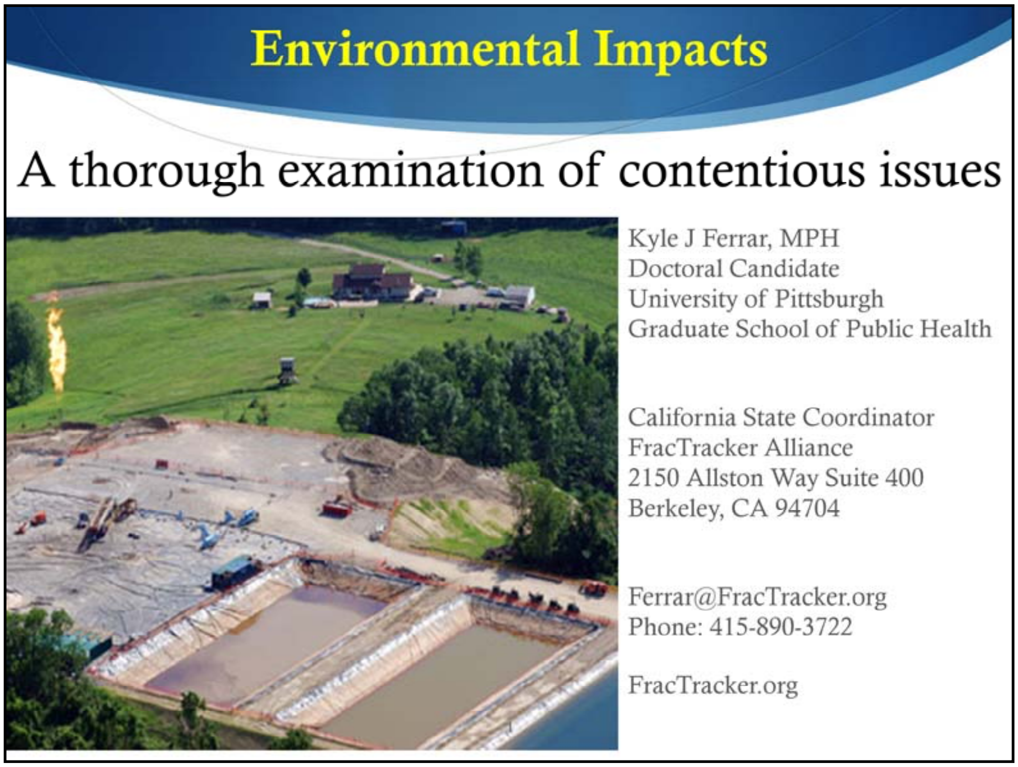
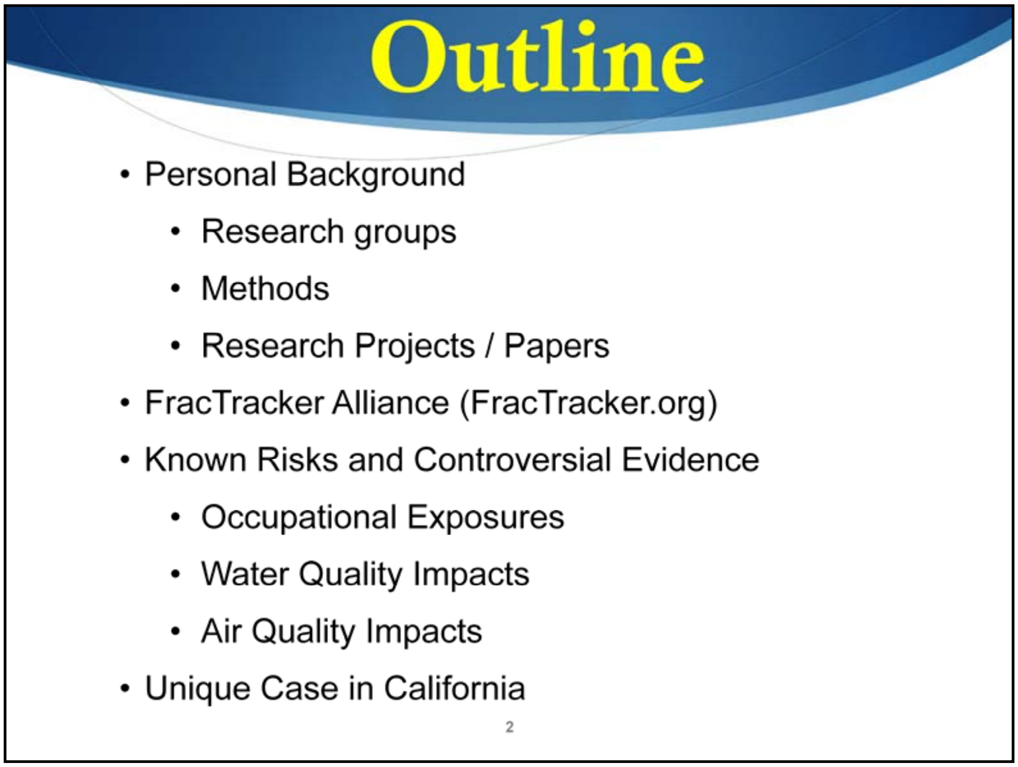


During my presentation I will consider the Environmental Health, Public Health, and Community Health impacts resulting from shale gas and oil development

I will touch on the industrial health issues and my own research, but I intend to focus on the most debated topics and lend a critical analysis.

I have several activities planned, but first will present my own research and other relevant research.



I would also like to talk a bit about my current work with FracTracker.

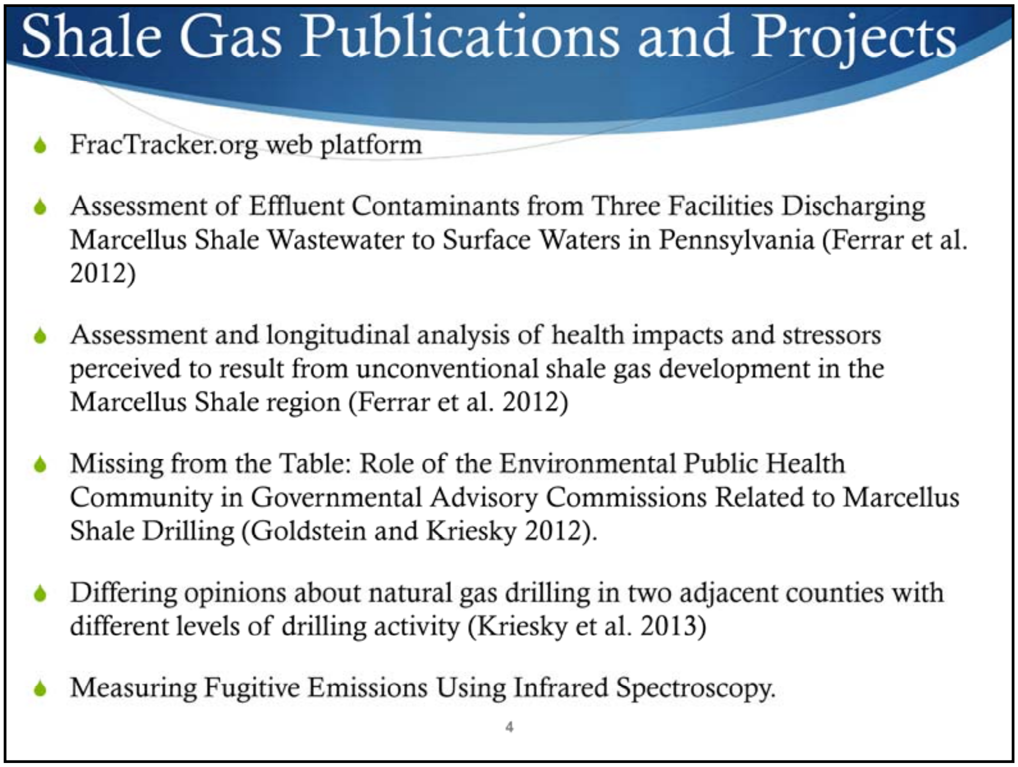
The majority of discussion will focus on water quality impacts, specifically the threat of groundwater contamination, and air quality issues, specifically contributions to green house has emissions via fugitive methane.

Center for Healthy Environments and Communities (CHEC)

3

For the last 7 years I've worked wit the CHEC doing environmental public health research. Principal Investigators have included Dr. Conrad Volz, Dr. Bernard Goldstein, and now Dr. Bruce Pitt.

The CHEC uses community based participatory research methods. This entails working directly with communities to identify concerns and threats, and then using scientific expertise to develop scientifically defensible research studies to evaluate these issues.



The CHEC's projects have included numerous environmental and community health assessments, policy reviews, and also includes the development of the FracTracker GIS platform.

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Assessment of Effluent Contaminants from Three Facilities Discharging Marcellus Shale Wastewater to Surface Waters in Pennsylvania

Graduate School of Public Health
Environmental and Occupational Health

Kyle Ferrar, Drew Michanowiz, Charles L Christen, Samantha Malone, Ravi Sharma
KyleFerrar@gmail.com

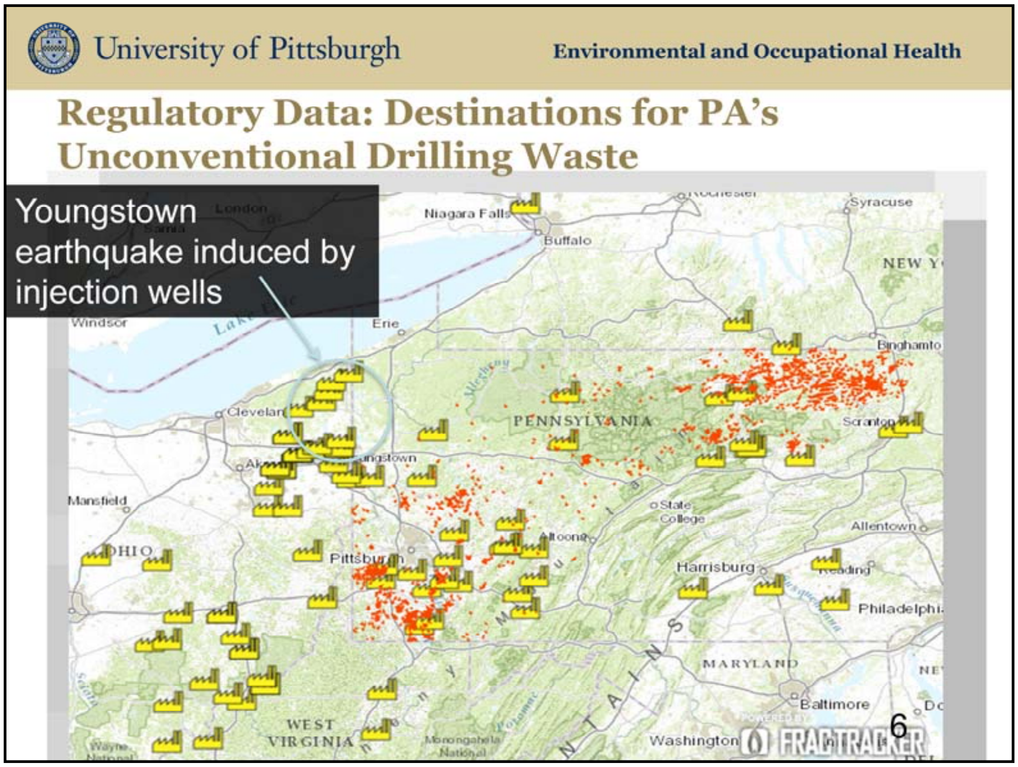
Link to Journal Article

High volume hydraulic fracturing (HVHF) produces less wastewater per unit than conventional wells, but the scale is overwhelming (570% increase in volume since 2004).

This has presented serious waste management issues in PA.

A joint study by the PADEP, USGS, and EPA identified elevated bromide levels and TDS in SWPA surface water. This had become an issue for local communities, as drinking water quality taken from the Monongahela had been impacted.

We developed this study to investigate a potential source.



Our goal was to:

Identify wastewater treatment plants accepting, treating, and discharging unconventional natural gas production wastewaters to surface waters

Sample "treated" effluent for fingerprints of shale gas wastewater, including analytes of public health importance

Compare concentrations of analytes to water quality standards.

Compare contaminant concentrations at each facility before and after the PADEP's request for a voluntary cessation.

This map on FT shows where the waste in PA is sent for treatment or deep well injection. Almost all of the facilities in PA are landfills or treatment centers, and the ones in Ohio WV and NY are often for deep well injection. (PA's geology doesn't readily support Class II injection wells.) PA waste goes as far north as Niagara Falls NY, Toledo OH to the west (not shown on this map), Cheshire OH to the south along the Ohio River, and East to Dunmore (near Scranton PA).

According to this data, that equates to roughly 121,000 square miles. Quite a carbon footprint for waste disposal.

Map available at:
http://maps.fractracker.org/2.0/?appid=7ee8b9c56b9a48b6b2bf319f059e5a4a

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Analyte Selection

- barium (Ba)
- calcium (Ca)
- magnesium (Mg)
- manganese (Mn)
- strontium (Sr)
- bromides (Br)
- chlorides (Cl)
- Sulfates (SO4)
- BTEX
- 2-butoxyethanol (2-BE)
- Total Dissolved Solids

Typical trace element wastewater composition

Analyte	Concentration (ug/L)
Aluminum	2,000
Arsenic	100
Barium	2,370,000
Calcium	24,000,000
Copper	250
Manganese	3230
Magnesium	1,830,000
Iron	158,000
Lead	30
Strontium	8,460,000
Zinc	840
TDS	345,000,000
Sulfate	100,000
Bromide	1,990,000
Chloride	185,000,000

7

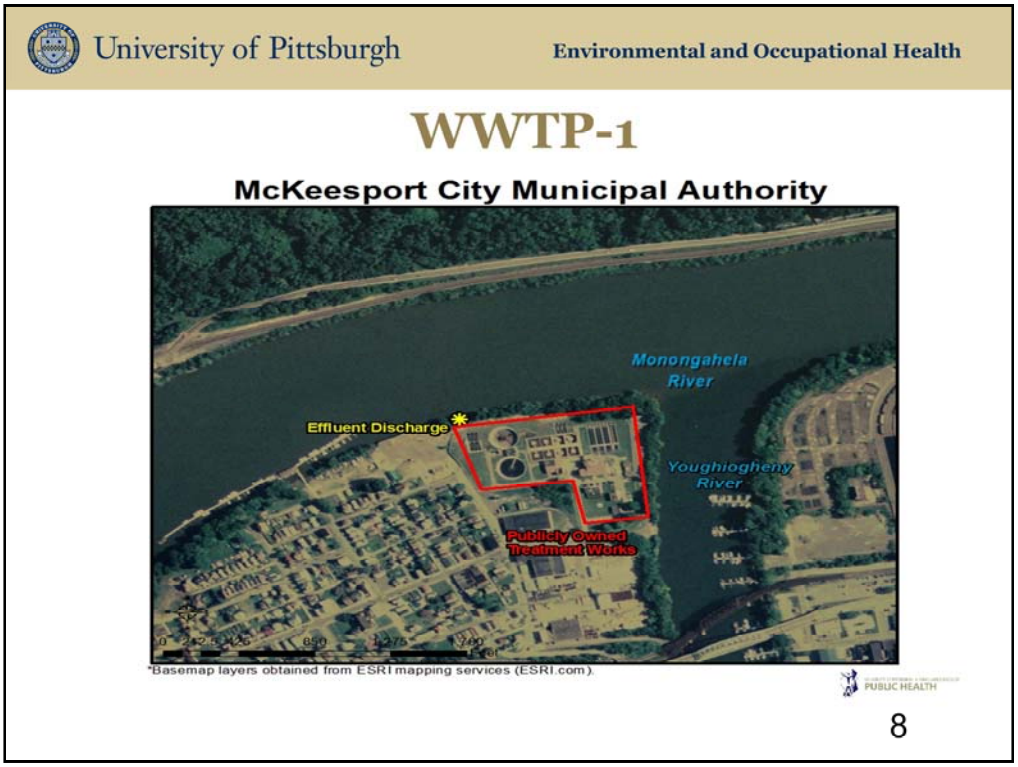
Wastewater is highly diverse, enriched with materials from the shale formation, such as brines, hydrocarbons, and naturally occurring radioactive materials, and the longer the fluid takes to return to the surface the greater the concentration of formation materials.

Cations are dominated by sodium and calcium, and the main anion is chloride.

Different sources give diff estimates for the amt of water that returns from a well after frac'ing. On average a well uses 4 million gallons for a frac, and under 30% returns. SRBC reports an average of 13.5%

The self-reporting numbers, and the numbers reported by the POTW's and other treatment facilities do not match up- it seems that the figures are under-reported.

We sampled discharges from 3 facilities (each treating a different amount of wastewater by volume) on multiple locations, both before and after the PADEP requested these facilities cease accepting treating and discharging unconventional oil and gas wastewater.

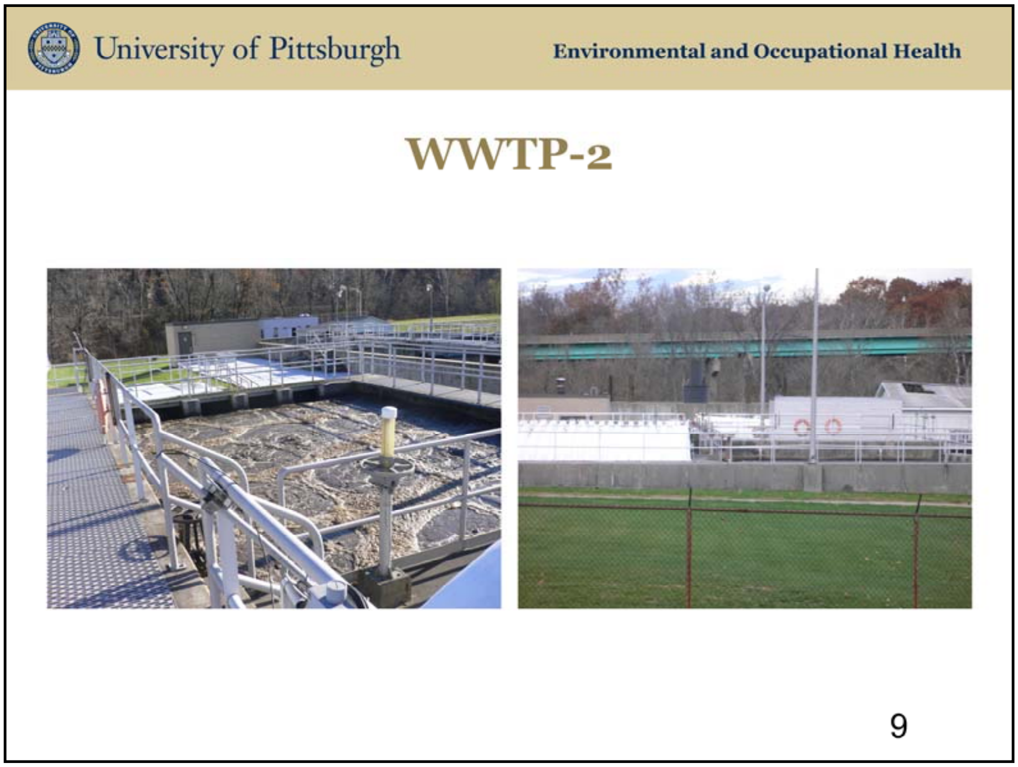


The first facility was a publically owned treatment works (POTW) accepting wastewaters via 5000 gallon residual waste tanker trucks

They were permitted to receive 1% by volume, or about 96,000 gallons according to their flow on these days (9.6mgd).

The wastewater was stored in a single cell all day then released into primary treatment at 7 pm. It takes approximately 8-12 hours for the slug of wastewater to flow through the entire system

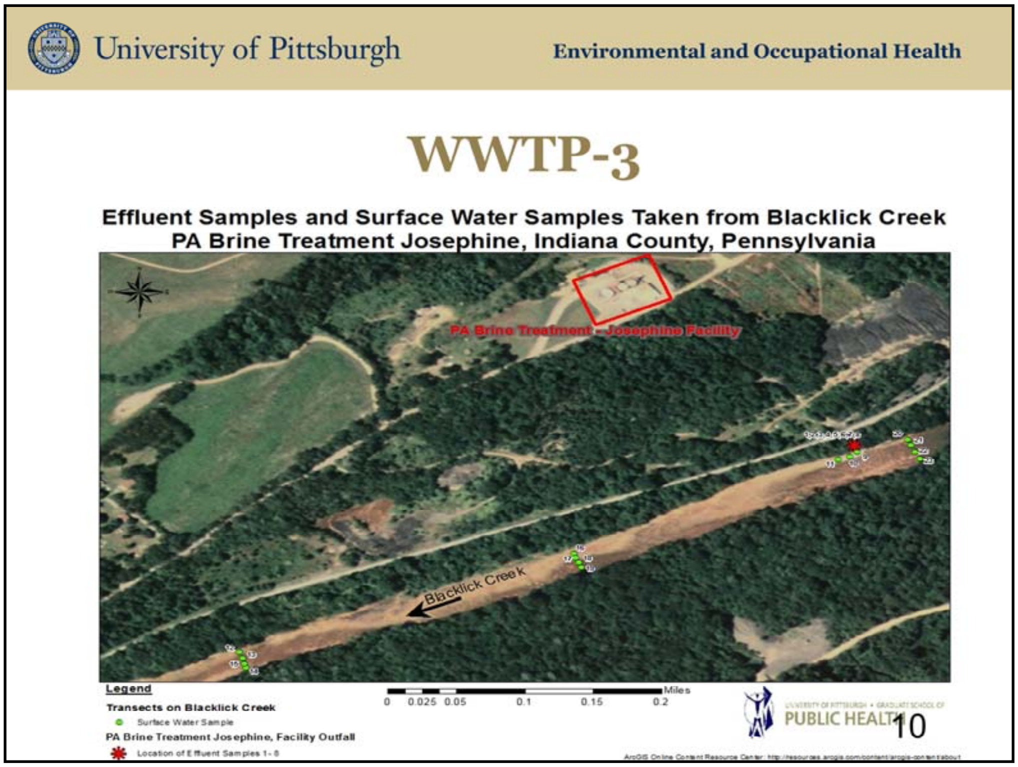
UNGD wastewater was no longer accepted as of April 19, 2011, but the facility continued to accept wastewater from shallow or conventional oil and gas field operations.



Facility 2, also a POTW, accepted the wastwater after primary treatment in a separate facility. The wastewaters were piped into the sewer system after undergoing a pretreatment process at the Tri-County Wastewater facility.

The plant discharges into the lower fork of Ten Mile Creek, a tributary of the Monongahela River in Waynesburg, PA. WWTP-2 treated the wastewater continuously and was allowed to accept 50 000 gallons per day (GPD) of UNGD wastewater from Tri-County Wastewater. According to the facility's files, the Tri-County pretreatment plant closed on March, 21 2011, thus WWTP-2 no longer accepts UNGD wastewater. During the first sample set (2A) at WWTP-2, the facility treated 53,200

gallons of UNGD wastewater November 10, 2010 and 52,600 gallons November 11, 2010. The average effluent flow was 0.982 million gallons per day (MGD) for this period, meaning UNGD wastewater comprised approximately 5.4% of the effluent by volume.



The PA Brine Josephine facility (WWTP-3) exclusively treats oil and gas wastewater, both conventional and unconventional. Wastewater is hauled on-site via 5000-gallon residual waste tanker trucks and is stored in enclosed storage tanks.

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WWTP-3

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Hart Resources PA Brine Josephine used a treatment process unique to this facility.

Sodium sulfate (Na_2SO_4) and a polymer agent are added to the oil and gas wastewater to aid the precipitation of barium and other alkaline earth metals such as strontium. A clarifying agent is also added regularly to reduce the bubbles you see.

As of September 19, 2011, the facility claims to have stopped accepting UNGD wastewaters,

Sampling Plan and Chemical Analysis

- Samples taken from discharge (effluent prior to mixing with surface water)
- Repeated grab samples (dt = 1–3h)
- Analysis was conducted by an independent commercial laboratory using U.S. Environmental Protection Agency (USEPA) approved methods.
- Analytes were measured for total metal content to compare to USEPA drinking water and surface water criteria.

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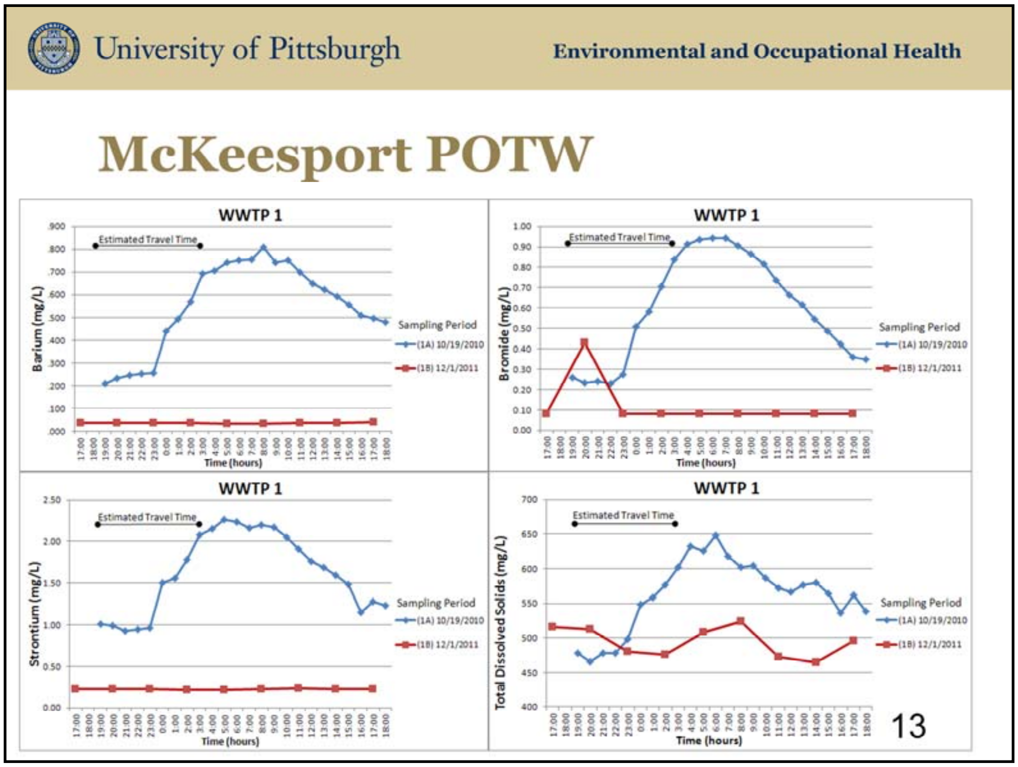
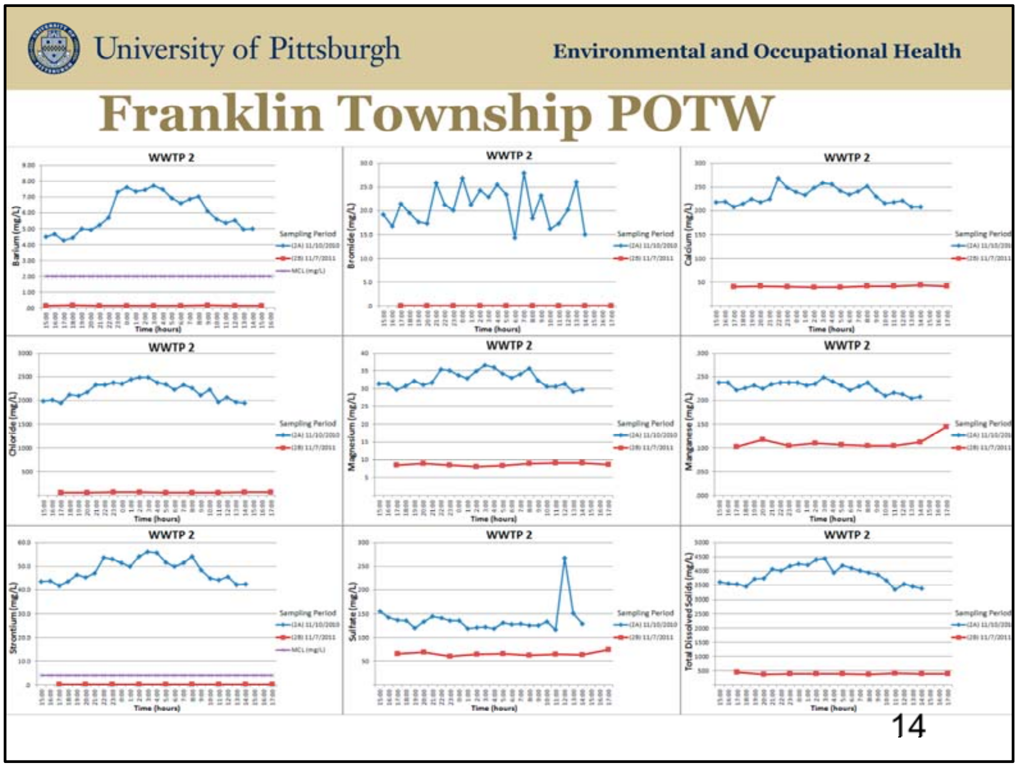
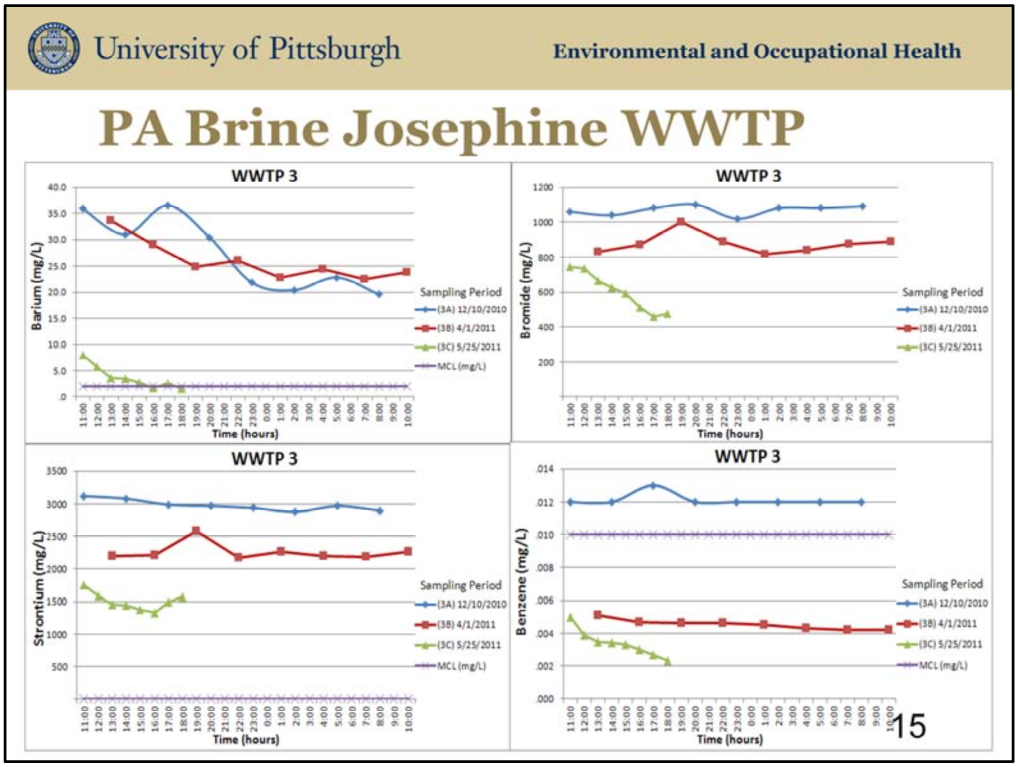


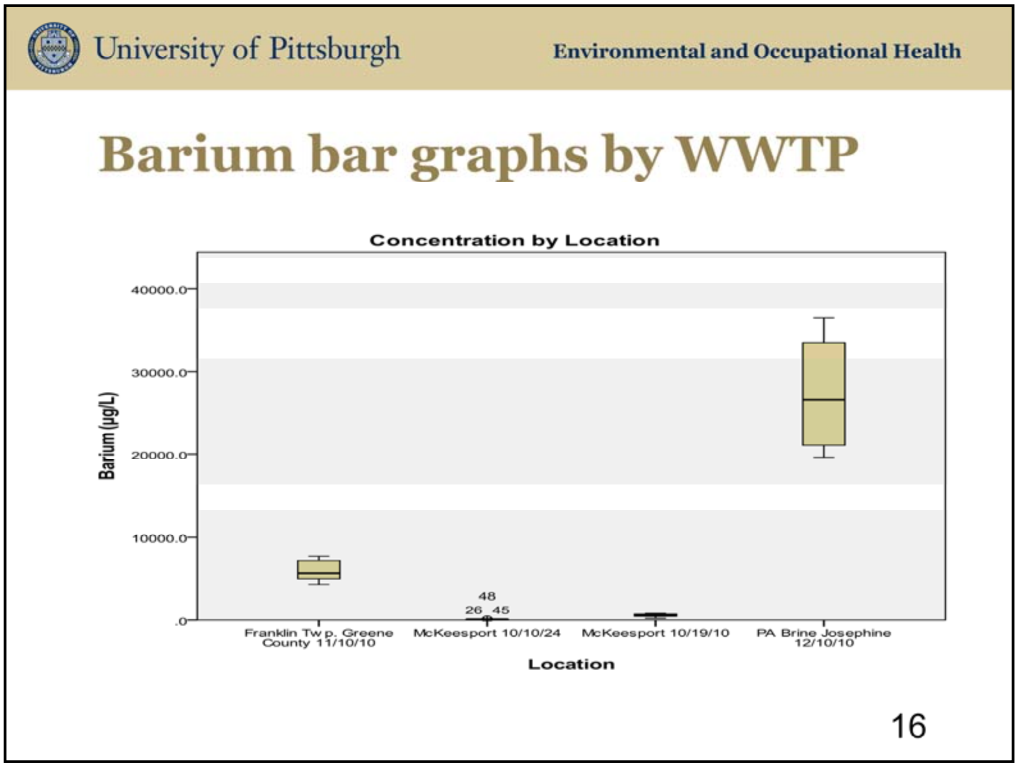
The transport period through the facility, from the UNGD wastewater entering as influent to being discharged, is labeled in the plots as the “estimated travel time.”



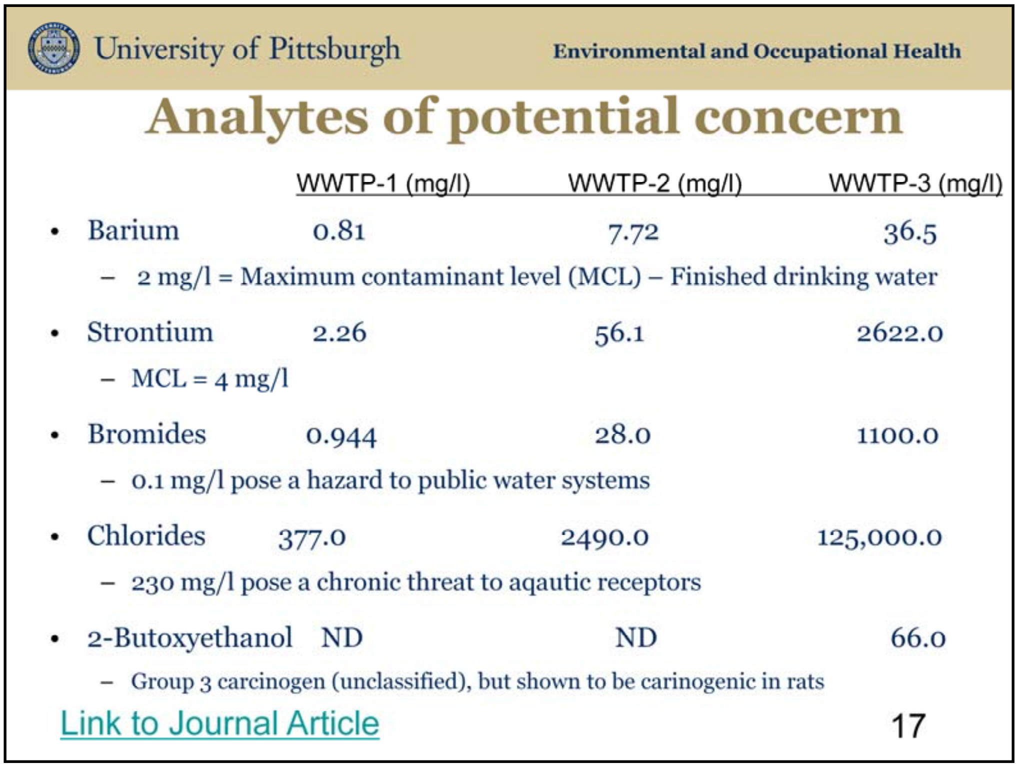
At this facility there was not a transport time, as the wastewater was continuously in the influent, was far as we were aware. In these graphs compare the blue wastewater trendline to the red baseline concentrations when the facility was not accepting oil and gas wastewater.



The industrial facility is a little more complicated as it continued to accept, treat, and discharge conventional oil and gas wastewaters. Sample set 3C represents discharges when the majority of influent was strictly conventional oil and gas wastewaters. The most apparent affect was on barium concentrations, an analyte representative of unconventional (Marcellus Shale) wastewater.



These comparisons did not make the cut for the paper, but here is a bar graph for reference, showing WWTP-2 on the left, WWTP-3 on the right, and two sampling periods from WWTP-1 in the middle.



Here are comparisons of sample concentrations to maximum contaminant levels. MCLs are for finished drinking water and are based on total concentration rather than dissolved, to be conservative of health.

Decreases in analyte concentrations were significant for most analytes at the three facilities, and most pronounced and consistent at WWTP-2, where all analytes decreased ($p < .05$).

The effect of the PADEP's request for a voluntary cessation at these facilities was successful in reducing concentrations of all analytes sampled at WWTP-2 and the majority of analytes at WWTP-1 and 3.

The consistent decreases in effect size at WWTP-2 provide evidence that the elevated concentrations of analytes in the effluent were attributable to the UNGD wastewaters, although this cannot be confirmed without influent sampling.

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Other research

- Further investigation into the dissolved phase of these metals downstream of the facilities should be conducted, as both Br and Sr readily precipitate nontoxic compounds in the presence of sufficiently high concentrations of dissolved sulfate.
- Site assessments should be conducted to evaluate the impact from the discharges of such WWTPs that continue to accept UNGD wastewater.

Link to Journal Article

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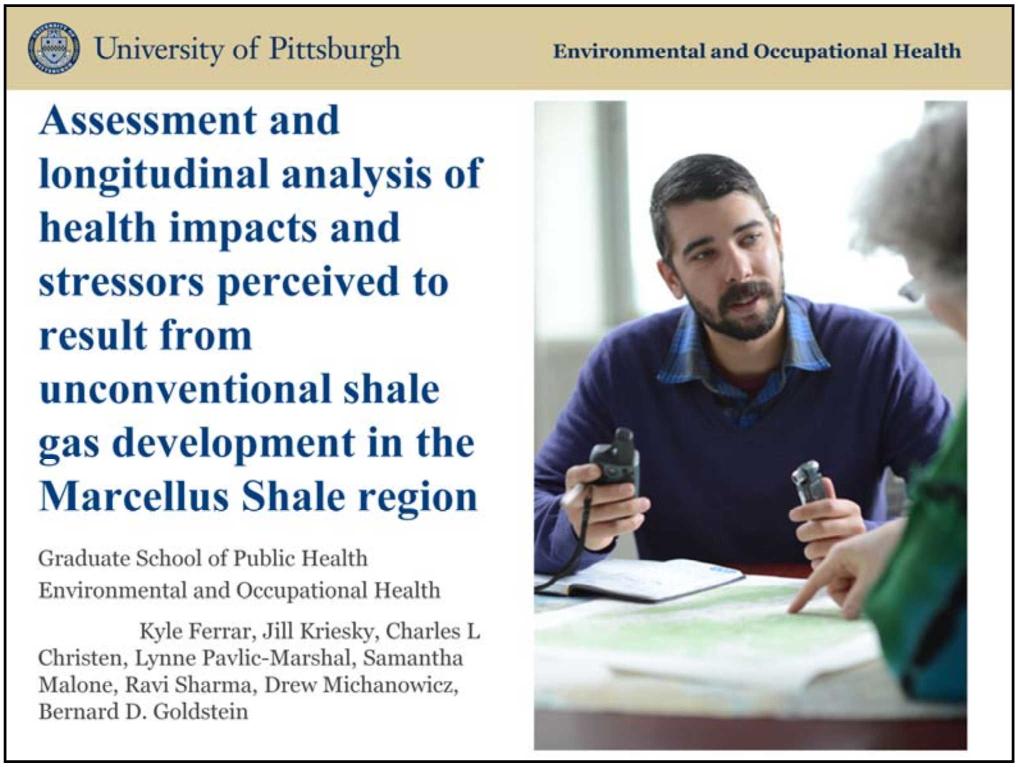
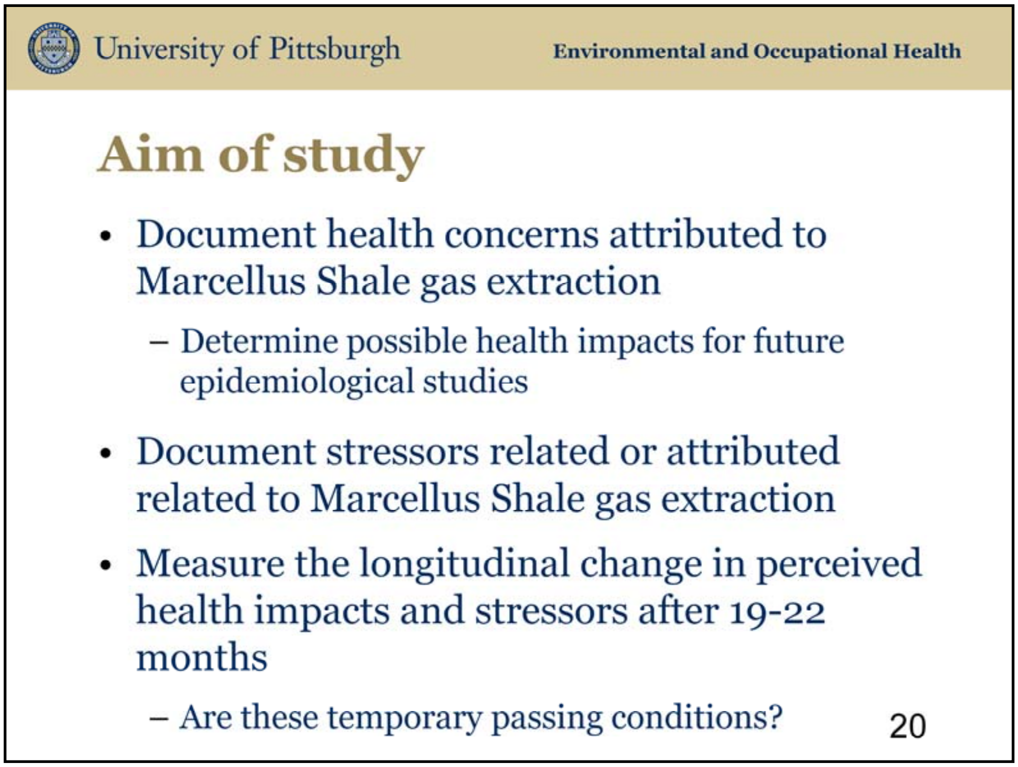
Additional research by Duke University and Carnegie Mellon University show elevated levels of bromide, barium, and radium downstream or in sediments.



This next project was an ethnographical research study focused on perceptions of health. It was published in the International Journal of Occupational and Environment Health.

33 individuals were interviewed extensively with 20 participating in follow-up interviews over a year later.



Point 1:

The factors determining the choice of health endpoints for epidemiological evaluation of an industrial activity ideally should include an expert assessment. For UNGD, this would include an evaluation of the toxicology and exposure pathways of the chemical and physical agents, and the psychosocial stressors involved. However, these endpoints should also include those that are of concern to the community — particularly as community members are often the first to anecdotally identify an adverse effect

After the 2nd point:

We use the term stressor here to broadly include the various nonsymptom concerns raised by the respondents, ranging from the sensory perception of an odor to the belief that their complaints were being ignored. Stressors can negatively impact both mental and physical health and were therefore necessary to document.

Point 3:

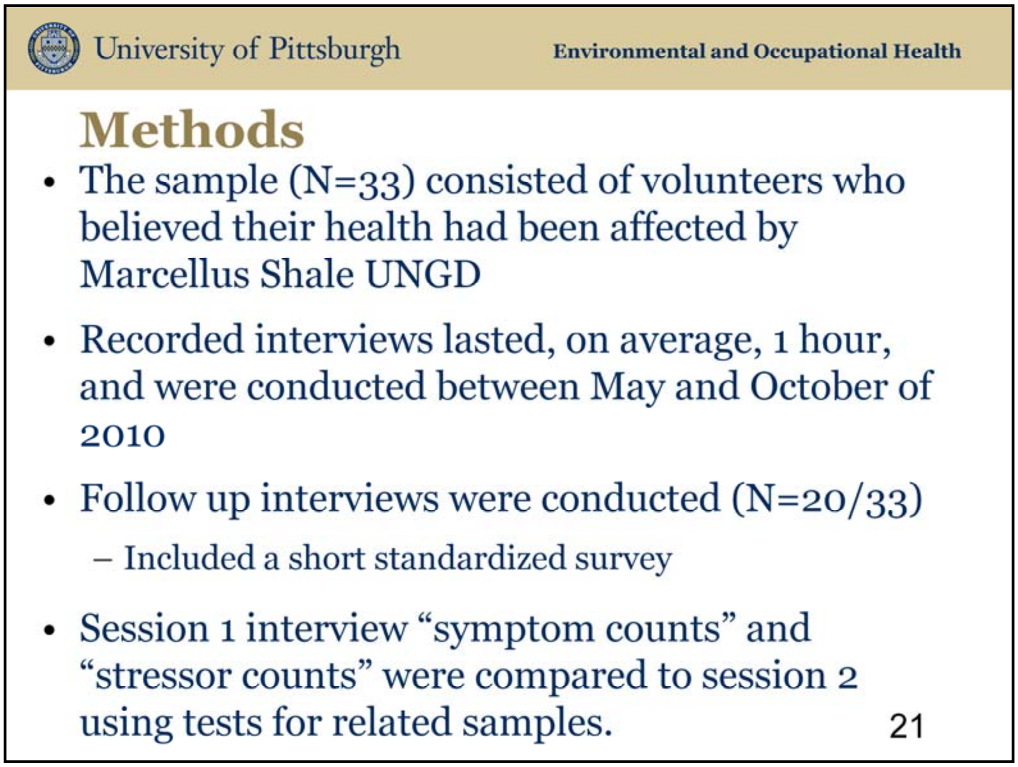
The focus of session 2 elaborated upon issues identified in session 1 relevant to public health interests, specifically community and individual health impacts and concerns including psychosocial stressors when self-reported by the participant.

The Pennsylvania state legislature has focused primarily on the financial benefits accompanying shale gas development, resulting in "boom-town" development of the shale play. Inattention to community health has led to a procedural inequity.

There has been speculation and controversy about health and ecological impacts resulting from this gas extraction process. Yet a thorough health impact assessment has not yet been conducted, resulting in environmental justice inequities for communities being developed for Marcellus Shale gas.

UGD activities in any one well have a temporal rhythm that changes over time. Drilling a single well may take 3-6 weeks and multiple wells are typically sequentially drilled from a single well-pad with the most intense activity tending to occur during the actual hydraulic fracturing and completion process, which lasts several days after drilling is finished.[19] After a well has been successfully drilled, drilling related activities decrease. The tall drilling structure is removed, truck traffic often declines substantially, and the number of transient workers decreases, although a noisy compressor and pipeline activities may continue to be stressors.

It is possible to contend that symptoms and perceived health effects associated with UGD will decrease when UGD activity lessens and the community becomes inured to the longer term changes, many of which may be financially and economically beneficial. Accordingly, a follow up evaluation was conducted. with participants from the original study to determine if their complaints had changed over time.



Participants represented a convenience sample of community members (n=33) living proximal to Marcellus Shale drilling activity, in or near Pennsylvania, during March - September, 2010.

These individuals came to CHEC with some type of 83 concern about the development of unconventional natural gas resources in their communities.

Three quarters of the participants resided in 5 of the 7 most heavily drilled counties in PA, with 18 from Washington County

A follow-up survey was performed in January-April, 2012, with 20 of the initial participants (n=20).

The shorter follow-up interviews (Session 2; n=20) were conducted over the phone (n=17/20) or in person (n=3/20), in January-April, 2012, and included 20 of the 33 initial participants. Time frames ranged from 19-22 months between interviews. We failed to reach 7 participants due to outdated information or lack of response to our requests; 6 others declined to participate.

Symptoms most likely to be reported*

Systems Affected and Symptoms	Session 1 (n=33)
Stress	76%
Rashes	27%
Loss of sleep	27%
General illness	24%
Headaches	24%
Diarrhea	24%
Shortness of breath	21%

*reported by over 20% of interviewees

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Symptoms most likely to be reported included the following.

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Top 6 stressors

Stressor	Session 1 (n=33)
Denied or provided false information	79%
Corruption	61%
Concerns/complaints ignored	58%
Being taken advantage of	52%
Financial damages	45%
Noise pollution	45%

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As you can see, the top concern was being denied information, which deals with the issue of transparency and honesty. Of particular importance is that the top 4 concerns can be easily address by industry and regulatory agencies.

“Acid taste” stressor was dropped from presentation due to no participants selecting it during session 1

“Health concerns” stressor was omitted due to vagueness.

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Remaining 6 stressors

Stressor	Session 1 (n=33)
Desire to move	42%
Animals died/sickened	42%
Estrangement from community	39%
Intimidation/fear of retribution	27%
Odors	13%
Light pollution	9%

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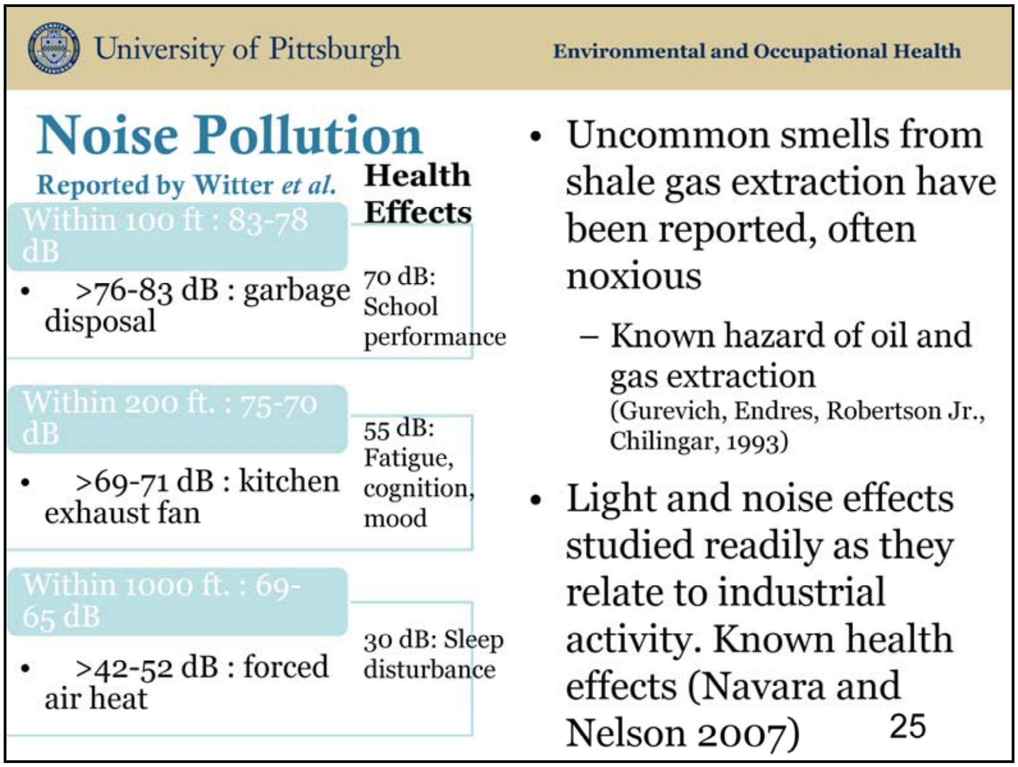
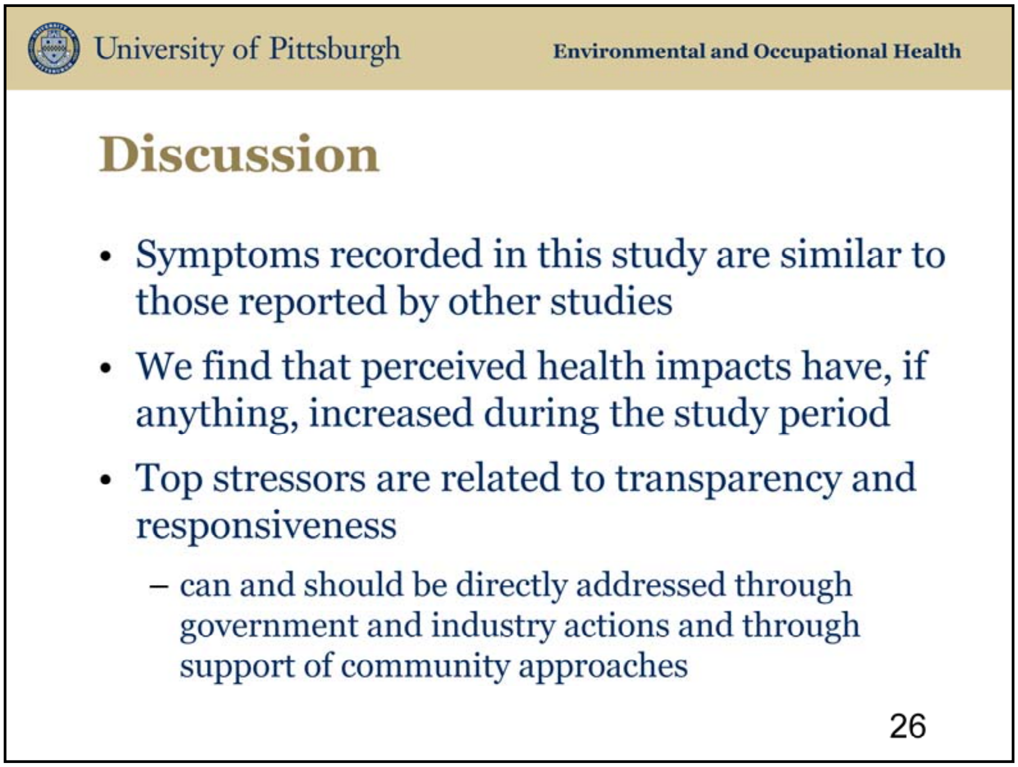
Death or sickness of companion animals (pets) or livestock was documented as a stressor both for livestock farmers citing financial hardship and for pet owners with emotional stress. Although this topic was included as a stressor in our study, it should also be recognized as an indicator of potential human health threats. Animals are sentinels of threats to human health, and these observations were consistent with Bamberger and Oswald's findings, including cases of animal death, failure to breed, and reduced growth rates.



Noise and Odors represent both a public health and industrial health risk.

Noise, Light, and Smell were also identified as factors influencing stress and allostatic load



Participants attributed 59 unique health impacts and 13 stressors to Marcellus Shale development activities. Among those who perceived that their health had been impacted, stress was the most frequently reported symptom.

After stress, symptoms associated with the dermal (integumentary), digestive, upper respiratory, and central nervous systems were the most prevalent.

Over time, symptoms and perceived health impacts increased for the sample population ($p<0.05$), while stressors resulting from Marcellus Shale activity remained consistent ($p=0.60$).

Stress can also result in direct health impacts. Chronic stress can result in allostatic load: the physiological consequences of chronic exposure tofluctuating or heightened neural or neuroendocrine response. The documented stressors may cause psychological and physical burdens for participants and contribute to the significant increase in perceived health impacts, which in turn increases allostatic loads.

Degradation of 'community wellness' as reported by participants was consistent with the HIA for Battlement Mesa, CO and the studies in PA and TX

A legitimate health impact assessment is necessary to provide communities with the necessary information to make an informed decision, whether to allow or not allow development.3

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Key Findings and Summary

- 59 unique health impacts and 13 stressors attributed to Marcellus Shale development
- Stress most frequently-reported symptom
- Over time (after 19-22 months) perceived health impacts increased (P=0.042)
- While stressors remained constant (P=0.855)
- Preliminary study, more research needed.

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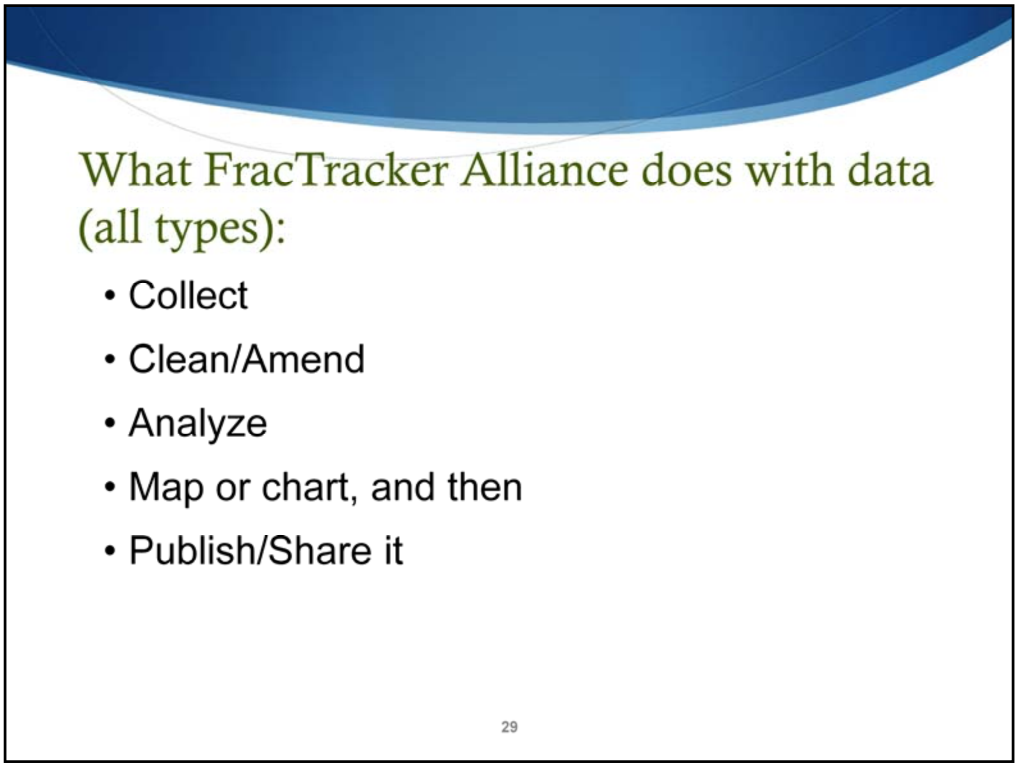
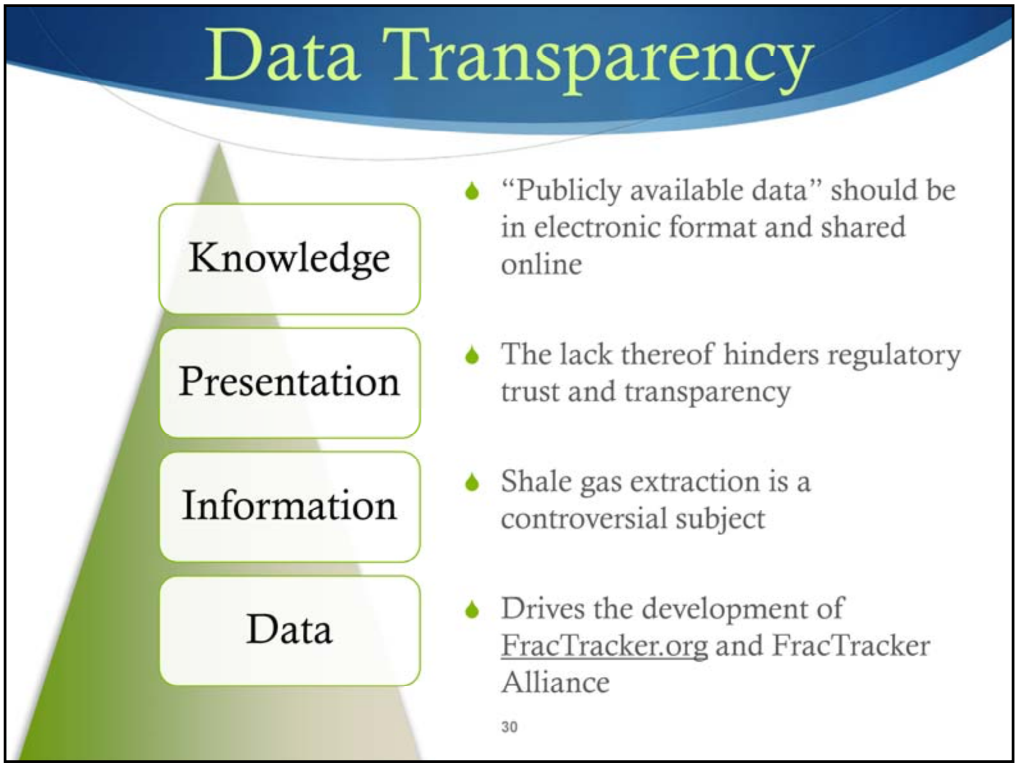
DOI: http://dx.doi.org/10.1179/2049396713Y.0000000024

My current line of work is focused on data transparency and coordinating activities for FracTracker in California.

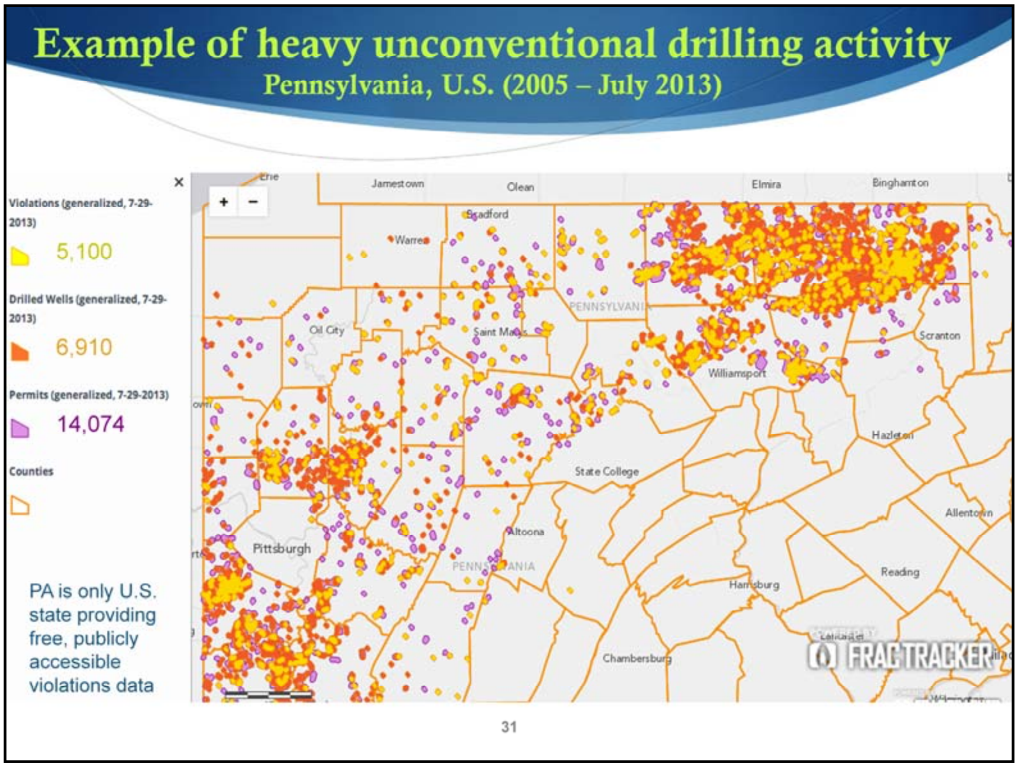


When FT started, drilling data not available electronically from most states, and certainly not on a comprehensive level.



For people to adequately access and absorb data, it should be published online in electronic formats that make the data easy to search, sort, and download. Too often data collected by the government or industry, or that which is of interest to the public, fails to be made available online in a consistent format. This hinders regulatory transparency.

The Internet offers the chance for organizations like FracTracker Alliance to catalyze regulatory transparency, providing new tools and resources for the public and media. As such, we work to make any and all shale gas data available online and in a digestible manner, often in the form of maps, charts, and graphs. Only when data is converted to information can it be fully utilized.



To give you an idea of scale, here is a map of wells that have been sunk into unconventional shale layers in PA (either the Marcellus or Utica).

These geologic formations are typically 100-200 feet thick, and deeper than 6,000 feet below the earth's surface.

In addition to Pennsylvania and the Marcellus Shale Basin, we have collected data on a number of other states, as well as national data.

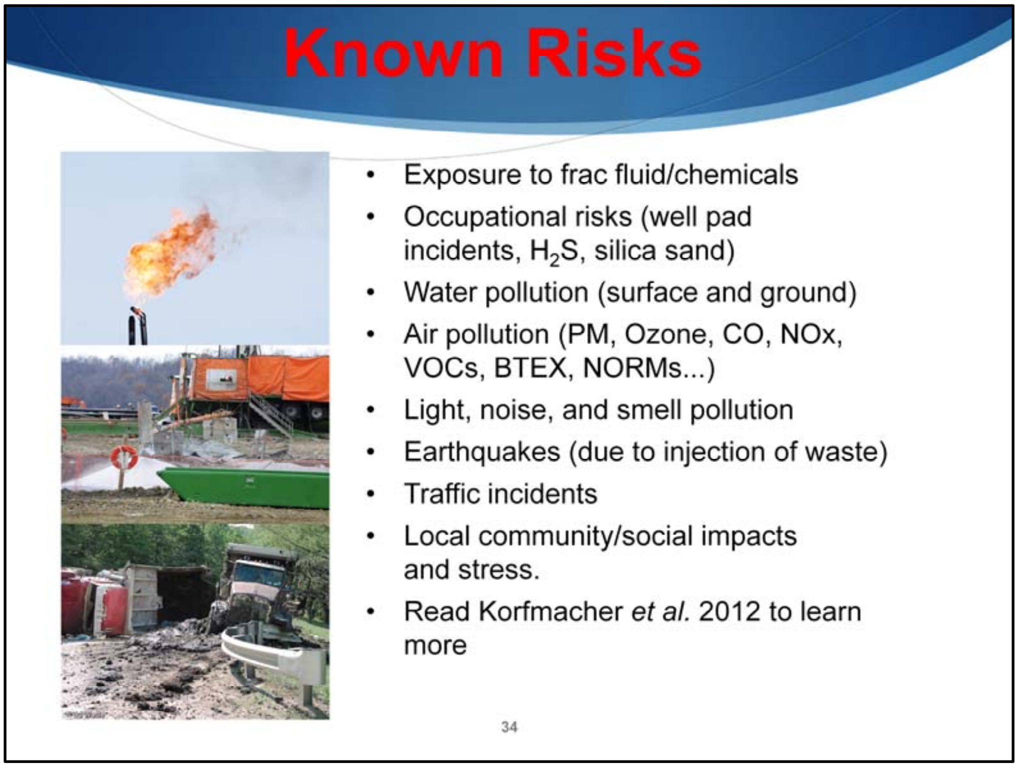
Who here see’s their states up on the map, a show of hands will do. If you have data we don’t, we would love to manage it for you and help you distribute it.

Ill assume that those who didn’t raise their hands don’t see their states listed. Some of your states may not have much shale development, or we just have not yet expanded to looking at your state in particular.

If unconventional development is going to expand in other shale basins such as the Monterey Shale in California, there is a lot that can be learned from the situation in Pennsylvania.

CHEC researchers Goldstein and Kriesky 2012 analyzed the extent to which human health issues are of concern to the public by reviewing presentations at the public meeting of the Secretary of Energy Advisory Board (SEAB) Natural Gas Subcommittee formed by the U.S. President’s directive. They also analyzed the extent to which advisory committees formed in 2011 by President Obama and governors of the states of Maryland and Pennsylvania contain individuals with expertise pertinent to human environmental public health.

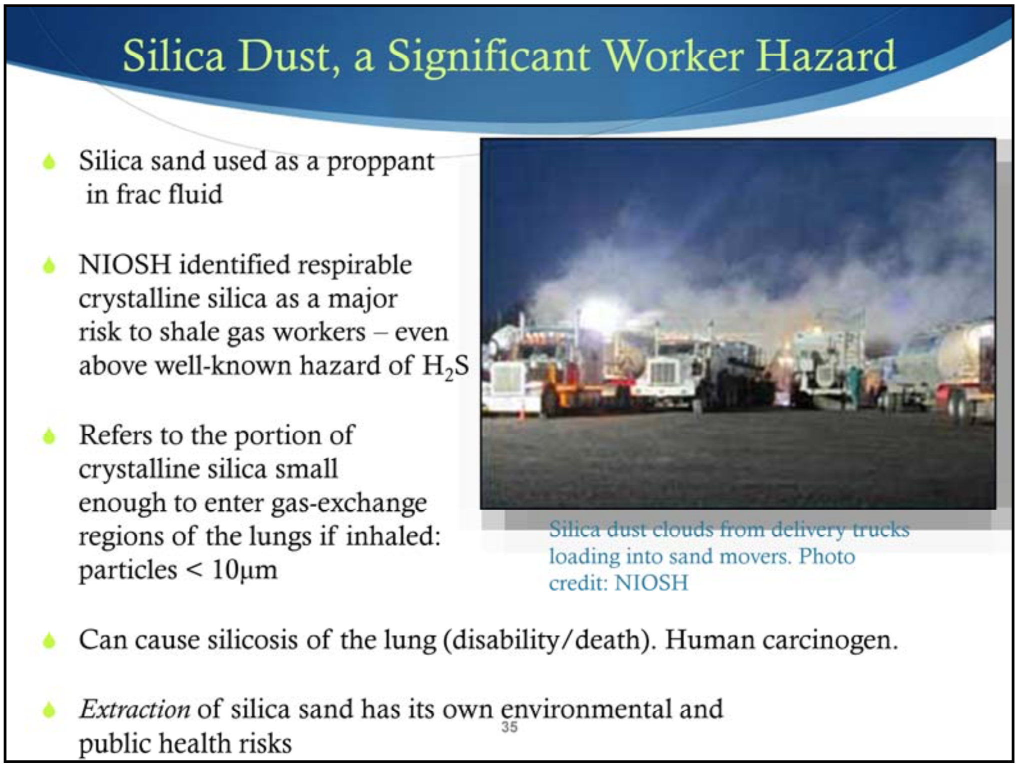
At a public hearing held by the SEAB Natural Gas Subcommittee 62.7% of those not in favor of drilling mentioned health issues. Although public health is specified to be a concern in the executive orders forming these three advisory committees, we could identify no individuals with health expertise among the 52 members of the Pennsylvania Governor’s Marcellus Shale Advisory Commission, the Maryland Marcellus Shale Safe Drilling Initiative Advisory Commission, or the SEAB Natural Gas Subcommittee.



Here is a short lists of risks that need to be considered.

These accompany unconventional extraction technologies, and require consideration and mitigation.

I’d like to talk a bit about occupational health risks because this is an industrial health conference after all, but the major focus of the rest of the presentation will be air pollution, and water quality issues.



Questions for class:

What does silica dust do to the body once inhaled?

What is the most common injury that these workers experience?

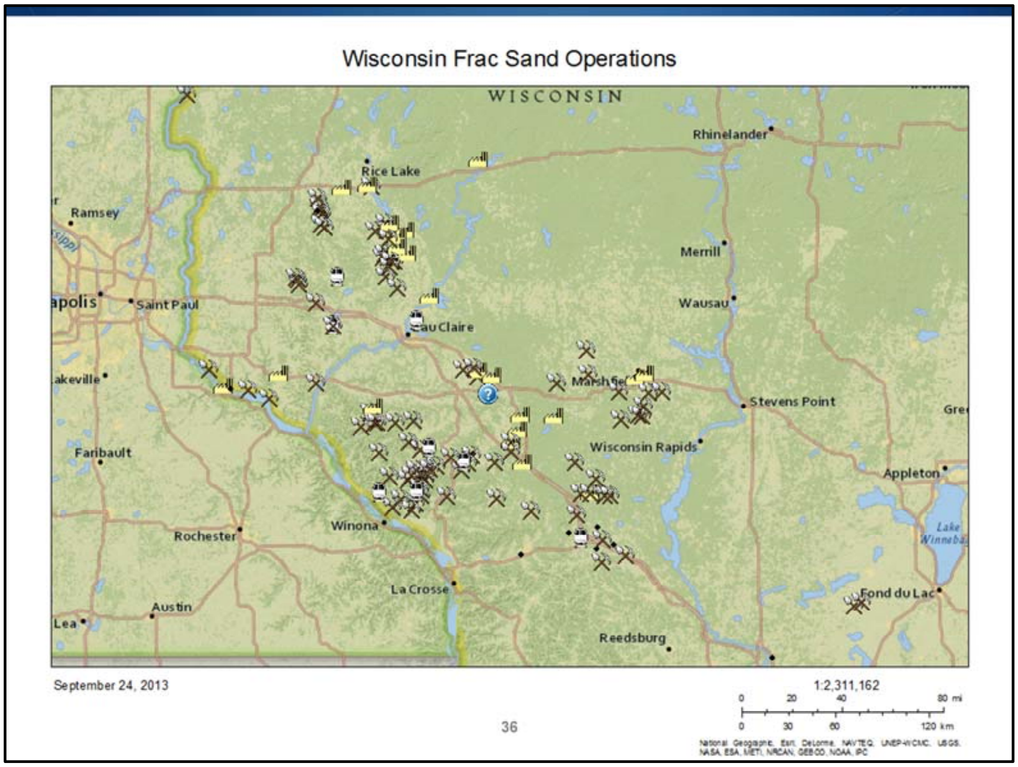
Talking Points:

Silica sand is used as a proppant

Identified as a risk via recent studies by the National Institute for Occupational Safety and Health (NIOSH) to workers conducting some hydraulic fracturing operations

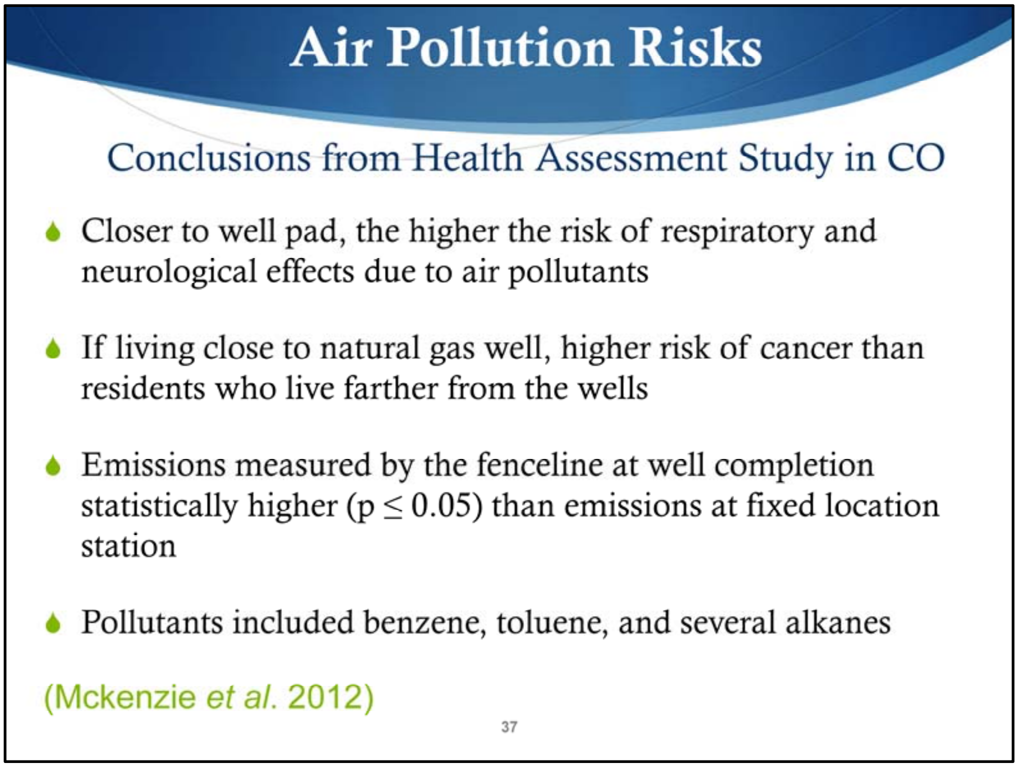
Respirable crystalline silica is the portion of crystalline silica that is small enough to enter the gas-exchange regions of the lungs if inhaled; this includes particles with aerodynamic diameters less than approximately 10 micrometers (µm).

NIOSH/OSHA: http://www.osha.gov/dts/hazardalerts/hydraulic_frac_hazard_alert.html



Here is a map of frac sand mining operations in Wisconsin

There are three basic types of facilities, including mining (pick and shovel icon), processing (industrial facility icon), and shipping (train icon),



Chemical air pollutants are another issue for occupational health, as well as public health.

McKenzie et al. used EPA guidance to estimate non-cancer and cancer risks for residents living > 1/2 mile from wells and residents living $\leq$ 1/2 mile from wells

This study measured ambient air hydrocarbon emissions

163 measurements from fixed monitoring station

24 samples from perimeter of well pads (130-500 feet from center) undergoing well completion

Conclusions:

Residents closest to well pads have higher risks for respiratory and neurological effects based on their exposure to air pollutants.

Residents living close to natural gas well are at higher excess lifetime risk for cancer than residents who live farther from the wells.

Emissions measured by the fenceline at well completion were statistically higher ($p \leq 0.05$) than emissions at the fixed location station. These pollutants include benzene, toluene, and several alkanes.

Don’t read, background info:

Did not measure ozone

Did not measure particulates (PM_{10}, $PM_{2.5}$)

EPA methods may underestimate health risks of mixed exposures

Air Pollution Risks

Sources of Air Emissions from Operations*

	Fugitive Emissions	Dehydration	Vehicles/ Engines	Flaring	Pits
PM		X	X		
H_2S	X			X	
Ozone	X	X	X		
CO			X	X	
NOx			X	X	
SO_2			X	X	
VOCs	X	X	X	X	X
BTEX	X	X	X	X	X
Methane	X	X			X
NORMs	X	X			X

(Mckenzie *et al.* 2012) * Table compiled by Leslie Walleigh MD, MPH (7-20-12)

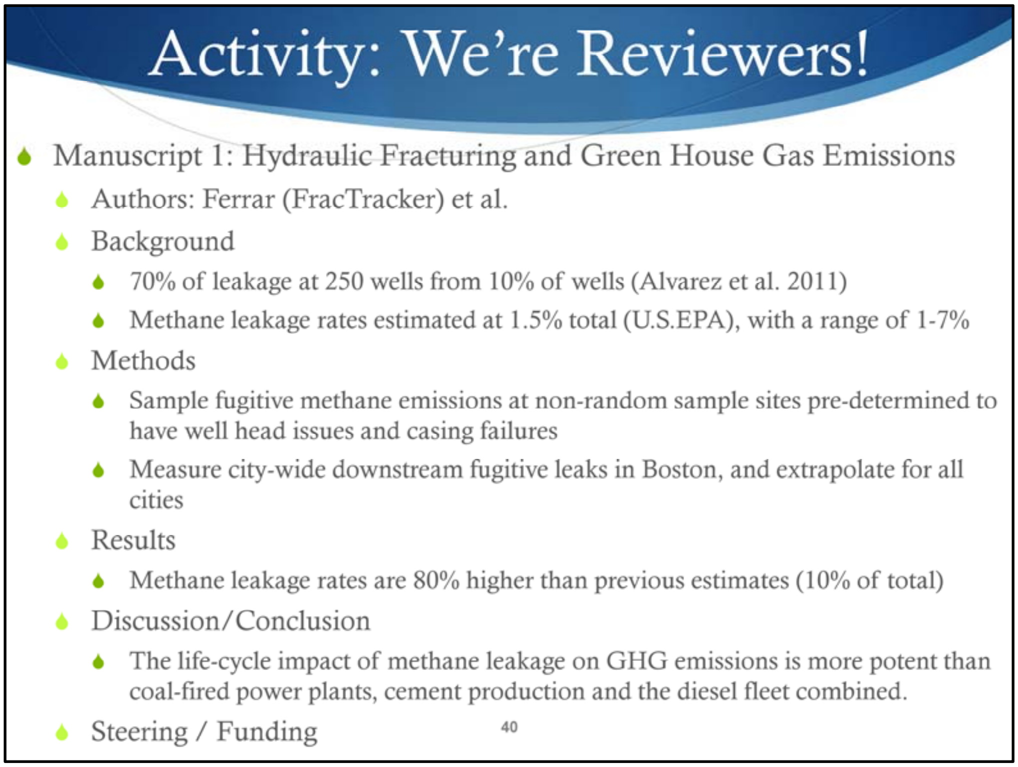
The study identified sources of air pollutants to direct monitoring and regulatory policies.

Recognized Health Effects of Air Emissions from Natural Gas Activities*

	Pulmonary	Neurologic	Reproductive	Dermal	Hematologic
PM	X			X	
H_2S	X	X		X	
Ozone	X				
CO		X	X		
NOx	X				
SO_2	X				
VOCS	X	X	X	X	X
BTEX	X	X	X	X	X
Methane					
NORMs			X	X	X

* Table compiled by Leslie Walleigh MD, MPH (7-20-12)

Health impacts to be considered were also identified.



So now that you have all digested all that background information, and are now experts on the subject, I would like to introduce our first exercise, and it deals with the impact fugitive methane emissions from the natural gas industry contribute to green house gas emissions.

I invite you all to be reviewers of this hypothetical manuscript being considered by… lets say the Proceedings of the National Academy of Sciences.

I would like you all to work in small groups of 4 or 5, or however many you have at your table.

First, my goal of this study is to "estimate the contribution of fugitive methane from the life cycle of industrial extraction and commercial supply, as a percentage of total methane gas extracted."

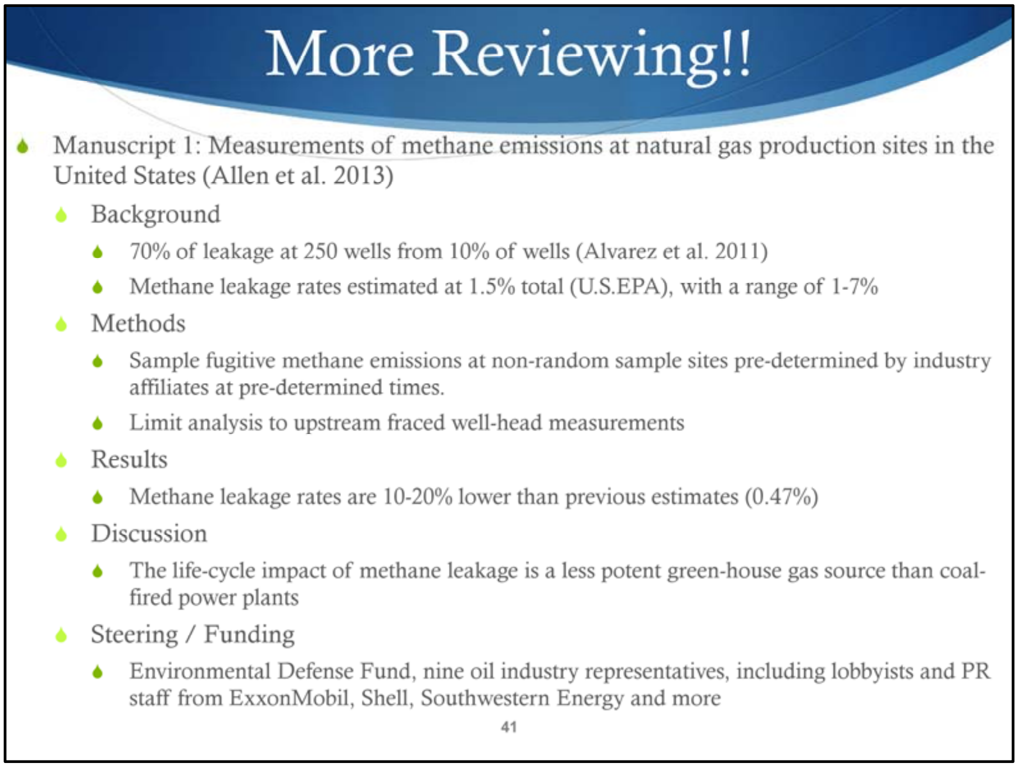
My background data shows that there are specifically bad actors and good actors, and the EPA estimates that 1.5% of methane extracted is lost through fugitive emissions.

Now I want you all to evaluate whether my methods are appropriate to answer my question, how they may bias my results, and whether my discussion/conclusion is justified. You have 5 minutes.

Biased sampling scheme

Worst Case scenario results

Boston has old infrastructure, and is not representative of all other cities.



And for our second activity, here is a study recently published by the National Academy of Sciences. It is a real publication just released in September 2013. We are going to go through this one the same way as the previous. The background and the goal of the study are the same.

Now I want you all to evaluate whether these methods are appropriate to answer the question, how they may bias my results, and whether the discussion/conclusion is justified. You have 5 minutes.

Biased sampling scheme

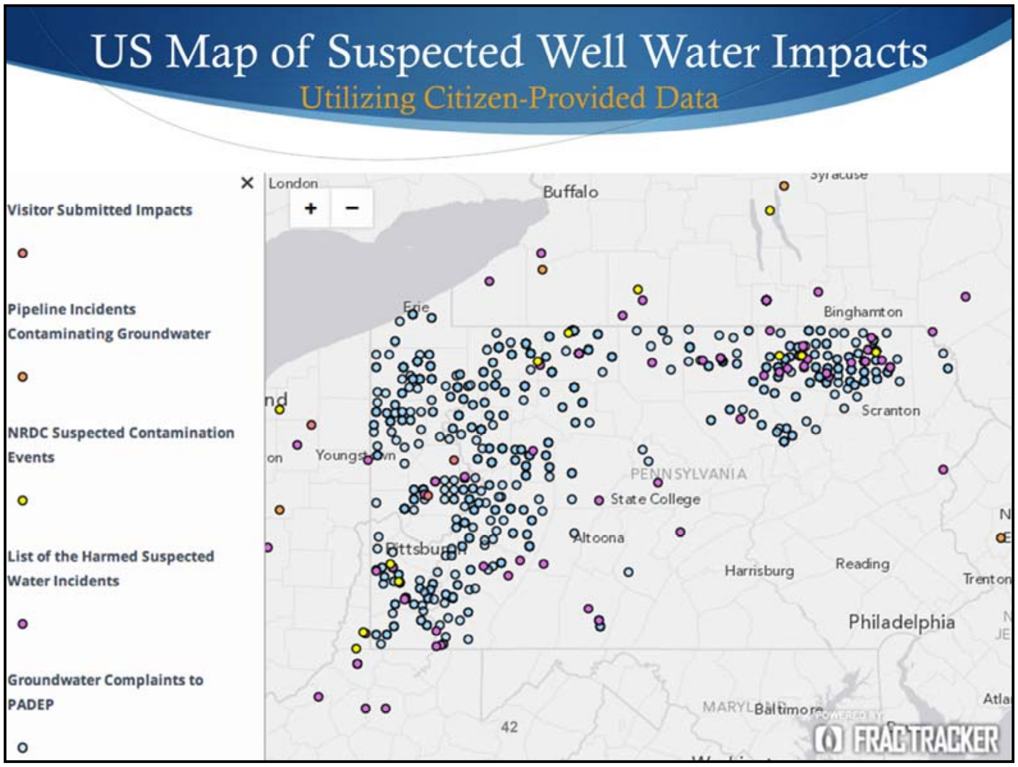
Best case scenario results

There is no consideration of upstream pipe leaks

The conclusions may not be true, as the results are most likely a vast underestimation.

Now as a show of hands, as reviewers, who would be concerned that the steering committee and funding sources could introduce bias into the study?

I am not saying that their measurements are flawed, but rather this type of study can only be viewed as a best case scenario.



Similar to how this map can be viewed as a worst case scenario for well water contamination in Pennsylvania.

The US Map of Suspected Well Water Impacts includes incidents in which oil and gas related events are suspected in events that have an impact upon ground water in the United States. There are multiple layers to the map, each with its own source, and therefore credibility.

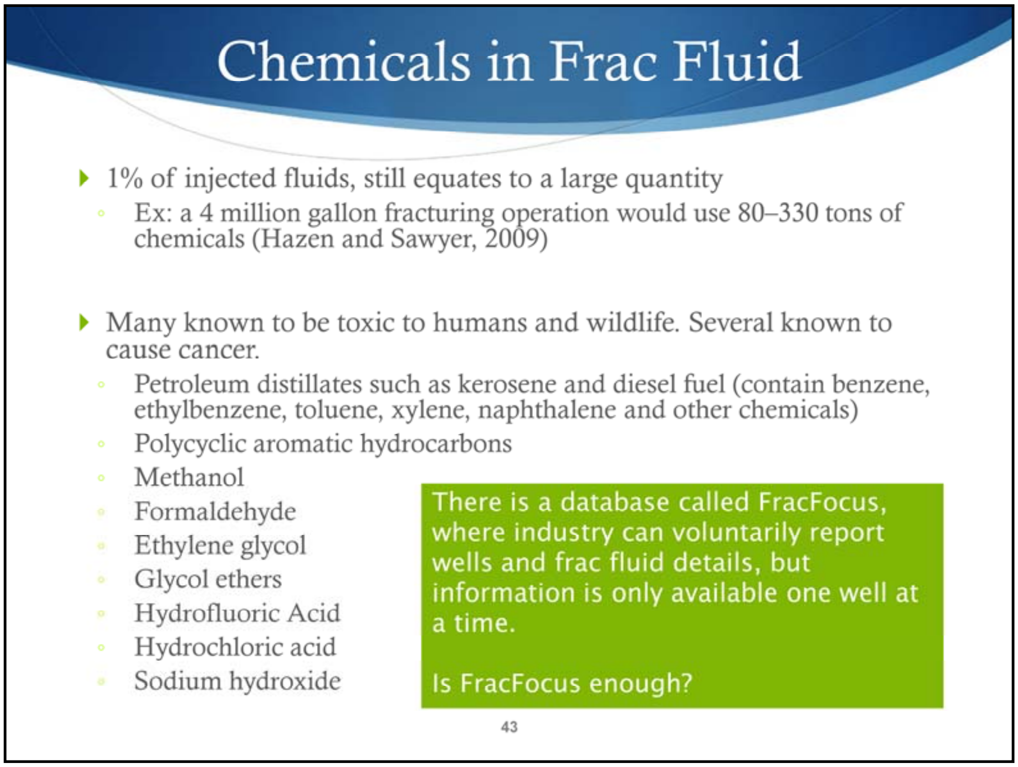
Visitor Submitted Impacts: This layer consists of viewer submitted form data describing suspected incidents of groundwater contamination by oil and gas extraction and related industries. The locations have been determined using the centroids or geometric center-points of the zip code in which the suspected incident occurred.

Pipeline Incidents Contaminating Groundwater: This data layer includes hazardous liquid pipeline incidents that were indicated as resulting in groundwater contamination between 1/1/2010 and 3/29/2013. The data were obtained by the US Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA). The data have been altered by the FracTracker Alliance in that it only includes incidents leading to groundwater contamination, and by the removal of several dozen columns of data about the incident.

NRDC Suspected Contamination Events: Amy Mall of the Natural Resources Defense Council compiled a list of 37 incidents where hydraulic fracturing is suspected of contributing to groundwater contamination. The list was compiled in December 2011, and each entry is linked to news reports of the event. This layer was mapped by the FracTracker Alliance based on the centroids or geographic center-points of the municipality, county, or state of the incident, depending on the best information available.

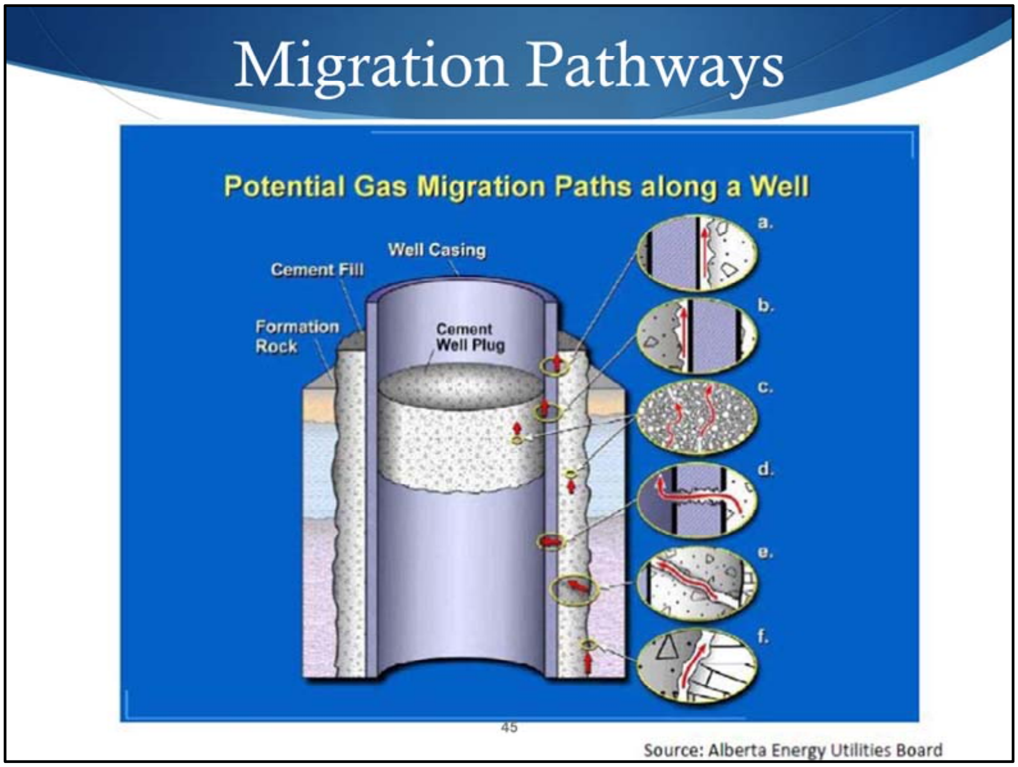
List of the Harmed Suspected Water Incidents: Jenny Lisak, co-director of the Pennsylvania Alliance for Clean Water and Air, maintains a list of people claiming to be harmed by hydraulic fracturing or related processes, called the List of the Harmed. This data layer is based on the February 23, 2013 update of the list, and contains only the events in which water is the suspected exposure pathway. This data was mapped by the FracTracker Alliance based on the centroids or geographic center-points of the municipality, county, or state of the incident, depending on the best information available.

Complaints to PADEP: Laura Legere, a reporter with the Scranton Times-Tribune, submitted a Right-to-Know law request to PADEP for documents related to people complaining of their well water being impacted by oil and gas drilling, hydraulic fracturing, and related activities. Inclusion on this map layer just means that there was a complaint to PADEP, and should not be construed as proof of a causal relationship between the gas well activity and supposed ground water impact. However, 161 of the incidents have documentation where PADEP establishes a connection between drilling activity and well water impacts. Please note that locations are not exact. They were created by finding the centroid, or geographic center-point, of each municipality. Names of those claiming well water impacts are not included in the data for this map.



One major difference in public health concerns between conventional and unconventional resource extraction, like high volume hydraulic fracturing, is the injection of all this fluid. So in addition to methane migration, which is a serious concern in itself, you have the additional presence of industrial chemicals, many at toxic concentrations.

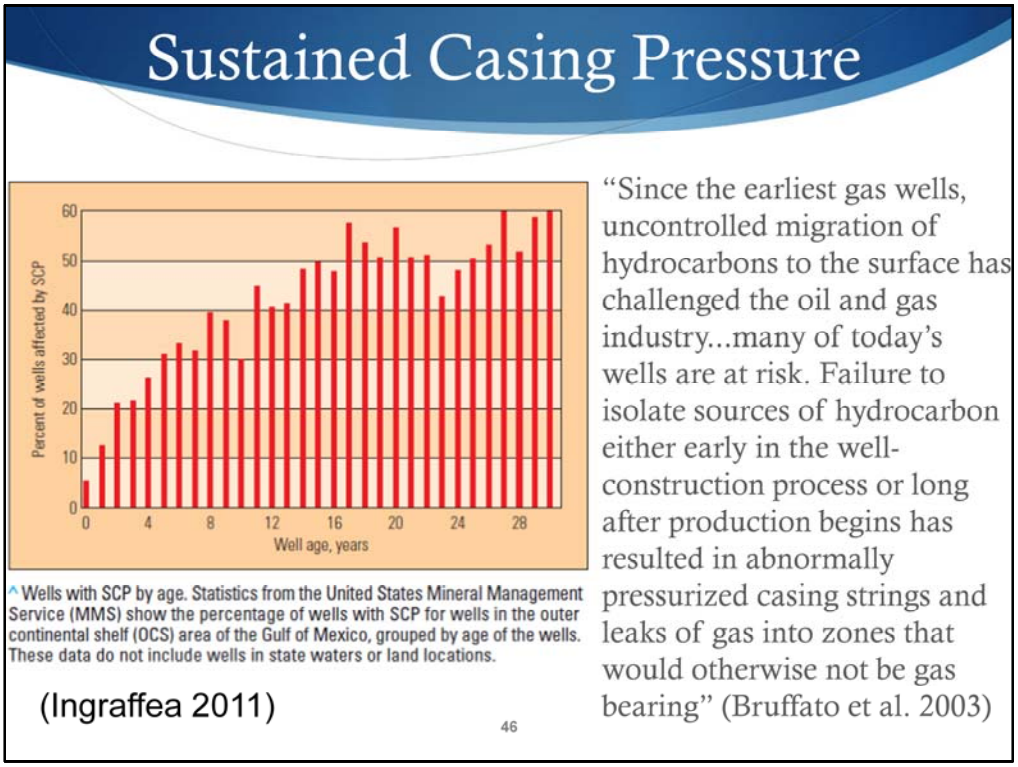
The most common form of water contamination has been to surface water, although above ground spills can contaminate both surface and groundwater resources.



As for methane migration, some experts have expressed the opinion that if we had increased domestic extraction of conventional gas resources we may have still experienced these same issues with methane migration.

As for the fluid itself, a recent study by Boufadel in 2012 used computer modeling to determine that natural faults and fractures in the Marcellus, exacerbated by the effects of fracking itself, could allow chemicals to reach the surface in as little as "just a few years."

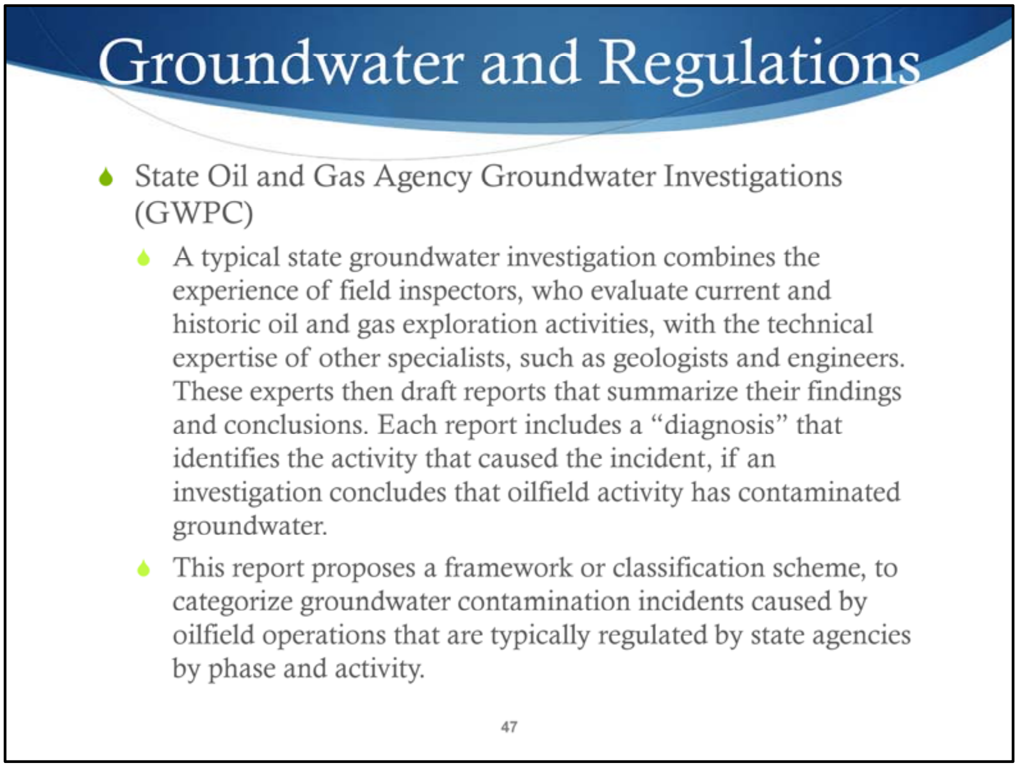
The models predict that fracking will dramatically speed up the movement of chemicals injected into the ground. Fluids traveled distances within 100 years that would take tens of thousands of years under natural conditions. And when the models factored in the Marcellus' natural faults and fractures, fluids could move 10 times as fast as that.



And what does history tell us??

Operator-wide statistics in Pennsylvania show that about 6-7% of new wells drilled in each of the past three years have compromised structural integrity.

It is too early to discern whether the other industry experience with this technical problem, an increase in loss of integrity with well age, will also be reflected. However, at play in modern shale gas development are many of the key factors identified by industry researchers as having a negative influence on well structural integrity: the need for deviated wells, rapid development of a field, presence of "shallow" high-pressure gas horizons, and disturbance of young cement due to adjacent drilling activities on the same pad. - See more at: http://www.damascuscitizensforsustainability.org/2012/11/well-casing-failures-explained/#sthash.voTa7gSM.dpuf



So how are these issues regulated and diagnosed?

Well each state has their own methodology, but the Groundwater Protection Council (an industry funded group) has published recommendations for states.

In it they break down a process for diagnosing the source of contamination. It includes a category for "stimulation" activities, specifying hydraulic fracturing.

Classifying Causation

Activity/ Phase	Potential Sources	Potential Contaminants	Possible Contaminant Release Mechanisms
3.) Well Stimulation (including hydraulic fracturing)	a.) Storage tanks for stimulation fluids and additives prior to stimulation	Stimulation fluids and additives	Storage vessel or pressurized line leaks followed by inadequate secondary containment and/or corrective action
	b.) Pumping directly into an aquifer (typically for stimulation of shallow coal bed methane bearing zones)	Stimulation fluids and additives	Direct pumping of stimulation fluids containing additives in sufficient volume and concentration to degrade groundwater quality
	c.) Migration of pumped fluids from a stimulated oil and gas reservoir hydraulically connected to an adjacent aquifer	Produced water / stimulation fluids, brine and petroleum hydrocarbons	Vertical migration of stimulation fluids into an aquifer
	d.) Out-of-zone stimulation	Produced water / stimulation fluids, brine and petroleum hydrocarbons	Failure of the production casing primary cement job,and failure to monitor and terminate the job as a result of abnormal annular pressure readings, and vertical migration.
	e.) Storage tanks for containment of flowback fluids following	Produced water / stimulation fluids, brine and petroleum hydrocarbons	Tank failure or flow line leaks followed by inadequate secondary containment and/or corrective action, or impoundment failure
	f.) Impoundments for temporary storage of flowback fluids	Produced water / stimulation fluids, brine and petroleum hydrocarbons	Synthetic liner failure, overtopping, or flow line leaks

The other activities of course are site preparation, drilling and completion, production including on-lease transport and storage, waste management and disposal, plugging and reclamation, and orphaned wells and sites.

The suggested use of this table is to guide consistent classification of groundwater contamination incidents identified by state agencies, but is not intended to be an exhaustive list.

For our next activity we are going to all play the role of regulators, and use the GWPC's table of guidelines to evaluate and classify the source of contamination

I am going to present several scenarios here. We are going to go through each one case by case, and in your small groups I would like you to discuss and answer two questions.

1. What is the source of contamination?
2. Is the contamination a result of hydraulic fracturing?

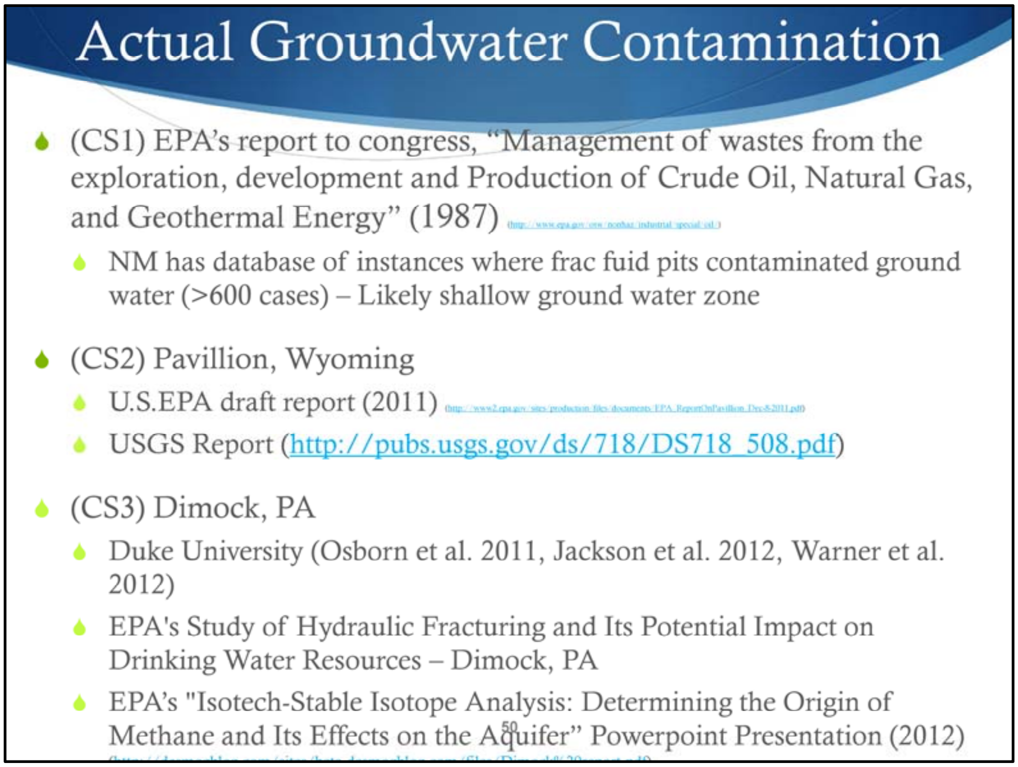
When you havee an answer to these questions, please raise a hand so I can have your group answer the two questions.

CS1: It is likely that that the unlined pits contaminated groundwater but there is not before and after sampling so it is inconclusive

CS2: The groundwater contamination is most likely due to migration from the boreholes. There is not a tracer, or before and after comparisons, so again it is impossible to conclusively rule out pre-existing conditions.

CS3: In this case, there are isotopic ratios, increasing concentrations with activity and proximity, and before and after sampling, that identify unconventional development activity as the source…..

Yet, this is not caused by hydraulic fracturing! And we will get into "why" in a moment.



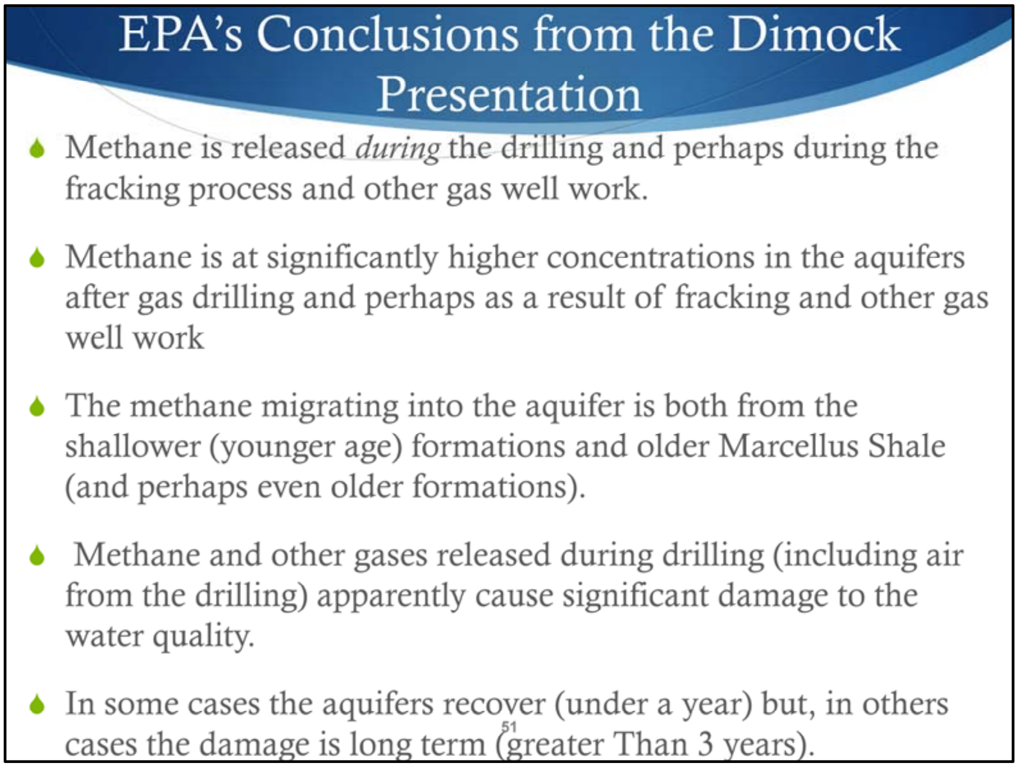
Of course these hypothetical scenarios are all actual documented contamination events. There are EPA records of all these events.

CS1: EPA reported on a clear case in which hydraulic fracturing fluids and natural gas from production operations contaminated a groundwater well in West Virginia, "rendering it unusable."

CS2: From the 2011 pavilion, WY EPA draft report, that showed extensive presence of fracking chemicals (natural and synthetic) in shallow and deep groundwater systems. Some of this contamination may have resulted from faulty wells drilled through groundwater aquifers; some of it may have resulted from surface seepage of fracking waste fluids escaping from badly designed and managed wastewater pits.

CS3: Results of the groundwater studies in both Pavilion, WY and Dimock, PA showed contamination of groundwater and identified the source

Duke University researchers found apparent migration of substantial amounts of methane from gas wells to private water wells as far out as 1000m in the Marcellus play in Pennsylvania. Documented geochemical evidence for possible natural migration of Marcellus formation brine to shallow aquifers in Pennsylvania.



This is transcribed directly from the EPA presentation

Hightlights from the presentation include quotes such as "Drilling creates pathways, either temporary or permanent, that allows gas to migrate to the shallow aquifer near [the] surface…In some cases, these gases disrupt groundwater quality."

They also cited contamination by manganese and arsenic.

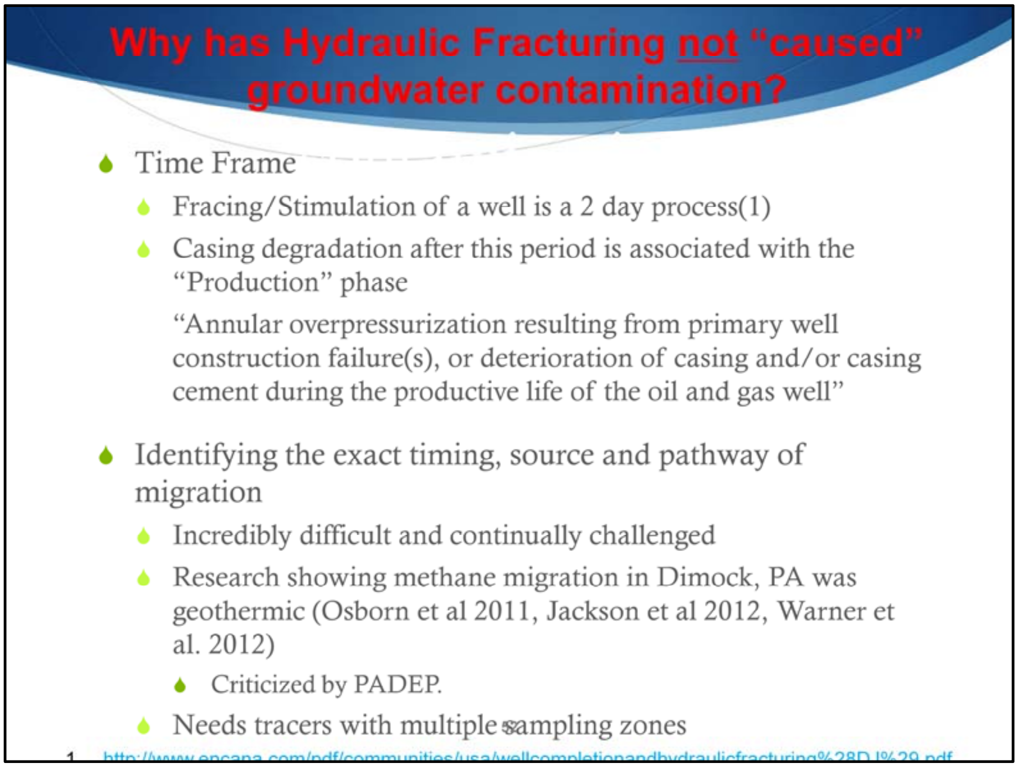
Of course the date of this report coincides with the 2012 election and was censored, while an official desk statement was issued saying the water in Dimock was safe for consumption.

It seems unbelievable that the EPA would stop this study, but this has been the trend of a series of events:

In March 2012, the EPA gave up on an investigation of methane in drinking water in Parker County, Texas, despite the fact that a geologist hired by the regulator confirmed that the methane was from gas production

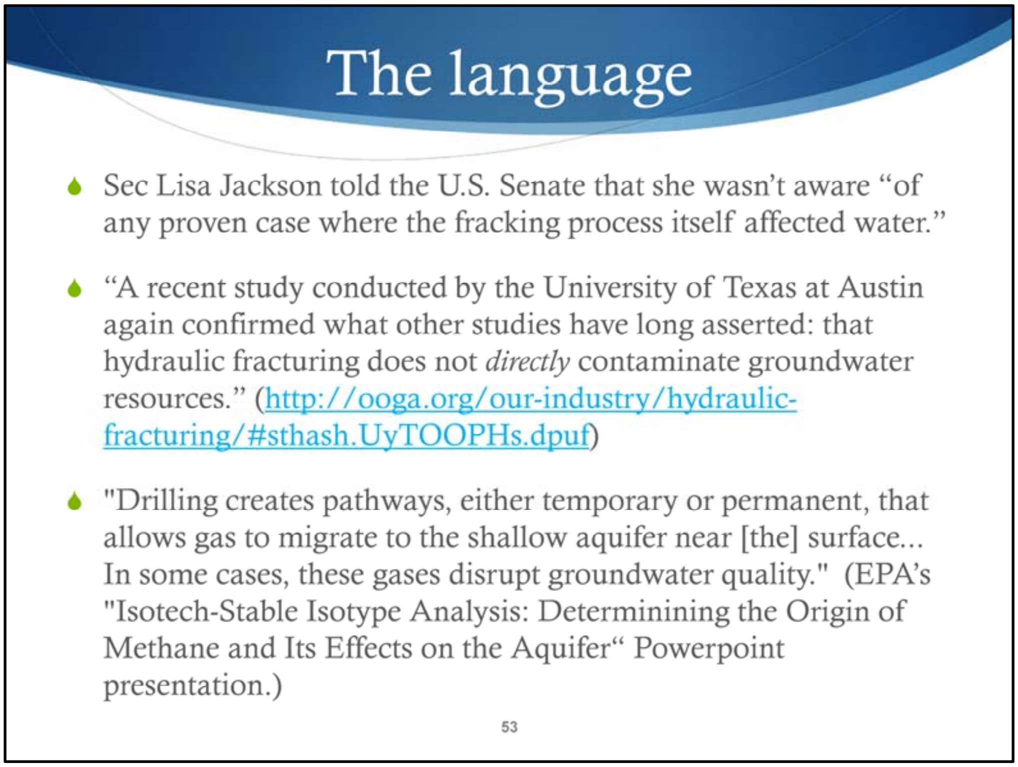
And just recently in June 2013, the EPA cancelled the groundwater study in Pavillion, WY.

You would think this data would provide enough evidence to warrant further study to understand it better.



What are the arguments against these cases being classified as the result of frac'ing?

Hydraulic Fracturing as a technical term is strictly limited to the actions of injecting fluid into a wellbore. This is stimulation. Even if this is a component in the failure of a well casing, which is often very hard to distinguish, implications that hydraulic fracturing plays a role in over-pressurization or degradation or migration through strata has been rejected by industry and policymakers alike. And any case of groundwater contamination in a hydraulically fractured well is attributed to other sources, typically well casing failures. The language used in discussing groundwater contamination from wells that have been hydraulically fractured very much reflect this sentiment.



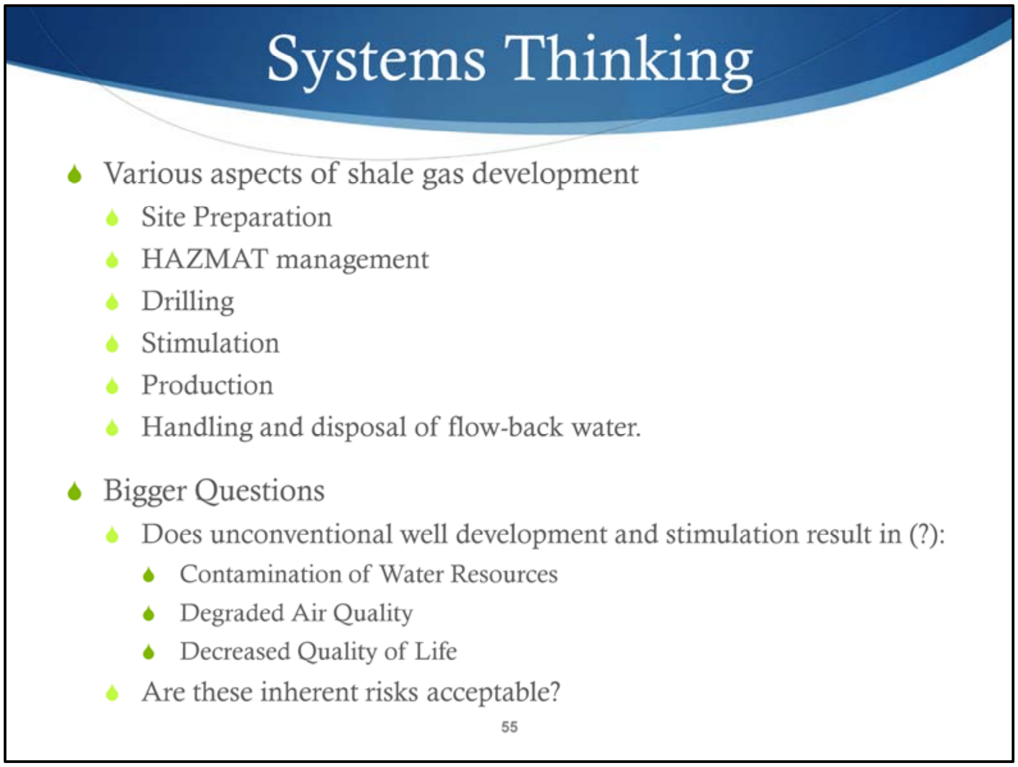
Industry rebuttals maintain that "hydraulic fracturing does not directly contaminate groundwater resources." Ohio Oil and Gas Association.

Commentary by the EPA and the current administration is similarly phrased, such as the response to the 2011 Pavilion, WY draft report. A letter from Sec Lisa Jackson to the governor states "I draw your attention to the careful language with which our conclusions are couched. We make clear the causal link to fracturing has not ben demonstrated conclusively." The study was then handed over to the state and funded by EnCana Corps., the drilling operator who's wells are being investigated.

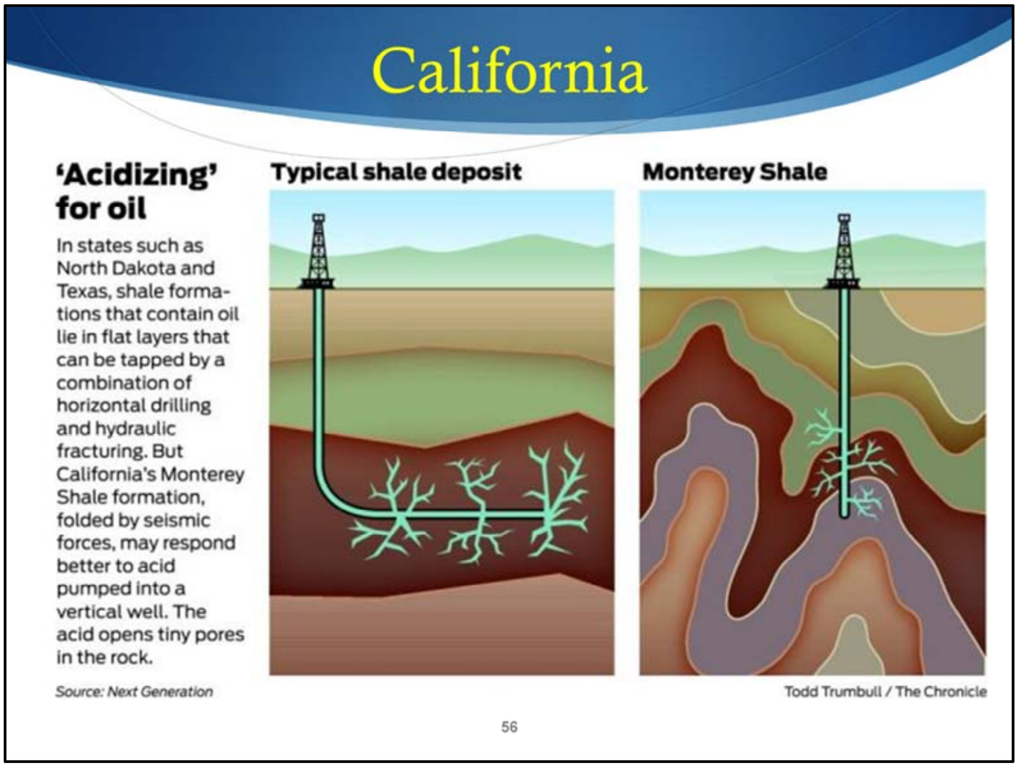
When it comes to ground water, why is high volume hydraulic fracturing being treated as completely separate issue than conventional oil and gas extraction by both industry and environmental advocates.

Advocates say the consequences and risk is larger on a well vs well basis, while industry says it is less invasive than drilling a much greater numbers of vertical conventional wells.

Then again, if this isn’t invasive



From a public health perspective, it is obvious that we should be considering the full process of unconventional development, rather than debating semantics. The full life-cycle of impacts should be considered rather than each individual phase of development individually. For that reason, systems thinking makes the most sense, like in other industries.



To wrap up my presentation, I would like to draw your attention to the unique case of California and the Monterey Shale.

Development of this resource will require the creation and implementation of new and different techniques. The most promising technique for Monterey shale development looks to be acidizing, where a mixture of hydrofluoric and hydrochloric acids are injected to dissolve the shale and increase pore permissivity. The newly passed regulations (SB4) will monitor development and two separate studies are being planned in the state. Yet the regulations disallow any type of state moratorium between now and 2015. As California and other states more forward, public and environmental health need to be prioritized.

Thank you for having me. Questions?

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Thanks to my coworkers at CHEC and FracTracker for assistance with this presentation.

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