Minutes of February 10, 2014, meeting of the Marcellus Shale Safe Drilling Initiative Advisory Commission

Approved April 14, 2014.

The Commission held its 25th meeting at The Department of Natural Resources and at the Garrett County Health Department (via webinar hookup and conference line) on February 10, 2014 beginning at 10:00 am. In attendance at the DNR location were Chairman David Vanko and Commission members Steve Bunker, Jeff Kupfer, Dominick Murray, Nick Weber and Harry Weiss. At the Health Department location were Commissioner James Raley, Paul Roberts, Mayor Jamison and Ann Bristow. Shawn Bender attended by conference call only. Also in attendance were MDE Secretary Bob Summers, staff of state agencies and members of the public.

Chairman Vanko called the meeting to order and explained the webinar protocol. The Commissioners introduced themselves.

Minutes of the January 6, 2014 minutes were approved.

The first speaker via webinar was Professor Anthony Ingraffea of Cornell University, who spoke on the Risk of Cement/Casing Failure: Leaking Wells. Dr. Ingraffea described how he collected data on over 41,000 gas and oil wells drilled in Pennsylvania since 2000; mined the data to identify wells with borehole integrity problems, and analyzed the results using the Cox Proportional Hazard Model. His observations and conclusions were:

1. At least 13% of all Marcellus wells drilled statewide in Pennsylvania since 2009 will experience loss of zonal isolation.
2. At least 45% of the unconventional wells drilled in Northeast Pennsylvania counties since 2009 will experience loss of zonal isolation.
3. Post-2009 unconventional wells in the Northeast Pennsylvania counties will experience loss of zonal isolation at a higher rate than pre-2009 wells.

Professor Ingraffea suggested that risks to drinking water wells could be mitigated in Garrett and Allegany Counties by:

- Permitting fewer gas wells and locating them appropriately
- Establishing long setbacks from drill pads (Example: Dallas, TX 2500 feet
- Inspecting frequently and vigorously enforcing
- Inspecting more thoroughly, recognizing that not all leaks produce bubbles.

To mitigate against greenhouse gas emissions, he recommended:

- Frequent inspections and tough enforcement for the life of the well
- Thorough inspection, realizing that gas migration can occur away from the wellhead

During the question and answer period, the following points were made:

- Leakage does not always result in contaminated groundwater; for example, the leak could be contained within the casing. Each well is different, and one would have to look at the annular pressure, the hydraulic connection to water wells, and other factors.

- Leaks occurring between casings are difficult to repair. Dr. Ingraffea said that "squeeze jobs" are about 50% effective.
- The proximity on multi-well pads of the different wells could put additional stress on casing and cementing integrity on other wells when one is drilled or fractured. He hypothesized that refracturing a well could also pose a risk of damaging the casing or cement of the refractured well and other wells on the same pad.
- The geology of Northeast Pennsylvania is similar to Garrett County. [In a later email, Dr. Ingraffea explained that the similarity is the complexity of the geology. An important measure of the complexity of the geology is rapid change in depth of the formation, because this can indicate folding/fracture/faulting. There are counties in NE PA where there are very rapid depth changes and where there have been significant problems with wellbore integrity. One sees the same characteristic beneath Garrett County. There are many counties in SW PA where such gradients do not occur. Hence his statement that the Marcellus shale geology beneath Garrett county is similar to that of a number of NE PA counties, and somewhat dissimilar from the westernmost SW PA counties.]
- Maryland should consider what rate of well failure we are willing to tolerate; how many wells should be drilled; and what the cost would be, then weigh the costs and benefits.
- In response to a question about what Maryland should do if it is serious, Professor Ingraffea said to adopt the largest setback industry will tolerate; inspect and enforce; realize that things can and do go wrong, and when they do, fix them and make the industry pay for the remediation.
- The data do not show a correlation between the leakage rate and the size of the operator.
- It is too early to tell whether the more protective casing and cementing practices adopted in Pennsylvania in 2011 would result in fewer failures.
- Cement serves more than one purpose and the best cement for providing strength may not be the best sealant against groundwater.
- The highest risk of methane migration occurs when the drill is passing through the aquifer, before the casing and cement are installed; another risk is the failure of the surface casing and cement.
- There is currently no real time device for detecting a developing leak, but technology improves over time. Perhaps subterranean probes could be installed away from the wellhead to detect stray gas.

The second speaker, also by webinar, was Dr. Zacariah Hildenbrand, who discussed characterizing groundwater quality in area engaged in unconventional drilling, based largely on his 2013 paper, An Evaluation of Water Quality in Private Drinking Water Wells Near Natural Gas Extraction Sites in the Barnett Shale Formation. He discussed the possible contamination of surface water and groundwater by waste pits, fluid spills, pipeline leaks, and in the event there were a hydrologic connection with deep fractures, but also postulated that the contamination could be indirect, in that the vibrations could liberate heavy metal ions from scale and rust in poorly maintained drinking water wells. The change in pH supports this hypothesis. He emphasized the importance of pre-drilling sampling for comparison with post-drilling samples and explained the capacity of his laboratory to do analyses.

During the question and answer period, the following points were made:

- Setbacks limit the number of wells and protect groundwater. Dallas has a setback of 1500 feet from a residence, while Fort Worth fought to get a 1000 foot setback.
- It was noted that Total Dissolved Solids (TDS) actually dropped in water sample after gas development. Dr. Hildebrand agreed, but said that some of the post-development TDS levels were very high.
- It was noted that groundwater moves very slowly – on the order of a few feet per year. The heavy metals had not likely traveled 3 to 5 km from the gas well to the drinking water well in the time period after drilling. This might support the idea that heavy metals might be released at a distance.
- Dr. Hildebrand said that he thought it was unlikely that contaminants could migrate upward 8,000 feet, but that vibrations could be generated vertically or horizontally.

Two representatives from ATK, Steve Moore and John Arrell, were at the Annapolis meeting and presented information on the use of solid rocket propellant as an alternative to hydraulic fracturing using water or another fluid. This well stimulation method would not require water or proppant, would use fewer chemicals, and would produce much less wastewater. ATK has used the technique in a number of wells worldwide with positive results. They need more data to develop a modeling tool. In response to questions, they indicated

- The propellant produces the typical byproducts of combustion: H2O, CO, CO2, and some HCl. The Gas Technology Institute is preparing a report on the topic that should be released in 6 months.
- When the propellant explodes at depth, it rocks the casing. ATK wants to do cement bond logging pre and post well stimulation to determine if there is an effect.
- The propellant breaks the formation into irregular shapes that won't close completely, eliminating the need for proppant.
- The fractures made by propellant can extend in 360 degrees, but travel only tens to hundreds of feet as compared to hundreds to thousands of feet for HVHF. Propellant will generate more surface area.
- There is no danger of igniting the methane in the well because there is insufficient oxygen to support a burn. The propellant carries its own oxygen.

Following a lunch break, Mike Parker, who was involved in the development of API's hydraulic fracturing standards and recently retired from Exxon Mobil, spoke. He advocated the use of API standards, practices and guidance in developing recommended practices. He suggested that the CGDP should not be required for exploratory wells, or that there be an exploration plan before the CGDP. What is learned in the exploratory phase may completely change the 5-year plan. He said monitoring data can be useful to fill data gaps. On the topic of chemical disclosure, he said he did not see a problem with pre-job disclosure, but suggested that there be a clearinghouse or library that service providers could populate with chemical information rather than having the permit applicant do it. He said that there must be some provision for last minute substitutions and changes. He noted that states can get data from FracFocus.

On the question of setbacks, he said that setbacks can be set to protect an aesthetic attribute or to assure that an environmental standard (air or noise levels) will be met. Any setback is arbitrary. A 2000 foot setback with a weak spill prevention and response plan is not as protective as a 500 foot setback with an excellent plan.

He noted that all wells need maintenance over time. He has a different view on casing and cement failures than Dr. Ingraffea; sometimes systems have redundancy, so that failure of one system has no effect because the other system prevents it. For example, a tank may leak, but the leaked material is caught in the secondary containment structure. He also stressed that the well operators perform inspections frequently. The casings are protected against corrosion (cement is a corrosion inhibitor); company staff may check annular pressure frequently. There are tools that can be run downhole, but interpretation is an art.

Mr. Parker said that the study of the wells in the Barnett shale has flaws. Nine of the nine reference wells were actually in a different aquifer than the study wells. Also 2011 was an extreme drought; this was not taken into account.

In exchanges with Commissioners, he said he thought the 90% recycling of flowback on site was unworkable. He said the usual practice is to fracture all the wells on a pad in sequence. Requiring onsite recycling would increase the size of the pad. The current practice is to have a centralized site to store and treat the wastewaters. The treated wastewater can then be used at other sites. One Commissioner asked if companies would release their inspection reports. Mr. Parker said that operators usually log their observations in field notebooks and only report to the state if there is a problem. Violations may be self-reported that caused no release or damage. Another Commissioner asked if the companies are carrying out their own contamination studies and how many of the claims brought against companies were valid. Mr. Parker said that he was not involved in evaluating lawsuits and could not comment. Mr. Parker said there were remote monitoring devices; one can see the array at the well site for beaming data to the company.

Mr. Parker said that trade secrets are valuable to the companies that develop and sell the products, and that confidentially should be preserved. He said that disclosure to health professionals could be done in a matter of minutes. Service providers have 1-800 numbers and first responders can get the information quickly. Commissioner Bristow asked about workers' exposure to silica from sand used as a proppant and referenced a 2012 National Institute of Occupational Safety and Health (NIOSH) hazard alert for worker exposure to silica during hydraulic fracturing. She asked whether Mr. Parker was aware of any biological monitoring for silica. He said that he was not aware of any, but that OSHA standards apply on-site to protect workers from exposure to hazards such as silica. He said that he thought there might have been some monitoring for silica off-site that did not show high exposures. Commissioner Bristow asked that he provide a reference for that data. [In a later email, Mr. Parker said that he had heard about the off-site data but that it had not been published. He also provided a link to a Respirable Silica Focus Group organized by The National Service, Transmission, Exploration & Production Safety (STEPS) Network, www.nationalstepsnetwork.org/initiatives_respirable.htm and to an article that is attached to these minutes.]

When asked about fracture length, Mr. Parker referred to an article by Kevin Fisher for the proposition that there is no evidence to support the argument that fracturestravel from the target formation to reach groundwater. A commissioner asked for the reference. [After the meeting, Mr. Parker provided

the document, which is attached. He also sent a citation to the same material in a technical journal.Du, J., Warpinski, N., & Fisher, K. (2010, January 1). Fracture Diagnostics And Reservoir Monitoring Using Microseismicity And Deformation-based Measurements. Society of Exploration Geophysicists.]

Mr. Parker could not say how many exploratory wells should be allowed before an operator should be required to develop a CGDP because each site and tract is unique. Multiple exploratory wells would not be drilled on a single pad; the wells would be spaced to prove the value of the larger tract. He said there could be 4 or 5 wells for thousands of acres.

When asked about the ATK technology, Mr. Parker said that the companies try to work out the best system for specific boundary conditions. He noted that, with the shorter fractures, it seems that more wells would be required if propellant were used. He also wondered whether the exploded rock will stay open without proppant. The question is which method best provides a safe and profitable option.

Assistant Attorney General Stephanie Cobb Williams and Brigid Kenney gave a presentation on trade secrets. The main point was that the law recognizes trade secrets as intellectual property and protects it. Various laws make provision for disclosure for health care reasons. The various provisions were briefly explained.

Commissioner Roberts was asked to report on his efforts to formulate a compensation plan for persons disproportionately impacted by HVHF. He expressed dismay that the severance tax bill had been introduced without a consideration of what funds would be needed for the compensation system. He said that he had held two public meetings and would propose a program modeled on Maryland's superfund law (Environment Article, Title 7, Subtitle 2).

There was a brief discussion of the 2014 legislative session. There was no consensus on whether the Commission should take a position on bills introduced that relate to Marcellus Shale activities, and the discussion was suspended.

Ms. Kenney noted that information requested by Commissioners at earlier meetings had been circulated in advance.

Commissioner Bristow voiced her concern that the Advisory Commission will be able to meet the August 1, 2014 deadline for the final report.

The public was then invited to comment.

Eric Robeson of Citizen Shale asked if the Gas Chromatography Mass Spectrometer(GCMS) installed at Piney Run would be capable of running analyses comparable to Dr. Hildebrand's on water samples. [Ms. Kenney later consulted MDE staff and found that the answer is no.] He said that FracFocus is voluntary and the state should have its own site for communicating the information on chemicals used. He said that setbacks should not be arbitrary, they should be based on science.

John Quilty, who chairs the Garrett County Commissioners' Shale Gas Advisory Committee, asked how we should evaluate and judge competing views. Ms. Kenney said that the state will evaluate the available information and explain what position the state is taking and why.

Tim Whitehouse of Physicians for Social Responsibility suggested that Maryland look at the Illinois and California rules for disclosure of trade secret chemicals. He said that the OSHA standard places too heavy a burden on a health professional who needs the information for other than emergency care. He said MDE should not put itself in the position of deciding if a trade secret claim is valid.

Rebecca Ruggles of the Maryland Environmental Health Network requested that the Commission arrange to hear from medical practitioners in areas where shale gas production is occurring to learn about their experiences. She said that this information would be different from what the health study is gathering. Chairman Vanko said that the Commission is receptive and will ask for recommendations before inviting anyone.

Aaron Mintzes of EarthWorks made four brief points. Industry has not offered any justification for exempting exploratory wells from the CGDP except industry convenience. Two years of baseline data is critical. There needs to be vigorous enforcement of whatever regulations are adopted. In addition to Illinois and California, we should look at the rules Alaska is proposing for disclosure of trade secrets.

Patrick Hammond, a hydrogeologist who retired from MDE in January 2013, spoke about his experiences in performing interference tests in areas of consolidated sedimentary rock. He said that in his experience, wells as far apart as 5,000 to 6,000 feet could be hydraulically connected. He noted that the current oil and gas regulations were developed in response to a proposed wildcat well in Charles County in the Coastal Plain. He said that he recommended that the state issue a permit for an exploratory well. The well was a dry hole, and very few wells have been drilled since. The current regulations are silent on hydraulic fracturing and should be amended.

James "Smokey" Stanton noted that the Commission's job is to weigh the evidence in the various presentations and develop the gold standard.

John Veil, a consultant who formerly worked at MDE and the Argonne National Laboratory, commented on the Duke report that found a correlation between elevated methane and proximity to a gas well. He said that the same data had been analyzed by Molofsky, who found that the data showed a correlation between elevated methane and topography, providing another plausible explanation of the data. [After the meeting, he provided additional information: "Those researchers initially published their findings in the December 5, 2011 issue of Oil and Gas Journal (http://www.ogj.com/1/vol-109/issue-49/exploration-development/methane-in-pennsylvania-water-full.html). They later augmented the data set and published an expanded version of the article in Groundwater (http://onlinelibrary.wiley.com/doi/10.1111/gwat.12056/pdf.)"] He also noted that, while FracFocus is voluntary, several states have enacted regulations requiring that oil and gas producers disclose their chemical usage through FracFocus.

The meeting adjourned about 4:00 pm.

Understanding Silica Exposure

By JOHN SNAWDER, MICHAEL BREITENSTEIN,
ERIC ESSWEIN, W. KARL SIEBER and MAX KIEFER
Centers for Disease Control and Prevention (CDC),
National Institute for Occupational Safety and Health (NIOSH),
Oil and Gas Extraction Safety and Health Program

The National Institute for Occupational Safety and Health (NIOSH) is conducting research to identify possible workplace exposures in oil and gas extraction. This article describes results and conclusions of wellsite measurements for respirable crystalline silica associated with the use of silica sand—the primary proppant used in hydraulic fracturing. To learn more about frac sand see Well Servicing, January/February 2012, Where Does Frac Sand Come From?

It is important that supervisors and employees understand that silica sand may contain up to 99 percent crystalline silica and depending on the concentration and duration of exposure, breathing fine dusts containing respirable crystalline silica can pose an occupational health hazard. Inhalation of respirable crystalline silica is associated with silicosis and lung cancer. For more information visit the OSHA-NIOSH Hazard Alert on the web and the NIOSH Science Blog.

The study
NIOSH partnered with operators and service companies to evaluate worker exposures to respirable silica at 11 completion sites in five states (CO, TX, ND, AR and PA). The majority of work involved slick water completions with a variety of silica sand (20/40, 40/70 and 100 mesh) and in some cases resin coated and ceramic proppant. Samples were collected in different weather conditions, altitudes and geographic locations. Workers who participated wore sampling equipment designed to collect full shift (typically 12 hours) personal breathing zone (PBZ) samples. Samples were analyzed by an American Industrial Hygiene Association accredited laboratory. Samples were analyzed first by weight for respirable dust and then by X-ray diffraction for crystalline silica. Quartz, a type of crystalline silica, was the only mineral detected above the limit of quantitation.

PBZ sample results were compared to occupational exposure limits (OELs) for respirable silica exposures. The Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) is not a fixed value like hydrogen sulfide (H2S) or carbon monoxide, it is calculated for each sample based on the percentage of silica present in the dust sample using the formula: 10mg/m3 ÷(%silica + 2). As an example, if the percentage of silica is 100 percent, the PEL is 0.098 milligrams of silica per cubic meter of air (mg/m3). The NIOSH recommended exposure limit (REL) for respirable silica is a fixed value (0.05 mg/m3) and the American Conference of Government Industrial Hygienist's Threshold Limit Value (TLV) for respirable silica is fixed at 0.025 mg/m3. Each of these exposure limits is a time-weighted average (TWA) for a work day.

Results
Employees who worked around sand movers (74% of the samples were above the PEL), transfer belts (83% of the samples were above the PEL) and blenders (50% of the samples were above the PEL) during sand moving and transfer operations—especially during hot loading—were more at risk for silica exposures than employees who worked farther from sand moving operations or who were upwind.

However, silica exposures exceeding the OELs were documented for sand coordinators who primarily worked upwind and not in the immediate area of sand movers (exposures likely due to dust generated from wellsite traffic) or who worked downwind from sand moving operations (e.g., water tank operators). Employees in data vans were protected because doors on the data van were always kept closed. However, chemical truck operators and blender operators working in cabs were sometimes overexposed to silica despite spending most of the day inside their trucks or cabs (which did not have fine particulate filtration or tight-sealing doors).

Sources of silica dust generation

Based on workplace observations NIOSH researchers identified eight (8) primary points of dust release or generation from completions equipment or workplace operations (Figure 1).

Figure 1 - Eight Primary Points of Dust Release or Generation from Completions Equipment or Workplace Operations

1. Dust ejected from thief hatches on top of the sand movers during refilling operations.
2. Dust ejected and pulsed through side fill ports on the sand movers during refilling operations.
3. Dust generated by on-site truck vehicle traffic including sand trucks and crew trucks, the release of air brakes on sand trucks and by winds.
4. Dust released from the transfer belt under the sand movers.
5. Dust created as sand drops into, or is agitated in the blender hopper and on transfer belts.
6. Dust released from operations of transfer belts between the sand mover and the blender.
7. Dust released from the top of the dragon's tail on sand movers.
8. Dust deposited on and released from worker's coveralls.

Controls for reduction/elimination of silica exposures

NIOSH working together with industry partners and the National STEPS Network, Respirable Crystalline Silica Focus Group (a volunteer organization comprising E&P operators, industry trade associations, completions companies, OSHA, and individual occupational safety and health experts), has identified controls that can be implemented immediately. Some controls are simple; some are more complex. The following controls are listed in

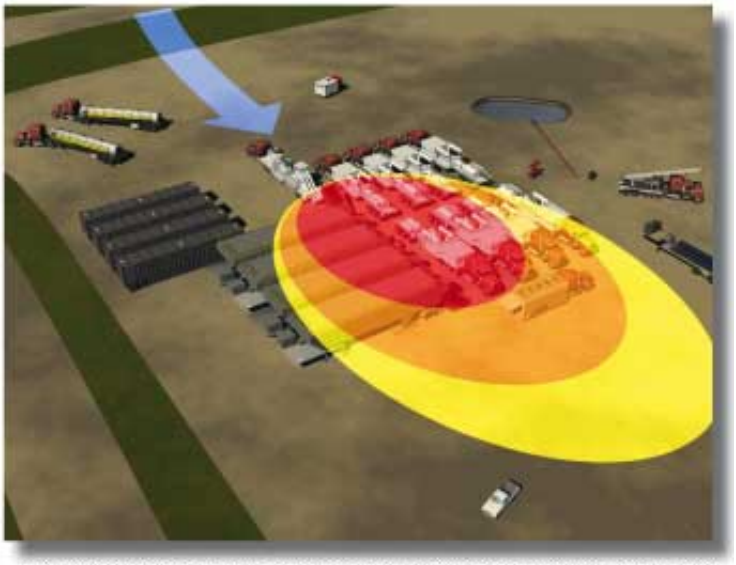
order of increasing complexity, costs and time to develop, as well as from the primary point sources of silica generation.

- Train employees on the hazards of silica exposures, locations of silica dust generation and the types of controls that are used to prevent exposures (see sidebar). Instruct employees to remove silica dust from hands, face, clothing and personal protective equipment (PPE) prior to leaving the wellsite and provide cleaning instruction for contaminated PPE including clothing. If silica cannot be removed from clothing instruct employees to change into clean clothes at the end of their work shift.
- Train sand truck delivery drivers to use lower air pressures (10 p.s.i. or less) when off-loading sand into sandmovers.
- Keep thief hatches on top of sandmovers closed as much as possible, especially when filling.
- Ensure that unused fill ports on sandmovers are capped. Capping unused fill ports eliminates silica dust release during filling. If the caps are missing, stuffing the opening with a rag can help reduce dust generation.
- Limit the number of workers, and the time spent in areas where dust and silica levels may be elevated; consider ways to perform dusty operations remotely.
- Minimize the drop height between the dragon tail and T-belts and blender hoppers. Limiting the distance that sand falls through the air can help reduce dust.
- Employ dust controls at the wellsite.
- When engineering and work practices controls do not control workplace exposures below OEL's, employers must provide respirators for workers. Whenever respirators are used, the employer must have a respiratory protection program that meets the requirements of OSHA's Respiratory Protection Standard (29 CFR 1910.134). This program must include proper respirator selection, fit testing, medical evaluations and training in worksite-specific hazards. Half-face respirators are not likely to be completely protective; use of respirators that offer more protection (e.g., a full-facepiece respirator, which will protect workers at silica levels up to 50 times the PEL) are likely to be needed in the absence of effective engineering controls. Full-face powered air-purifying respirators (PAPR) provide more protection than half-face airpurifying respirators. In general, workers find PAPRs to be more comfortable.

Practices that involve equipment changes/modifications:

- Use passive enclosures on machinery where silica dust can be released. Installation of plastic or heavy cloth stilling or staging curtains around the bottom sides of the sand movers can limit dusts released from belt operation. Hardsided enclosures can also be added along and at the ends of the dragon tail and along sand transfer belts.
- Install appropriate ventilation engineering controls (on-board filtration, aftermarket baghouses) that effectively contain release of respirable silica dust from sand movers.
- Investigate and install alternative ways to transfer proppant including slurry systems, use of screw augers instead of belts on sand movers and non-pneumatic transfer systems such as gravityassist silos.

Figure 2 - Effect of Wind (Blue Arrow) and the Potential for Windborne Movement of Crystalline Silica during Sand Handling and Transfer During Completions



Until dust controls are in place on sand movers, T-belts or sand delivery trucks, workers within the red zone should be adequately protected with proper use of a full-face respirator and P-100 cartridges (assigned protection factor = 50). Workers within the orange zone should be adequately protected by proper use of a half-mask, elastomeric facepiece respirator (P-100 cartridges) or N-95 or greater (e.g., P-100) filtering facepiece respirator (both respirators have assigned protection factors of 10). Unprotected workers should avoid the area within the yellow oval or be in that area only when wearing properly fitted, N-95 (or greater) respiratory protection.

Summary

Exposure to respirable crystalline silica is an occupational health hazard for completions crews. Sand mover and blender operators appear to be at greatest risk for exposures but other crew members have exposure risks as well.

Until a variety of engineering controls can be developed and implemented, employers and employees should:

- Restrict access to areas with potential exposure to respirable silica to workers trained to recognize and avoid silica hazards and post signs warning of the silica hazard (Figure 2).
- Conduct personal breathing zone sampling for silica. Workers should participate in all air monitoring or training programs offered by the employer.
- Where respirators are required, workers must wear respirators approved for protection against crystalline silica-containing dust with an assigned protection factor based on the risks determined.
- Clean contaminated work clothing using clothes cleaning booths or change into clean clothing before leaving the worksite.
- Do not eat, drink or use tobacco products in areas where there is dust containing crystalline silica.

NIOSH is looking for additional E&P industry partners to work with us to evaluate worker exposures to chemical hazards and develop controls as needed, any of the authors can be contacted for more information.

Resources

- OSHA has an InfoSheet for completion workers that addresses potential exposures to respirable silica during hydraulic fracturing http://www.osha.gov/dts/infosheets/silica_hydraulicfracturing.html.
- For information on silica hazards and ways employers can protect workers and workers can protect themselves OSHA and NIOSH have jointly prepared "A Guide to Working Safely with Silica. If it's Silica, It's Not Just Dust" http://www.cdc.gov/niosh/pdfs/silicax.pdf.

• NIOSH published Best Practices for Dust Control in Metal/Nonmetal Mining (NIOSH Informational Circular 9521) which discusses dust control in underground mining operations.
http://www.cdc.gov/niosh/mining/UserFiles/