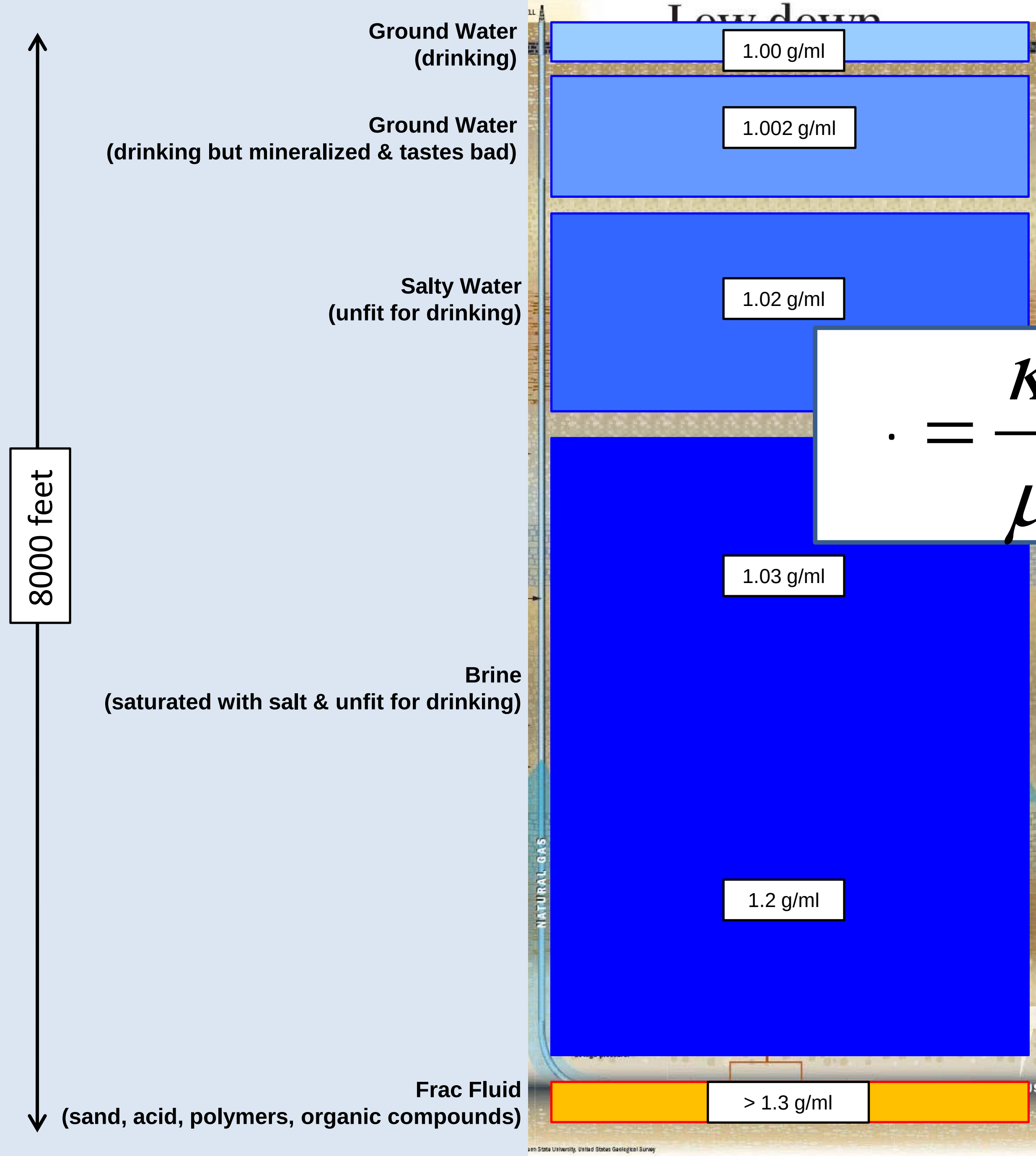
The Principle of Buoyancy

Lesson: Fluids stack by density with less dense fluids rising to the top.





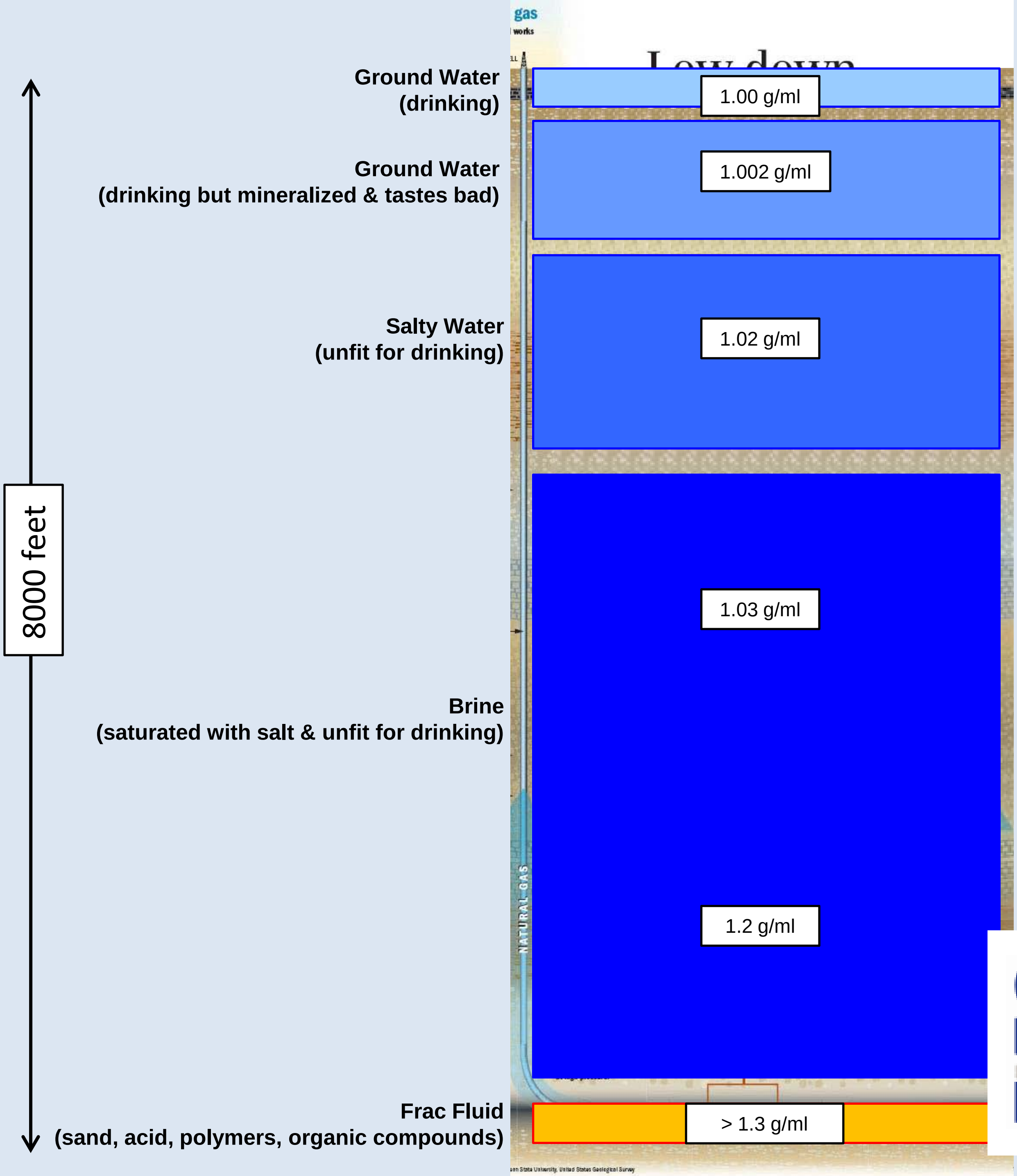
<u>Lesson</u>: Stacking of fluids by density is stable as indicated by the persistence of fresh water in wells.



Lesson: Force of Buoyancy does not operate when fluids in the Earth's outer crust stack by density.

$$\cdot = \frac{\kappa A}{\mu L}\underbrace{\left(P_{high} - P_{low}\right)}_{0}$$

This is a zero flow situation with no force to drive frac fluid to the surface!



Lesson: the long-term stability of density-stratified crust is one of the greatest assurances that frac fluid is not a threat to ground water.

Q to Zero

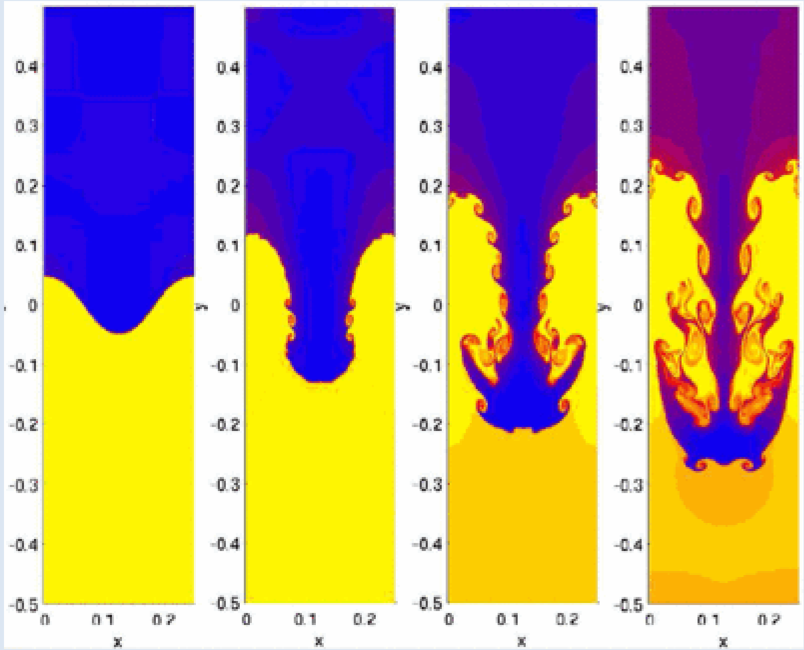
GROUNDWATER PROTECTION

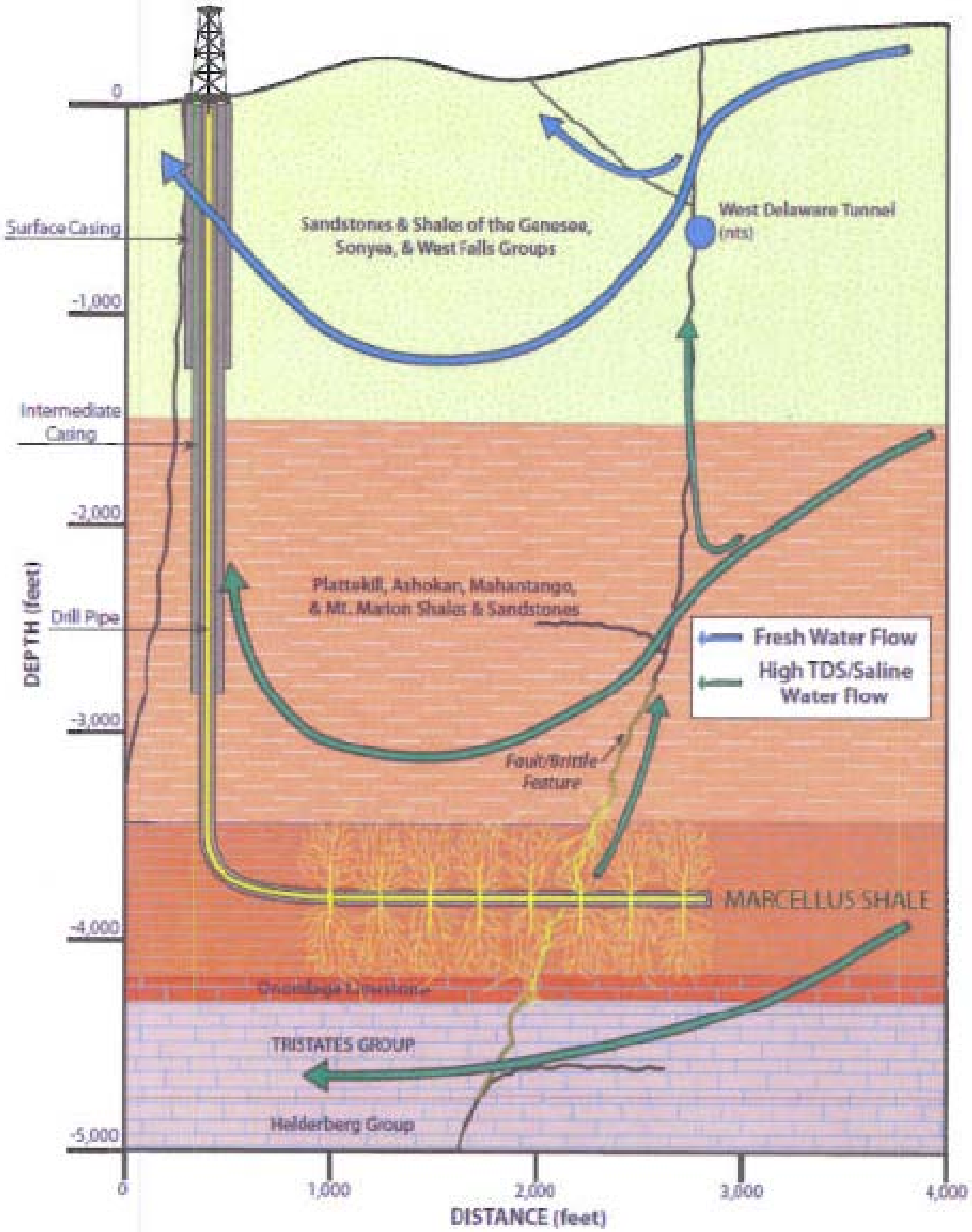
Another mechanism to achieve a stable density stratification

Rayleigh-Taylor instability

- gravity acts on a dense fluid above a fluid of lesser density.

This model is particularly applicable when moving fluids up a <u>fault</u> or <u>fracture</u> in the absence of an external pressure differential





<u>Technical Problems?</u>:

This is figure 4-1 on page 42 of the Hazen and Sawyer report

Impact Assessment of Natural Gas Production in the New York City Water Supply Watershed

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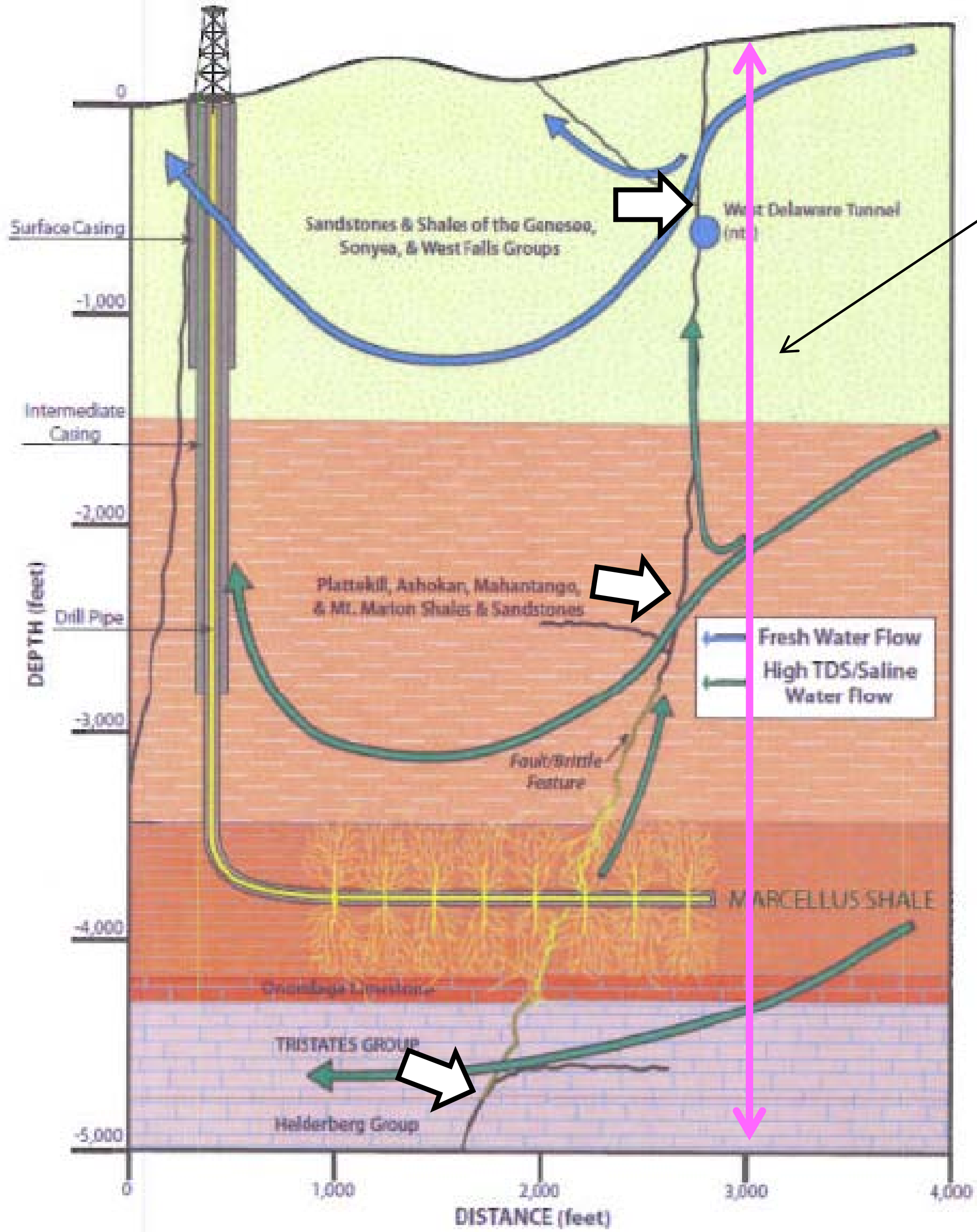

Why would there be upflow?

Technical Problem #1:

The use of lineaments as a basis for mapping crustal faults is extraordinarily controversial. Outside of the Clarendon-Linden fault zone of WNY, listric faults cutting the from the basement up through the Devonian section are extremely rare in outcrop!

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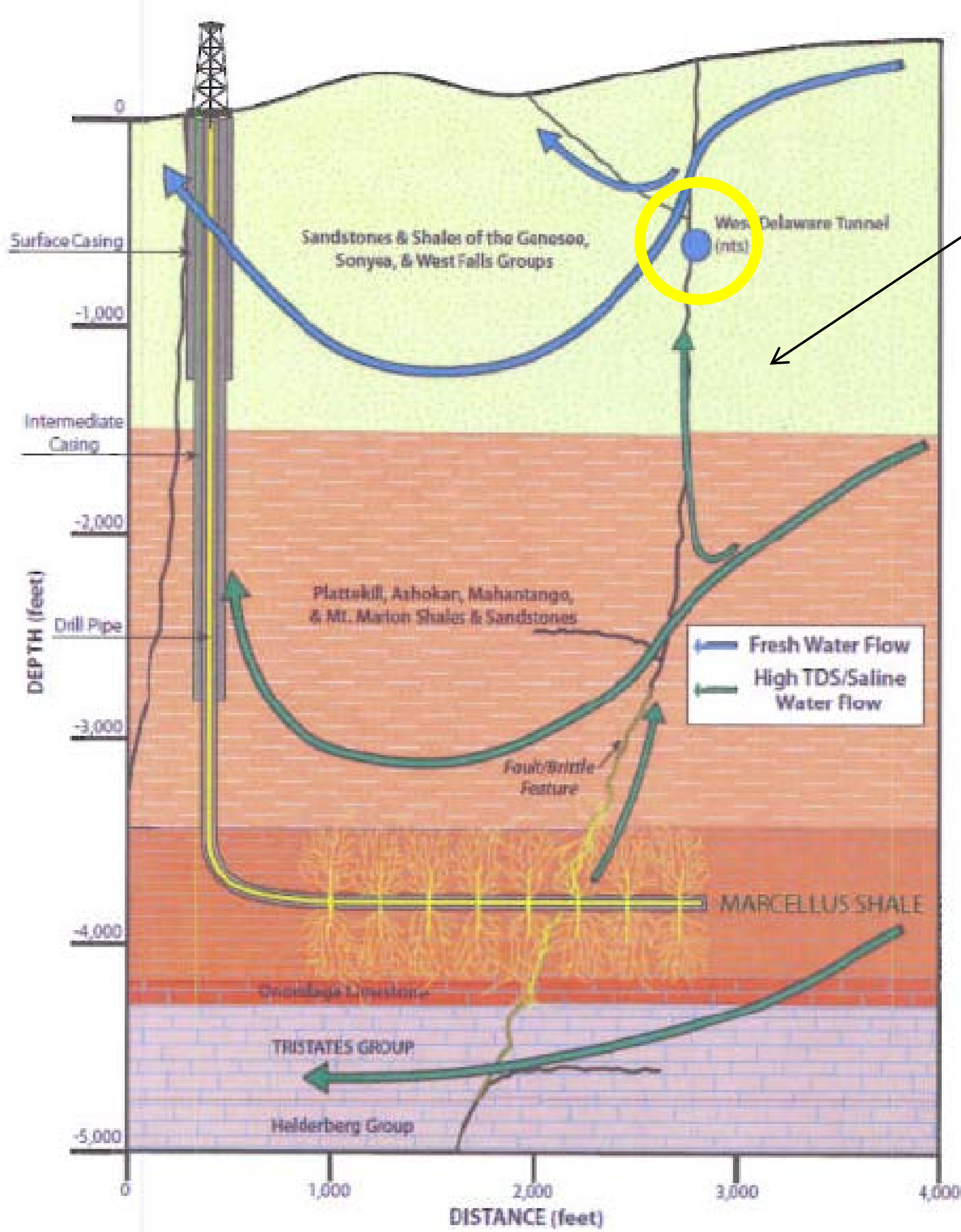

Why would there be upflow?

Technical Problem #2:

While it is true that the West Delaware Tunnel offers a depressed pressure head, to create an effective pressure difference on this scale the tunnel and fault must be co-axial. They are NOT!

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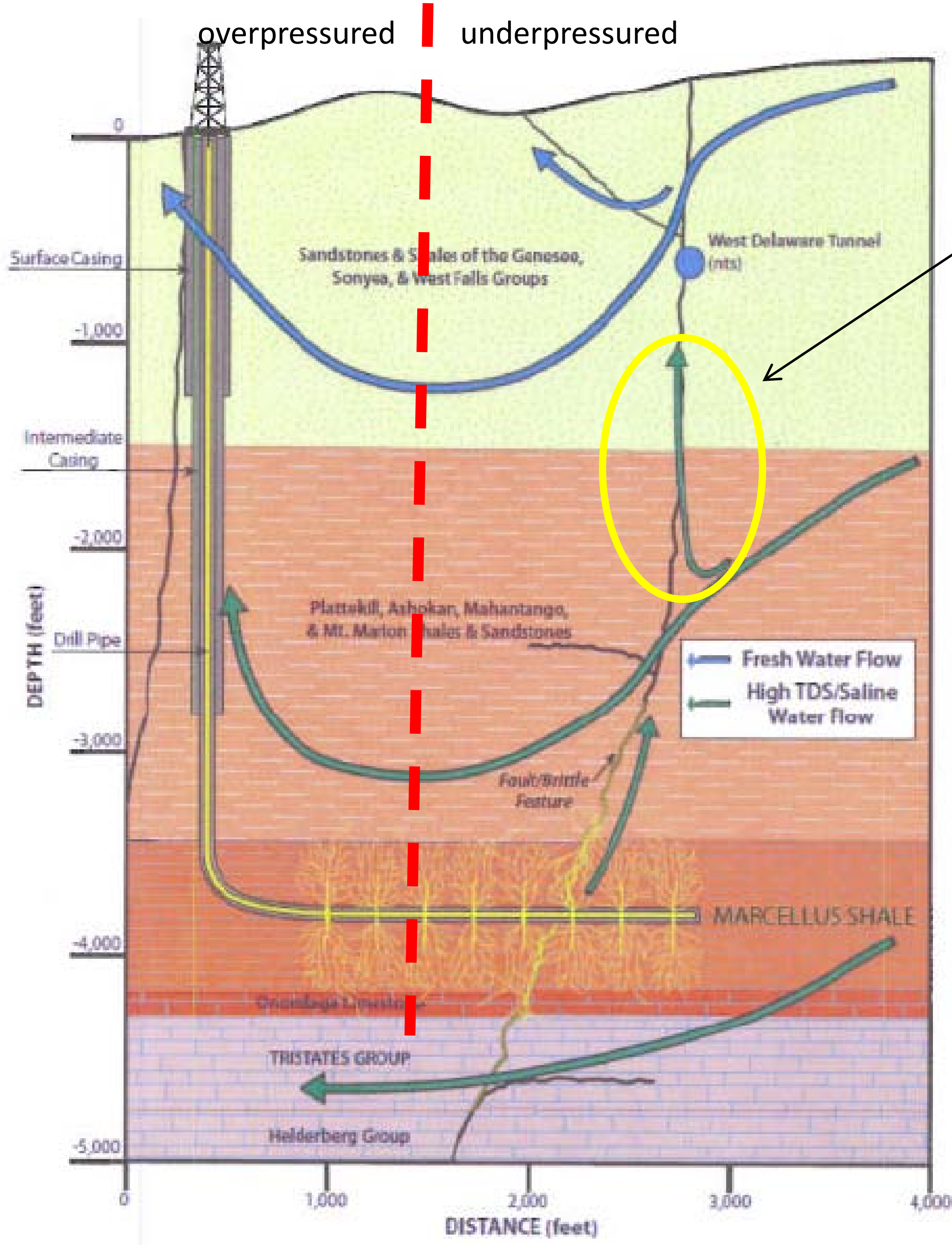

Why would there be upflow?

Technical Problem #3:

There is no artesian flow on the upstream side of regional streamlines because downflow is underpressured!

$$Q = \frac{\kappa A}{\mu L}\left(P_{high} - P_{low}\right)$$

points downward and away from ground water

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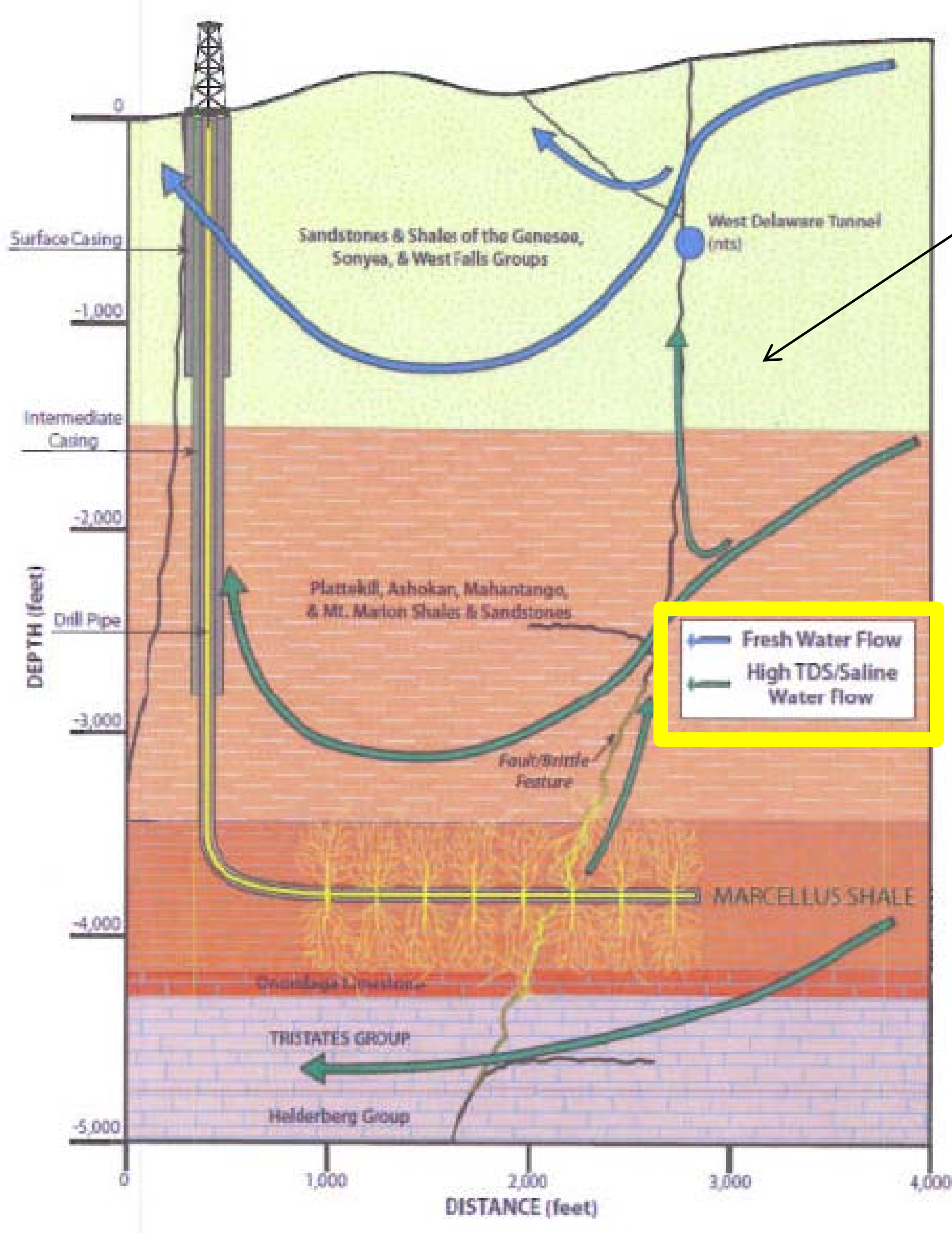

Why would there be upflow?

Technical Problem #4:

There is no buoyancy drive because high TDS/Saline is stable under fresh water!

$$\cdot = \frac{\kappa A}{\mu L}\left(\underbrace{P_{high} - P_{low}}_{0}\right)$$

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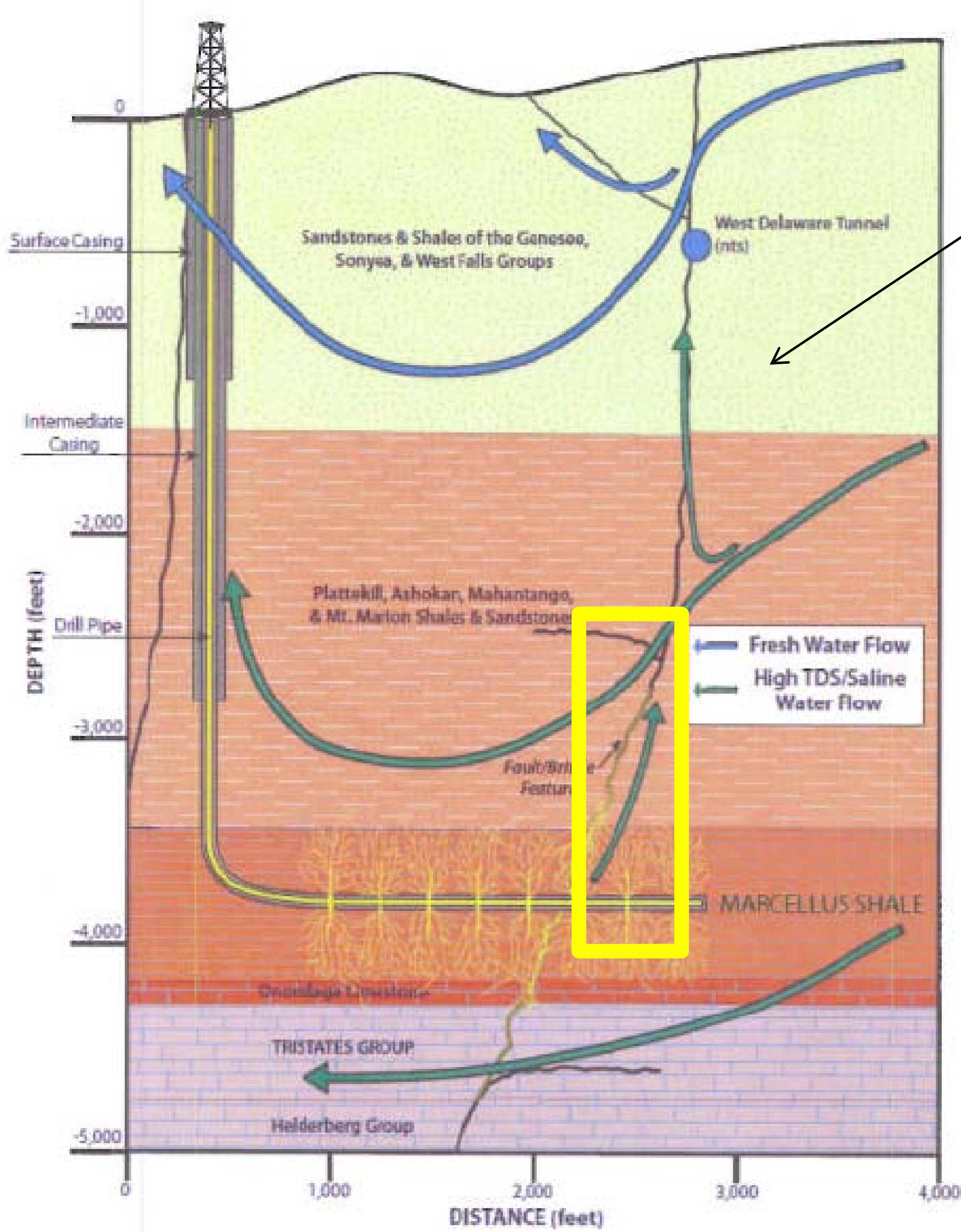

Why would there be upflow?

Technical Problem #5:

By the "*Principle of Viscosity*", if a low viscoisty gas can **NOT** migrate up the fault in 100s of millions of year, a high viscosity frac fluid is not going to do this it in a few generations.

$$\cdot = \frac{\kappa A}{\mu L}\left(P_{high} - P_{low}\right)$$

$\boldsymbol{\mu}$ large: ***Q*** small

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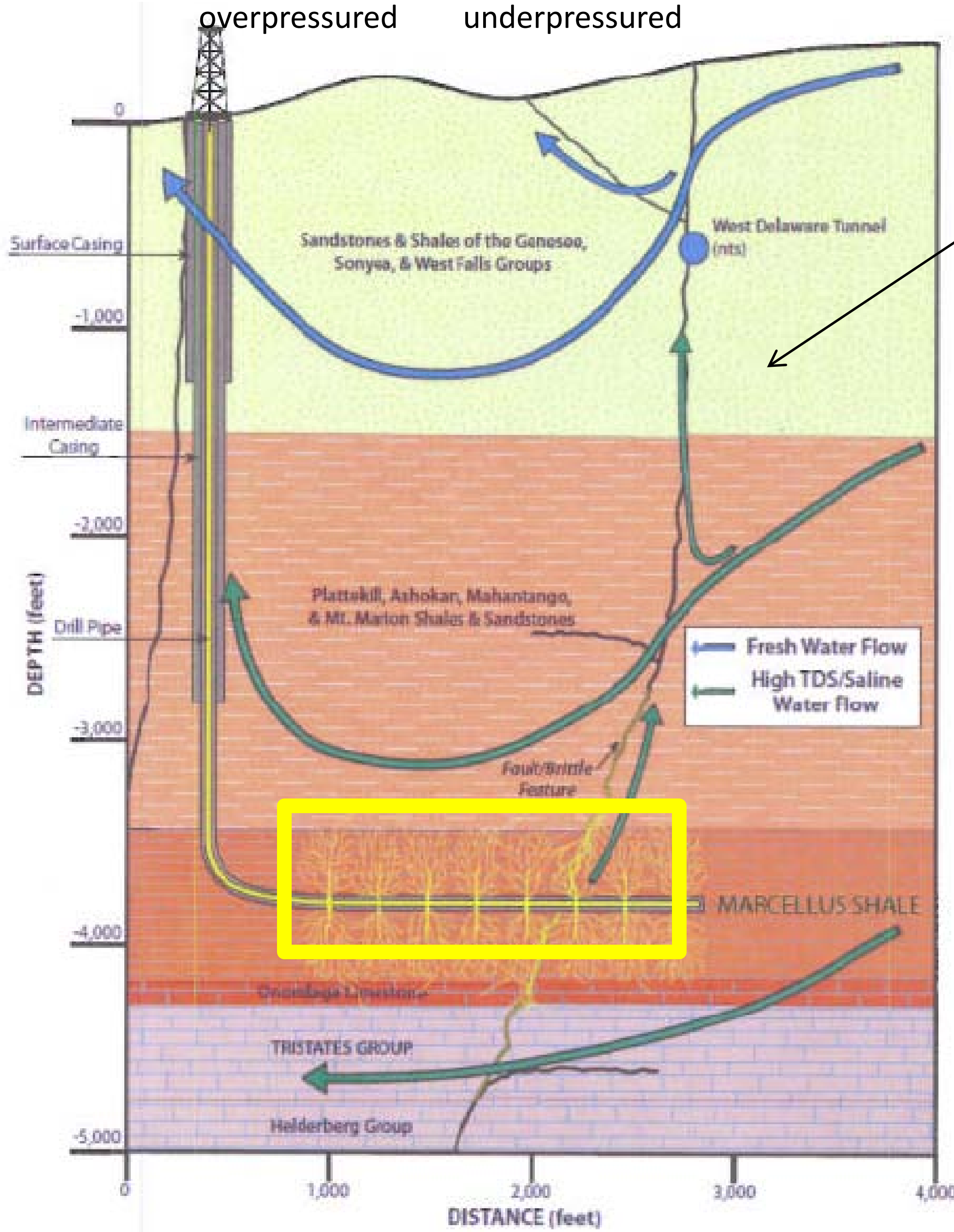

Technical Problem #6:

If seismic surveys show fracture stimulations confined in a zone under the Tully throughout PA, why should fracture stimulations under the NYC watershed fracture into overlying rock? Overlying shale is ductile enough to adsorb a 1% volume expansion in the Marcellus.

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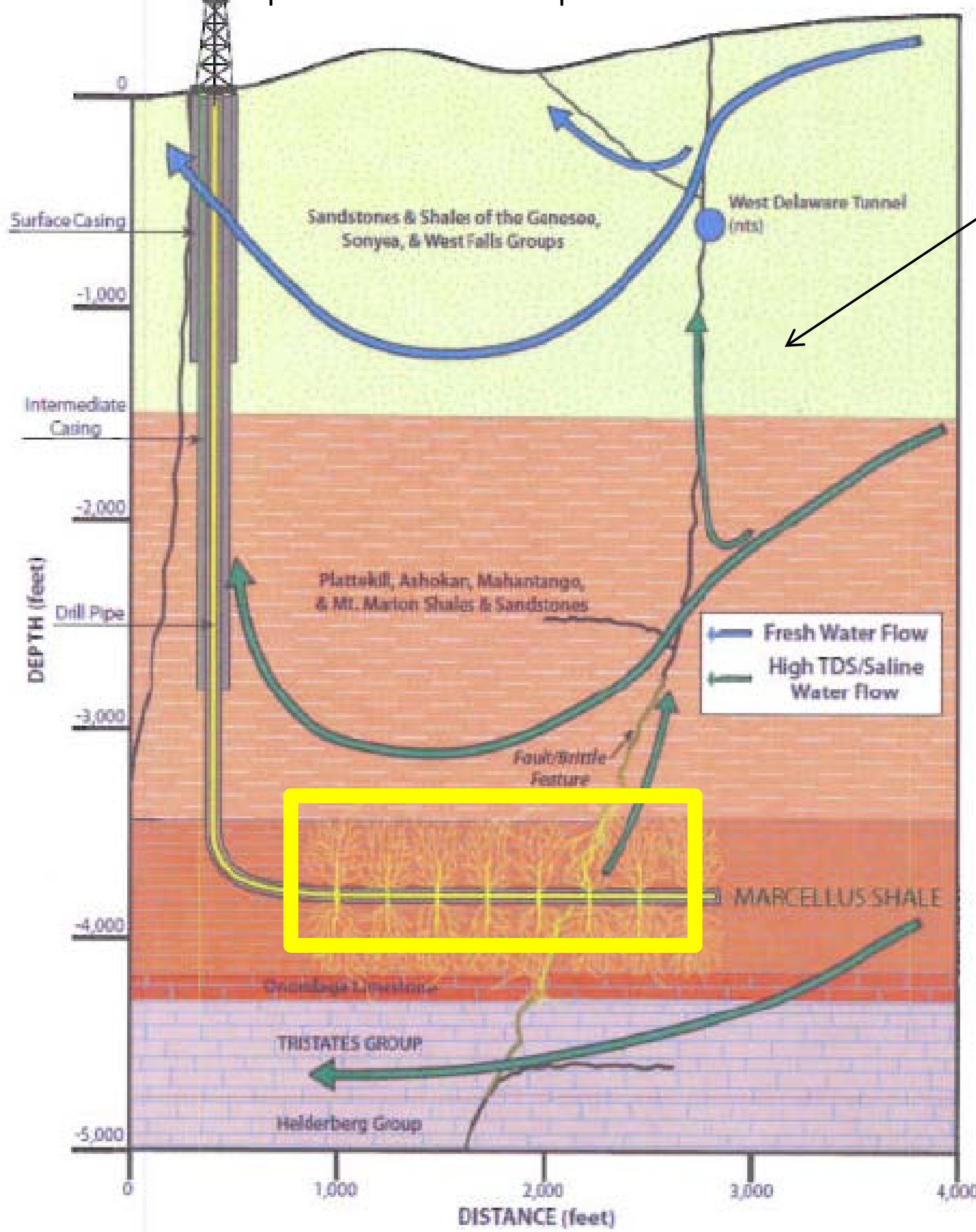
overpressured underpressured



Why would there be upflow?

Technical Problem #7:

Flowback immediately relieves any differentual pressure that the frac fluid may have had during stimulation

$$\cdot = \frac{\kappa A}{\mu L}\left(P_{high} - P_{low}\right)$$

0

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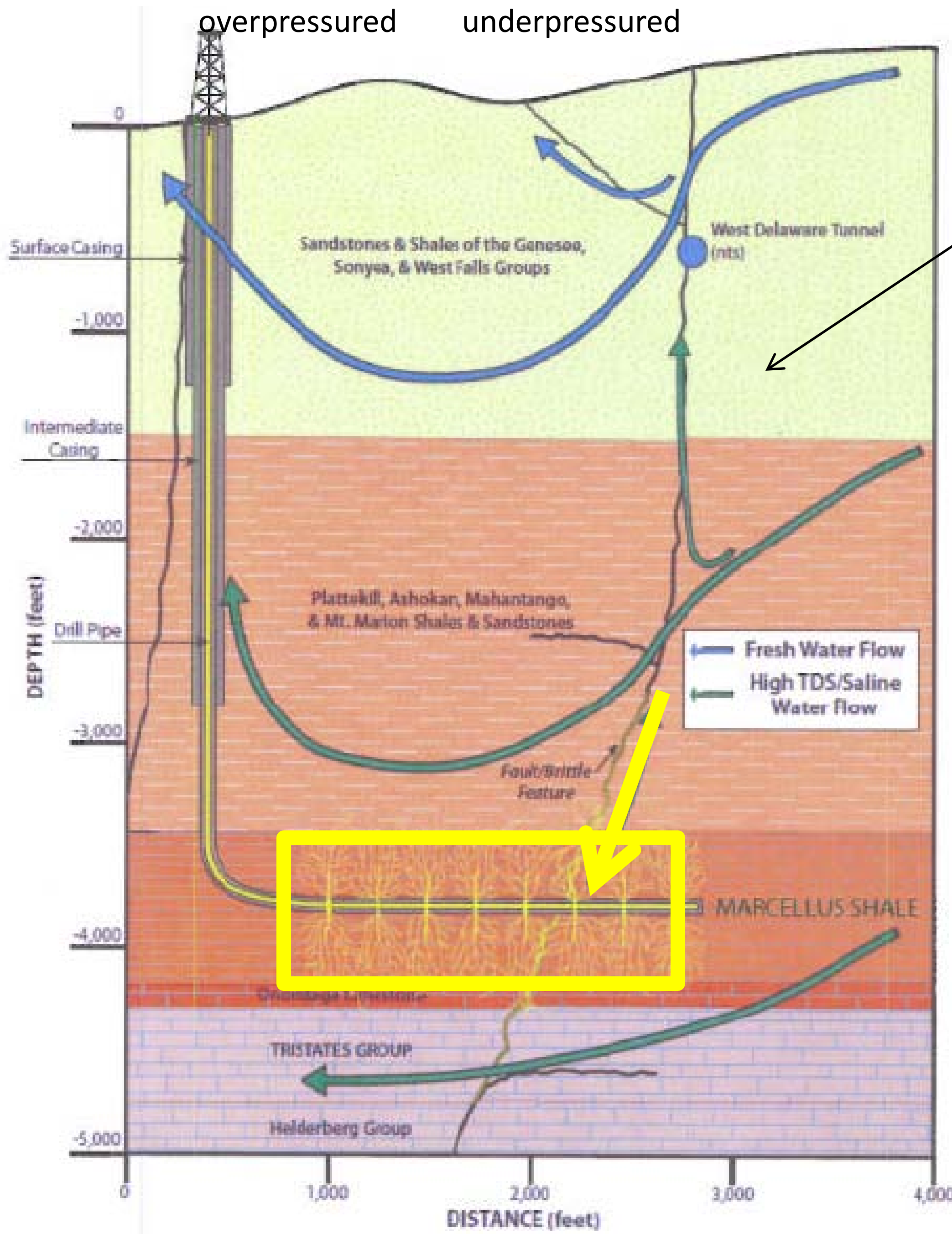

Why would there be upflow?

Technical Problem #8:

Production of gas leads to pressure reduction in the Marcellus and inward flow of fluids

$$Q = \frac{\kappa A}{\mu L}\left(P_{high} - P_{low}\right)$$

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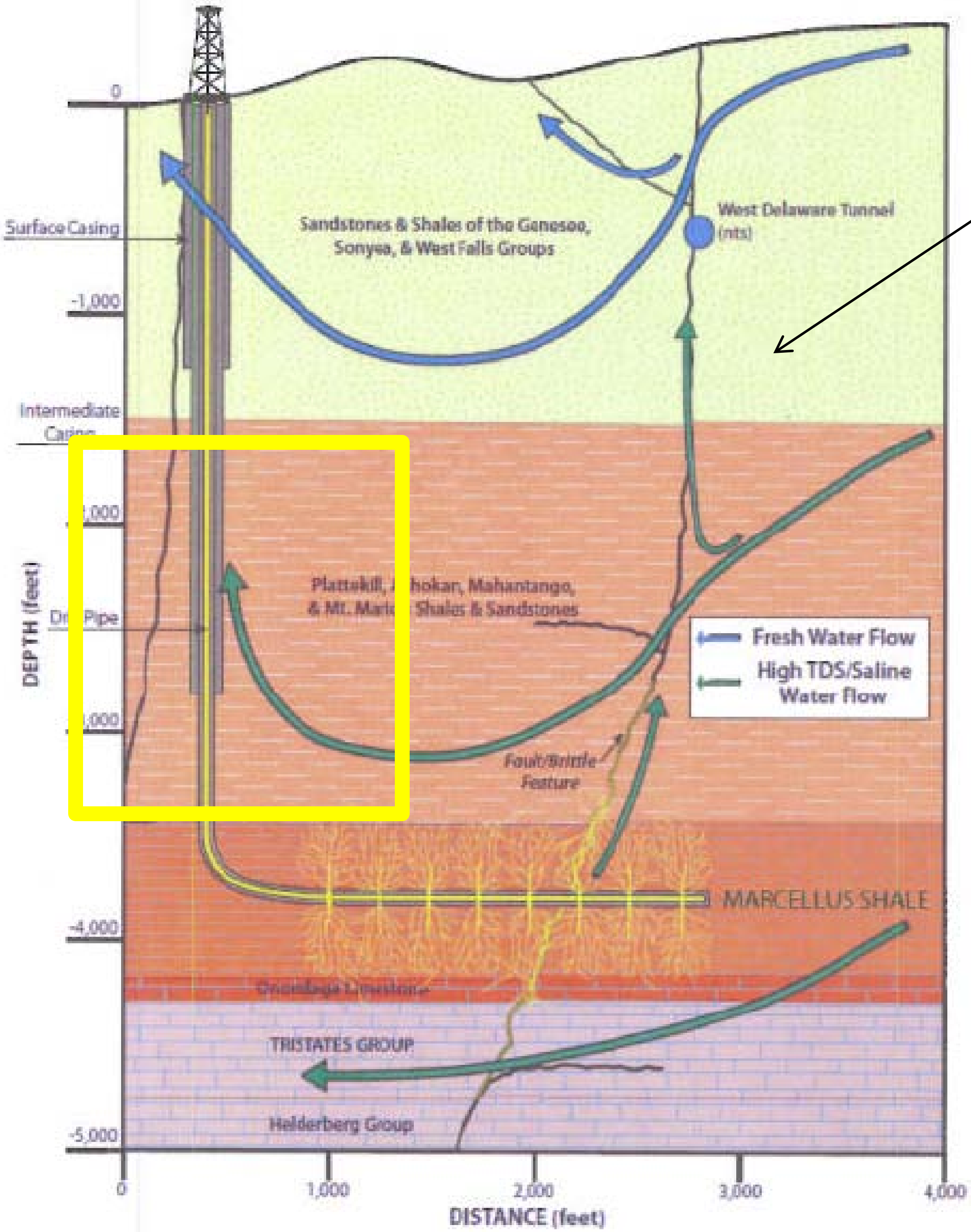

Why would there be upflow?

Technical Problem #9:

Ever seen an inverted cone of depression around a production well?

$$Q = \frac{\kappa A}{\mu L}\left(P_{high} - P_{low}\right)$$

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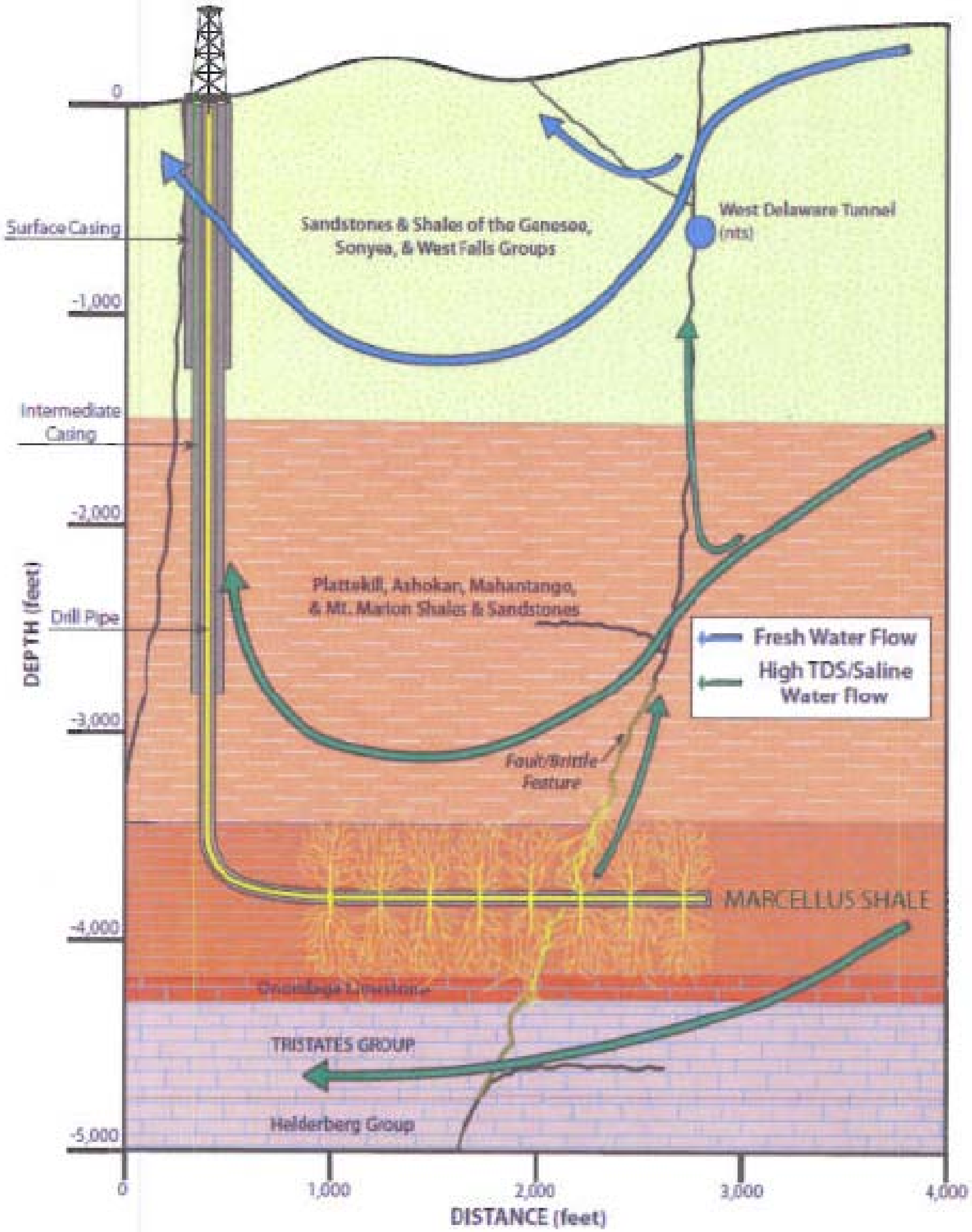

Technical Problem #10:

Cartoons like this are probably not a good idea, given the gravity of the issues at hand!

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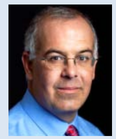
Punch Lines

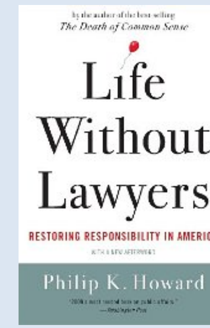
- This is an example of the science produced under the New York State moratorium on drilling and hydraulic fracturing in the Marcellus of the Southern Tier of the State.
- If moratoria lead to such science, there is no reason to conclude that they will be effective.
  - Why: operators can only learn by experience which is a collaboration among :

Landowners (especially those who carry an unfair burden), Regulators (DEP), Environmentalists (Riverkeeper), Taxers Collectors (Gov. Rendell), Media (the eyes & ears), Roughnecks (especially tough PA boys), and the policy markers (President Obama)!

Conclusions

The Responsibility Deficit
By DAVID BROOKS
Published: September 23, 2010





Howard acknowledges, but it is better to live in an imperfect world of individual responsibility than it is to live within a dehumanizing legal thicket that seeks to eliminate risk through a tangle of micromanaging statutes.

PA-DEP, Ohio DNR, Railroad Commission, etc regulate according to local conditions

EPA trying to keep Frac, the Genie, in his bottle when:

1. It can't be done by engineering
2. Nature (Darcy's Law) is doing the job anyway
3. EPA should be helping the States in dealing with Meth-Mud, the Genie that can be governed by engineering