Children's Environmental Health on the Border:
Protecting Children Where They Live, Learn, and Play

September 24-25, 2015
Texas Tech University Health Sciences Center – El Paso
El Paso, Texas

Health Impacts of Unconventional Petroleum Exploration on Children

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Southwest Center for Pediatric Environmental Health

PEHSU

Children's Environmental Health Symposium

This presentation was supported by the American College of Medical Toxicology (ACMT) and funded (in part) by the cooperative agreement award number 1 U61TS000238-01 from the Agency for Toxic Substances and Disease Registry (ATSDR).

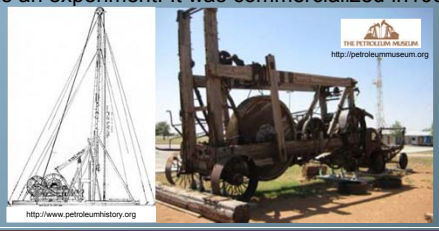
Acknowledgement: The U.S. Environmental Protection Agency (EPA) supports the PEHSU by providing partial funding to ATSDR under Inter-Agency Agreement number DW-75-92301301-9. Neither EPA nor ATSDR endorse the purchase of any commercial products or services mentioned in PEHSU publications.

Objectives

- Define unconventional petroleum exploration
- Discuss the actual and potential physical and chemical risks to children from increased drilling activity
- Discuss the risks of negative impact on drinking water
- Describe the possible prenatal health concerns
- Identify issues related to environmental justice
- Discuss the need for application of the precautionary principle

Conventional drilling, early 20th century

- Cable tool rig
- Vertical well
- Hydraulic fracturing initiated in 1947, when it began as an experiment. It was commercialized in1950.



What is unconventional petroleum exploration?

- Directional drilling
  - The practice of controlling the direction and deviation of a wellbore to a predetermined underground target or location. (www.petrowiki.org)
- Hydraulic fracturing – "fracking"
  - The creation of fractures within a reservoir that contains oil or natural gas to increase flow and maximize production…fluid is pumped down the well at pressures that exceed the rock strength, causing open fractures to form in the rock. (www.epa.gov)

Hydraulic fracturing ("fracking") A to Z

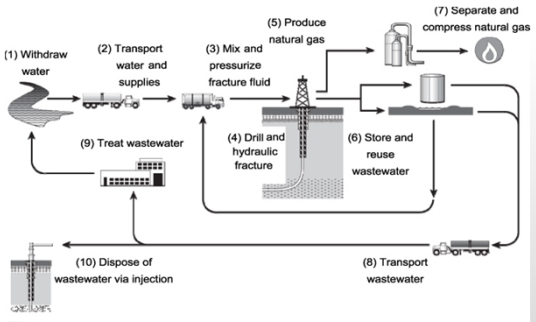
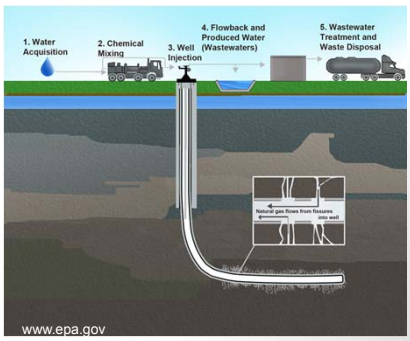
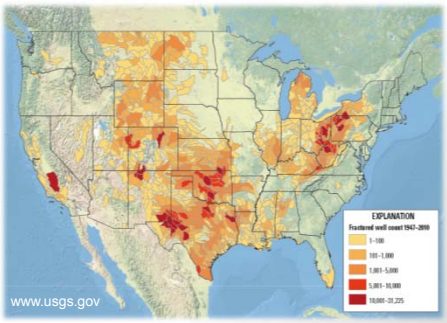


Figure 1 from Estimation of regional air-quality damages from Marcellus Shale natural gas extraction in Pennsylvania Aviva Litovitz et al 2013 Environ. Res. Lett. 8 014017 doi:10.1088/1748-9326/8/1/014017

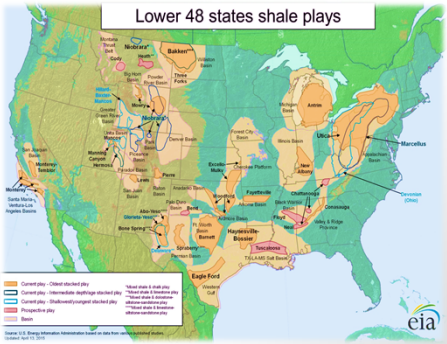
How is hydraulic fracturing ("fracking") done?



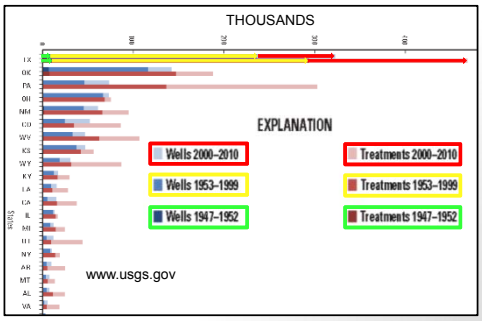
Where is fracking common?



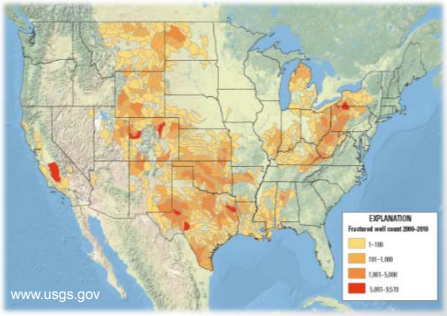
Shale plays



Fracking has gone on for 70 years. Why talk about it now?



Hydraulic fracturing activity 2000-2010



Physical risks

Increased traffic = increased accidents

- An estimated 2300 to 4000 truck trips per well are needed for transport of fracking fluids
- Death toll in Texas fell for decades until the boom in fracking
- 2009 – 2013
  - Traffic fatalities rose 8%
  - Deaths linked to commercial crashes rose by >50%
- In North Dakota, population increased 43% and traffic fatalities increased 350% over the last decade.
- Consequences
  - Parental death and disability
  - Child injuries & deaths

http://www.npr.org/; October 12, 2014
http://www.huffingtonpost.com/; May 5, 2015

Increased traffic = increased accidents

http://www.usgs.com

Increased traffic = increased accidents

- Inexperienced drivers
- Poor road conditions
  - Not adapted, deterioration
  - Unsafe passing
- Fatigue (long shifts, boring scenary)
- Drug use (stimulants/sedatives)
- Alcohol use

Photo: Texas Department of Public Safety

http://www.npr.org/; October 12, 2014
http://www.huffingtonpost.com/; May 5, 2015

Increased traffic = increased accidents

- "The fracking boom has led to congestion, crumbling pavement and potholes, and fatal accidents in counties where drilling is most active."
- Specifically, TxDOT has estimated that maintaining infrastructure impacted by the drilling boom will cost $4 billion dollars a year

Fracking Effects on Texas Rural Public Transit Research Project Statement 16-6, FY16 Annual Program, TX DOT

Large truck-related fatalities

Quick Facts 2013

Early Release** DOT HS 812 100 12/2014

Large Trucks

Fatalities in Crashes Involving Large Trucks	
2013	3,964
2012	3,944
2011	3,781

Source: FARS

People Injured in Crashes Involving Large Trucks	
2013	95,000
2012	104,000
2011	88,000

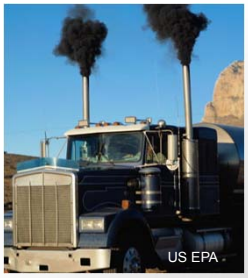
Source: GES

Percent of Fatalities in Crashes Involving Large Trucks by Person Type			
	Truck Occupants	Occupants of Other Vehicles	Nonoccupants
2013	17%	71%	11%
2012	18%	72%	10%
2011	17%	72%	11%

Source: FARS

Increased traffic = Increased pollutants

- More diesel vehicles
  - Drilling rigs
  - Compressors
  - Tractor tankers
  - Mud trucks
- More dust due to poor road conditions



Increased traffic = Increased pollutants

- Respirat
  - Bernst affic related air poll risk factors for whe ly childhood. Furthe re long-term effects oment of asthm

Table. AORs (95% CIs) for ECAT exposure levels and wheezing without a cold adjusted for sex, race, maternal smoking, child care attendance, breast-feeding, pet ownership, and visible mold in the home[21]

Exposure to ECAT (μg/m³)	AOR (95% CI)
0.2	1.00 (reference)
0.3	1.23 (1.01-1.50)
0.4	1.51 (1.01-2.26)
0.5	1.86 (1.02-3.39)
0.6	2.29 (1.03-5.09)
0.7	2.82 (1.04-7.65)
0.8	3.46 (1.05-11.40)
0.9	4.26 (1.06-17.2)

AORs, adjusted odds ratios; CIs, confidence intervals; ECAT, elemental carbon attributable to traffic.

  - Ghio 2012 - Inflammation after diesel exhaust and DEP exposure is evident at higher concentrations only; there appears to be a threshold dose for DEPs approximating 300μg/m

Increased traffic = Increased pollutants

- Respiratory illness in children
  - Darrow 2014 – Results suggest that primary traffic pollutants, ozone, and the organic carbon fraction of PM2.5 exacerbate upper and lower respiratory infections in early life, and that the carbon fraction of PM2.5 is a particularly harmful component of the ambient particulate matter mixture.
  - Gass 2015 - Adverse associations with pediatric asthma were observed for 8-day exposure to particles generated from diesel-fueled vehicles

Increased traffic = Increased pollutants

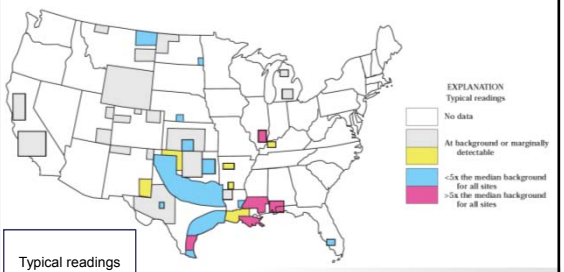
- Effects on pregnant women and fetus
  - Wu 2011
    - Elevated risk for preeclampsia, pre-term birth and very preterm birth associated with traffic-related air pollution exposures

Potential for exposure to radionuclides

- Naturally Occurring Radioactive Material (NORM) is found in:
  - Produced water
  - Sludge
  - Pipe scale
- EPA considers NORM a hazard mostly to site workers
- Typically contains:
  - Radium-226
  - Radium-228
  - Radon and daughters
  - Uranium
- Risk to children depends on:
  - Dose*, proximity, duration
  - Internal contamination
- Paraoccupational exposures?

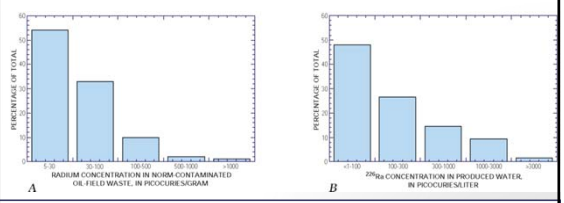
www.poison.org

How "hot" is NORM?



Typical readings for NORM wastes
USGS Fact Sheet FS–142–99
September 1999

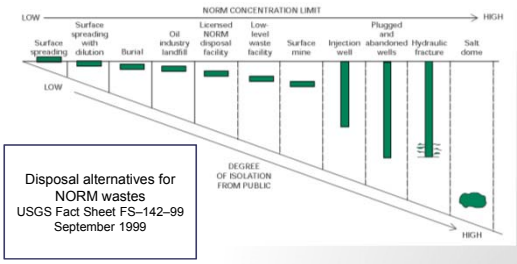
How "hot" is NORM?



Estimated distribution of radium concentration in:
A) Solid oil field waste and B) produced water
USGS Fact Sheet FS–142–99
September 1999

What does one do with radioactive waste?

No US government regulations



Disposal alternatives for NORM wastes
USGS Fact Sheet FS–142–99
September 1999

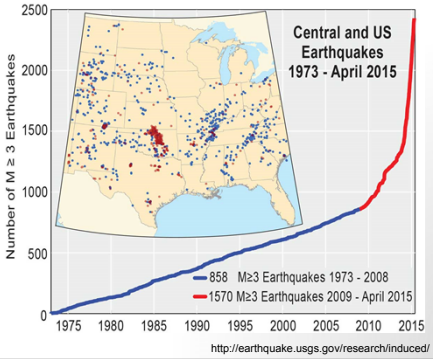
What should one NOT do with radioactive waste?

Radioactive 'Oil Socks' Found Illegally Stockpiled In Abandoned North Dakota Gas Station - 2013

- "In the past, some contaminated piping and other scrap metal have been **used inadvertently by schools and other organizations for playground equipment**, welding material, fencing, etc. because this contaminated metal was recycled before it was found to be contaminated."

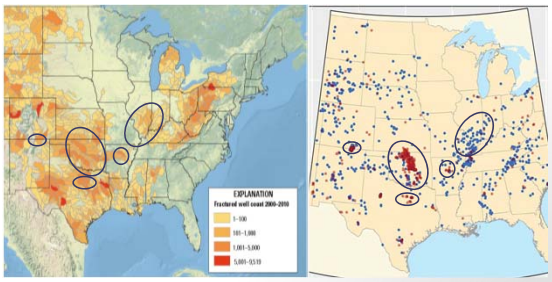
https://www.ndhealth.gov/aq/rad/norm.htm

Earthquakes: A strange coincidence?



http://earthquake.usgs.gov/research/induced/

Earthquakes: A strange coincidence?



http://earthquake.usgs.gov/research/induced/

Earthquakes: A strange coincidence?

- 11/2011 – Oklahoma State officials referring to a series of 3 earthquakes including a 5.7 tremor that was Oklahoma's largest ever, near Prague, OK:
  - **"an act of nature, and it was nobody's fault."**

http://www.nytimes.com

Earthquakes: A strange coincidence?

- 5/2014 - Robert Williams, research geophysicist with the USGS Earthquake Hazards Program on OK quakes:
  - "But we know from other cases around the world that if you have an increasing number of small earthquakes, the chances of a larger one will go up."
- 5/2015 – CEO of ConocoPhillips Ryan Lance:
  - "We've followed all the data and the evidence and it does appear that in some areas water disposal is creating seismic events. We're trying to understand how widespread it is."

http://www.thefiscaltimes.com

Earthquakes: A strange coincidence?

- "Fracking causes small earthquakes, but they are almost always too small to be a safety concern... The injection of wastewater into the subsurface can cause earthquakes that are large enough to be felt and may cause damage."
- There are more than 50,000 disposal wells in Texas servicing more than 216,000 active drilling wells, according to the Railroad Commission

http://www.usgs.gov/faq/categories/9833/3428

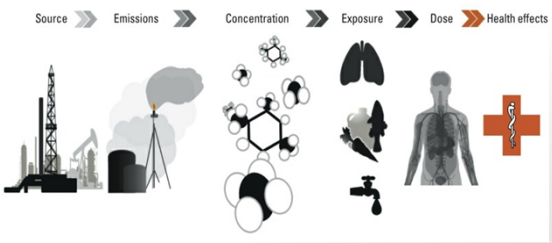
Earthquakes: A strange coincidence?

- "How large are the earthquakes induced by fluid injection?"
  - "Of the case histories for which there is a scientific consensus that in injection operation induced earthquakes, the largest are magnitude*5."
- "Is there any possibility that a wastewater injection activity could interact with a nearby fault to trigger a major earthquake that causes extensive damage over a broad region?"
  - "So far, there is no conclusive example linking injection operations to triggering of major earthquakes, however we cannot eliminate this possibility."

http://www.usgs.gov/faq/categories/9833

Chemical constituents in unconventional gas exploration

Chemical exposures from oil and gas exploration



Shonkoff SB, Hays J, Finkel ML. Environmental public health dimensions of shale and tight gas development. Environ Health Perspect. 2014 Aug;122(8):787-95.

Chemical constituents in oil and gas exploration

- What goes in…
  - Methanol
  - Isopropanol
  - Crystalline silica
  - Ethylene glycol monobutyl ether
  - Ethylene glycol
  - Hydrotreated light petroleum distillates
  - Sodium hydroxide
  - Variably 1000 others
  - Water!
- What comes out…
  - Flowback water
  - Produced water
    - 2.4 billion gal/day
    - Brine
    - NORM
    - Metals
    - Ionic constituents
    - Total dissolved solids
  - Methane
  - Hydrogen sulfide
  - VOC

http://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=244651

U.S. House of Representatives, Committee on Energy & Commerce. "Chemicals used in hydraulic fracturing." April 2011

Chemical constituents in oil and gas exploration

EPA : 1076 chemicals used in hydraulic fracturing fluids

- Acetaldehyde
- Acrylamide
- Benzene
- Diesel
- Diethanolamine
- Ethylbenzene
- Formaldehyde
- Hydrogen chloride
- Hydrogen fluoride
- Lead
- Naphthalene
- Phthalic anhydride
- Toluene
- Xylene

U.S. House of Representatives, Committee on Energy & Commerce. "Chemicals used in hydraulic fracturing." April 2011

Chemical air contaminants

Hydrogen sulfide (H_2S)

- Acute, potentially fatal to children
  - Sastre 2013 – Household sewer, mother & infant
  - Claudet 2012 – Manure tank submersion 13y
  - Maebashi 2011 – 17 suicides, including 16y, 18y
  - Oesterhelweg 2007 – Case series including child of 3y, from manure
  - Nikkanen 2004 – 16 y employee of fish hatchery
- Acute-on-chronic, non-fatal
  - South Karelia Air Pollution Study: 1992 – 1996 Community near pulp mill

Hydrogen sulfide (H_2S)

- Chronic Respiratory
  - Guidotti 2010 - Not clear whether prolonged or repeated exposure is associated with chronic respiratory impairment
  - Bates 2015 - No evidence of reductions in lung function, or increased risk of COPD or asthma, from recent or long-term H2S exposure at the relatively high ambient concentrations found in Rotorua

Hydrogen sulfide (H_2S)

- Chronic Neurological
  - Guidotti 2010 – Evidence remains weak for effects associated with chronic, low level exposure.
  - Reed 2014 - The results provide evidence that chronic H2S exposure, at the ambient levels found in and around Rotorua, is not associated with impairment of cognitive function.

Volatile Organic Compounds

- Benzene and hematological cancers
  - Duarte-Davidson 2001 – "Any risk of leukemia at concentrations of exposure in the general population of 3.7 – 42 mcg/m3 is likely to be exceeding small."
  - Pyatt 2010 – "The collective literature does not indicate that exposure to environmental levels of benzene is related to an increased risk of childhood leukemia."
  - Talbott 2011- Study of gasoline tank spill implicating low level benzene exposure and cancer risk.

Volatile Organic Compounds

- Benzene and hematological cancers
  - Heck 2014 - Risk of ALL and AML were increased with 3rd trimester exposure to benzene (among other chemicals)
  - Macey 2014 - Benzene, formaldehyde, and hydrogen sulfide commonly exceed acute and other health-based risk levels near oil and gas production

Pollutants exceed safety guidelines

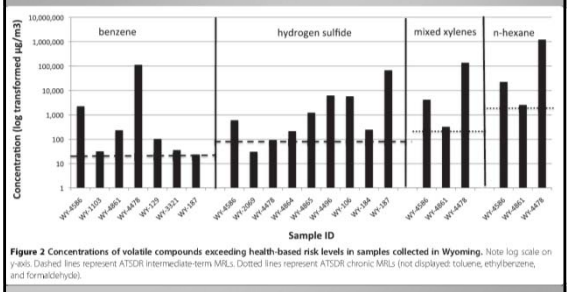


Figure 2 Concentrations of volatile compounds exceeding health-based risk levels in samples collected in Wyoming. Note log scale on y-axis. Dashed lines represent ATSDR intermediate-term MRLs. Dotted lines represent ATSDR chronic MRLs (not displayed: toluene, ethylbenzene, and formaldehyde).

Macey 2014 Environ Health 13, 82

Zoning issue? What zoning issue?

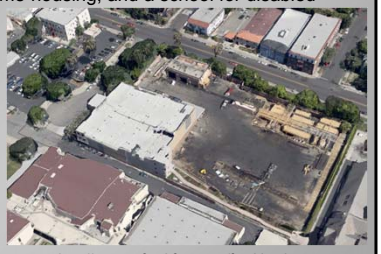
David McNew – Getty Images

Environmental Justice Issues

- Wells are drilled where the oil companies have leased mineral rights
- In many cases, this occurs near rental properties of the rural or urban poor
- For example, recent reports estimate that 70% of the 5,194 active oil wells in LA are located within 1500 feet of sensitive land use areas like homes, schools, and hospitals.
- Sixty-seven percent of Angelenos who live within a quarter mile of an oil or gas well are Hispanic/Latino http://www.cafrackfacts.org/fracking-in-california/urban-oil-extraction/

Environmental Justice Issues

- AllenCo site in South LA,flanked by Mount St. Mary's College, low-income housing, and a school for disabled adults.
  - Nearby residents complain of respiratory problems, nosebleeds, headaches, nausea, and other symptoms.
  - The site was temporarily shut down by the EPA and AllenCo fined $99000.



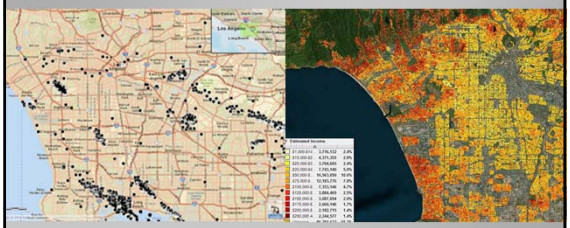
http://www.cafrackfacts.org/fracking-in-california/urban-oil-extraction/

Environmental Justice Issues

- One commonly thinks of petroleum production as occurring strictly in rural areas. This is not the case, as is seen in this map of oil wells in Los Angeles.
  - Additional studies of health effects of petroleum production are needed

http://www.cafrackfacts.org/fracking-in-california/urban-oil-extraction/

Environmental Justice Issues



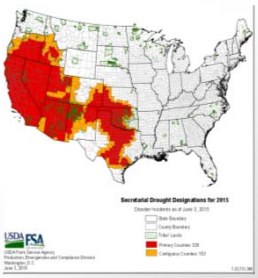
http://www.cafrackfacts.org/fracking-in-california/urban-oil-extraction/

Censusviewer.com

Water, water everywhere but…

Fresh water use

- Fracking requires 2 to 10 million gallons/well
- In TX Barnett Shale, ~50% of water usage in 2006 was for fracking
- In TX Eagle Ford Shale, fracking could account for 89% of total water use in peak production
- 1/2001-9/2012: 25,450 wells reported using 65.8 billion gallons of water – the annual need for 2.5 million Americans



Richardson J. "Water Scarcity: Who's the Gorilla in the Room?" USDA Outlook, 2015, Texas A&M University

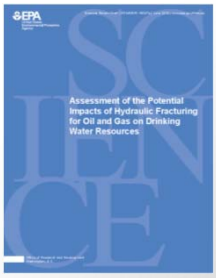
Contamination of aquifers and surface water

- On-site releases
- Leaking vessels
- Illegal dumping
- Insufficient waste removal
- Leaks from injection wells
- Leaks in drilling well casings

www.businessinsider.com

Water use and production from hydraulic fracturing

- Released 6/5/2015 for public comment
- Addresses
  - Fracking process
    - Water acquisition
    - Chemical mixing
    - Well injection
    - Flowback & produced water
    - Wastewater treatment & waste disposal
    - ID and hazard evaluation of chemicals across the cycle
  - Drinking water resources



http://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=244651

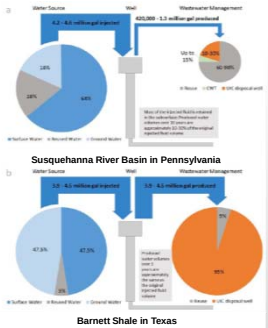
Water use and production from hydraulic fracturing

- 2000-2014: 25-30K new wells drilled and hydraulically fractured
- 2000-2013: ~9.4 million people and 6,800 drinking water sources serving 8.6 million people within 1 mile of a hydraulically fractured well.
- Fracking in at least 25 states; top 4 for numbers of wells:
  - Texas
  - Colorado
  - Pennsylvania
  - North Dakota
- Fracking used on average 44 billion gal of water/y in 2011-2012 (<1% TL)
  - ≥10% in 6.5% of counties
  - ≥30% in 2.2% of counties
  - ≥50% in 1.0% of counties
- Vast majority is fresh water
- Southern and western Texas:
  - Hydraulic fracturing water use, low water availability, drought, and reliance on declining ground water has the potential to affect the quantity of drinking water resources.

http://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=244651

Water use and production from hydraulic fracturing

- Eastern wells tend to use more surface water and a larger percentage of reused water
- 60 to 90% of produced water is reused
- Western wells use more groundwater
- About 5% of produced water is reused and the remainder injected in deep wells



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Water use and production from hydraulic fracturing

- "Of the potential mechanisms identified in this report, we found specific instances where one or more mechanisms led to impacts on drinking water resources, including contamination of drinking water wells. The number of identified cases, however, was small compared to the number of hydraulically fractured wells."

http://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=244651

Summary

- The enormous increase in unconventional drilling activity has augmented the risk of physical injury, toxic exposures, and water scarcity/quality issues for children, though reported injuries are, to date, few.
- Diesel emissions, hydrogen sulfide, and volatile organic compounds are only a few of the many potential toxic effluents contributing to air pollution
- Exposures in children have been insufficiently studied, conclusions about causality remaining elusive
- Efforts should be made to minimize risks through expansion of alternative fuel sources, engineering controls to minimize exposures, and enhanced environmental regulations and compliance efforts

Southwest Center for Pediatric Environmental Health

TEXAS TECH UNIVERSITY HEALTH SCIENCES CENTER - EL PASO

Education-Research-Patient Care Beyond Borders

QUESTIONS?

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PEHSU Pediatric Environmental Health Specialty Units