Jason Sullivan

From: Charles Ritter <critter1841@gmail.com>
Sent: Saturday, December 8, 2018 3:07 PM
To: Jason Sullivan
Subject: [Ext] Fracking Induced Earthquake Data

Mr. Sullivan,

As discussed at the last Planning Board meeting on Tuesday, I promised to submit to you clear evidence that the fracking process causes earthquakes.

There is an abundance of evidence that the fracking process causes earthquakes. The fracking process is done in two steps. The first the actual “frack” followed by the “wastewater disposal”. It is the second step of fracking, the deep well injection step that causes about 98% of earthquakes. The wastewater lubricates subsurface stress that when relieved results in an earthquake.

The evidenced below should be more than adequate proof to support my position that fracking within 3 miles of Shearon Harris Power Plant or Harris Lake (that provides the critical control rod cooling) could cause a **nuclear event**, if the earthquake exceeds either:

- The design limit of the power plant or
- The design limit of the dam holding in the water essential to cool the control rods

Shearon Harris is built to withstand a 6.0 earthquake. To date the largest fracking process induced earthquake was a 5.6, much too close for comfort, considering our nuclear plant is especially vulnerable being built next to the Jonesboro fault line. This could be the perfect storm. Harris Lake dam is a rockfill/earth type dam of questionable ability to withhold the emergency cooling for our nuclear plant in the event of an earthquake.

It is better to be safe than sorry. In this case the consequences could be catastrophic if not properly addressed.

Thanks for your help in this matter.

Charles Ritter

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PS Further information available upon request

PROOF THE FRACKING PROCESS CAUSES EARTHQUAKES

https://insideclimatenews.org/news/19062015/yes-those-earthquakes-are-caused-fracking-boom-studies-confirm indicates that:

“Scientists at the University of Colorado Boulder and the **United States Geological Survey** analyzed data from earthquakes and more than 106,000 active injection wells across the central and eastern part of the nation, the largest such study to date. They found that "the entire increase in the number of earthquakes in the U.S. midcontinent is associated with injection wells," according to Matthew Weingarten, a doctoral candidate at the university who led the study.

Weingarten and his colleagues also discovered that wells blasting the most wastewater into the ground, and at a faster rate—more than 300,000 barrels a month—were more likely to be linked to earthquakes. Their research was published Thursday in the journal *Science*.

Similarly, two geologists at Stanford University discovered that greater seismicity in certain counties in Oklahoma was often preceded by 5- to 10-fold increases in the volume of wastewater injected. Their findings were published Thursday in the journal *Science Advances*.

These two papers, the latest in a series of studies on the issue, add to the growing consensus among scientists that the spike in mid-U.S. earthquakes is man-made—and the oil and gas industry is to blame. Conventional oil and gas production has always generated wastewater, but the boom in unconventional **fracking**, a method to extract previously elusive oil and gas reserves, has led to the production of much more water that needs to be injected below the surface, prompting disposal in seismic-prone areas.”

From a reference in the **USGS** research paper:

https://earthquake.usgs.gov/research/induced/references. References:

Hornbach, Matthew J. et al. (**2015**), Causal factors for seismicity near Azle, Texas, *Nature Communications, doi: 10.1038/ncomms7728*. in turn indicates that:

“The analysis therefore indicates subsurface stress changes associated with brine production and wastewater injection represents the most probable cause of recent earthquakes in the Azle area. The study highlights the need for better subsurface pore pressure and seismic monitoring to address future potential-induced seismicity hazards.”

Marcellus Shale fracking waste caused earthquakes in Ohio

Colin Schultz

Eos, Transactions American Geophysical UnionVolume 94, Issue 33

First published: 13 August 2013

Abstract

Abstract

Before January 2011, Youngstown, Ohio, had never had an earthquake since observations began in 1776. In December 2010 the Northstar 1 injection well came online; this well was built to pump wastewater produced by hydraulic fracturing projects in Pennsylvania into storage deep underground. In the year that followed, seismometers in and around Youngstown recorded 109 earthquakes—the strongest of the set being a magnitude 3.9 earthquake on 31 December 2011.

Here are many more **USGS** references supporting my position:

https://earthquake.usgs.gov/research/induced/references.php

Induced Earthquakes

USGS Publications

2016

- Choy, G. L., Rubinstein, J. L., Yeck, W. L., McNamara, D. E., Mueller, C. S., Boyd, O. S. (**2016**) A Rare Moderate-Sized (Mw 4.9) Earthquake in Kansas: Rupture Process of the Milan, Kansas, Earthquake of 12 November 2014 and Its Relationship to Fluid Injection, Seismol. Res. Letters, v. 87, p. 1-9, DOI: 10.1785/0220160100.

- NJ van der Elst, MT Page, DA Weiser, THW Goebel, SM Hosseini (**2016**), Induced earthquake magnitudes are as large as (statistically) expected, Journal of Geophysical Research: Solid Earth 121 (6), 4575–4590.

- Petersen, M.D., C.S. Mueller, M.P. Moschetti, S.M. Hoover, A.L. Llenos, W.L. Ellsworth, A.J. Michael, J.L. Rubinstein, A.F. McGarr, and K.S. Rukstales (**2016**), 2016 One-year seismic hazard forecast for the Central and Eastern United States from induced and natural earthquakes, *U.S. Geological Survey Open-File Report 2016-1035, 52 p., doi:10.3133/ofr20161035*.

2015

- Benz, Harley M., McMahon, Nicole D., Aster, Richard C., McNamara, Daniel E., and David B. Harris (**2015**), Hundreds of Earthquakes per Day: The 2014 Guthrie, Oklahoma, Earthquake Sequence, *Seismological Research Letters, V 86, Number 5, doi: 10.1785/0220150019*.

- Catchings, R.D. et al. (**2015**), Structure of the Koyna-Warna Seismic Zone, Maharashtra, India: A possible model for large induced earthquakes elsewhere, *J. Geophys. Res. Solid Earth, 120, doi:10.1002/2014JB011695*.

- Ellsworth, William L. et al. (**2015**), Increasing seismicity in the U. S. midcontinent: Implications for earthquake hazard, *The Leading Edge 34, 6(2015); pp. 618-626 doi: 10.1190/tle34060618.1*.

- Hauksson et al. (**2015**), A century of oil-field operations and earthquakes in the greater Los Angeles Basin, southern California, *The Leading Edge 34, 6(2015); pp. 650-656 doi 10.1190/tle34060650.1*.

- Hornbach, Matthew J. et al. (**2015**), Causal factors for seismicity near Azle, Texas, *Nature Communications, doi: 10.1038/ncomms7728*.

- Hough, S.E. and M. Page (**2015**), The Petroleum Geologist and the Insurance Policy, *Seismological Research Letters, 87:1, 171-176, doi:10.1785/0220150218*.

- Hough, S.E., and M. Page (**2015**), A Century of Induced Earthquakes in Oklahoma?, *Bulletin of the Seismological Society of America, Vol. 105, No. 6, doi: 10.1785/0120150109*.

- Hough, Susan E. (**2015**), Shaking intensity from injection-induced versus tectonic earthquakes in the central-eastern United States, *The Leading Edge 34, 6(2015); pp. 690-697 doi: 10.1190/tle34060690.1*.

- Kaven, J.O. et al., (**2015**), Surface Monitoring of Microseismicity at the Decatur, Illinois, CO2 Sequestration Demonstration Site, *Seismological Research Letters Volume 86, Number 4 July/August 2015, doi: 10.1785/0220150062*.

- M. Schoenball, N.C. Davatzes, J.M.G. Glen (**2015**), Differentiating induced and natural seismicity using space-time-magnitude statistics applied to the Coso Geothermal Field, *Geophysical Research Letters, 42, 6221-6228, doi:10.1002/2015GL064772*.

- McGarr, A. et al. (**2015**), Coping with earthquakes induced by fluid injection, *Science, 347, 830-810, doi: 10.1126/science.aaa0494*.

- McGuire, J. J. et al. (**2015**), Relationships among seismic velocity, metamorphism, and seismic and aseismic fault slip in the Salton Sea Geothermal Field region, *J. Geophys. Res. Solid Earth, 120, 2600-2615, doi:10.1002/ 2014JB011579*.

- McNamara, D. E. et al. (**2015**), Efforts to monitor and characterize the recent increasing seismicity in central Oklahoma, *The Leading Edge 34, 6(2015); pp. 628-639, doi: 10.1190/tle34060628.1*.

- McNamara, D. E., G. P. Hayes, H. M. Benz, R. A. Williams, N. D. McMahon, R. C. Aster, A. Holland, T. Sickbert, R. Herrmann, R. Briggs, G. Smoczyk, E. Bergman, and P. Earle (**2015**), Reactivated faulting near Cushing, Oklahoma: Increased potential for a triggered earthquake in an area of United States strategic infrastructure, *Geophys. Res. Lett., 42, doi:10.1002/2015GL064669*.

- McNamara, D. E., H. M. Benz, R. B. Herrmann, E. A. Bergman, P. Earle, A. Holland, R. Baldwin, and A. Gassner (**2015**), Earthquake hypocenters and focal mechanisms in central Oklahoma reveal a complex system of reactivated subsurface strikeslip faulting, *Geophysical Research Letters, http://dx.doi. org/10.1002/2014GL062730*.

- Petersen, M. D. et al. (**2015**), Incorporating Induced Seismicity in the 2014 United States National Seismic Hazards Models: Workshop and Sensitivity Studies, *U. S. Geological Survey Open-File Report 2015-1070*.

- Rubinstein, J.L. and Mahani, A. B (**2015**), Myths and Facts on Wastewater Injection, Hydraulic Fracturing, Enhanced Oil Recovery, and Induced Seismicity, *Seismological Research Letters Volume 86, Number 4 July/August 2015, doi: 10.1785/0220150067*.

- Weingarten, M., et al. (**2015**), High-rate injection is associated with the increase in U.S. mid-continent seismicity, *Science, 348(6241), pp 1336-1340*.

2014

- Barbour, A. J., and F. K. Wyatt (**2014**), Modeling strain and pore pressure associated with fluid extraction: The Pathfinder Ranch experiment, *Journal of Geophysical Research: Solid Earth, 119(6), 5254-5273*.

- Barnhart, W. et al. (**2014**), Seismological and geodetic constraints on the 2011 Mw5.3 Trinidad, Colorado earthquake and induced deformation in the Raton Basin, *J. Geophys. Res., 119, doi:10.1002/2014JB011227*.

- Dixit, M.M. et al. (**2014**), Seismicity, faulting, and structure of the Koyna-Warna seismic region, Western India from local earthquake tomography and hypocenter locations, *J. Geophys. Res. Solid Earth, 119, 6372-6398, doi: 10.1002/2014JB010950*.

- Frohlich, C. et al. (**2014**), The 17 May 2012 M4. 8 earthquake near Timpson, East Texas: An event possibly triggered by fluid injection, *Journal of Geophysical Research: Solid Earth, 119(1), 581-593*.

- Gupta, H. et al. (**2014**), Probing reservoir-triggered earthquakes near Koyna, India, through scientific deep drilling, *Scientific Drilling, v. 18, p. 5-9, doi:10.5194/sd-18-5-2014*.

- Hough, S.E. (**2014**), Shaking from injection-induced earthquakes in the central and eastern United States, *Bull. Seism. Soc. Am. 104:5, 2619-2626, doi:10.1785/0120140099*.

- Kaven, J. O. et al. (**2014**), Seismic monitoring at the Decatur, IL, CO2 sequestration demonstration site, *Energy Procedia, v. 63, p. 4264-4272, doi:10.1016/j.egypro.2014.11.461*.

- Keranen, K. M., M. Weingarten, G. A. Abers, B. A. Bekins, S. Ge (**2014**), Sharp increase in central Oklahoma seismicity since 2008 induced by massive wastewater injection, *Science, 25 July 2014: Vol. 345 no. 6195, pp. 448-451, doi: 10.1126/science.1255802*.

- McGarr, A. (**2014**), Maximum magnitude earthquakes induced by fluid injection, *Journal of Geophysical Research, DOI: 10.1002/2013JB010597*.

- Rubinstein, J. L. et al. (**2014**), The 2001–Present Induced Earthquake Sequence in the Raton Basin of Northern New Mexico and Southern Colorado, *Bull. Seismol. Soc. Am., 104(5), 2162-2181, doi:10.1785/0120140009.*.

- Sumy, D.F. et al. (**2014**), Observations of static Coulomb stress triggering of the November 2011 M5.7 Oklahoma earthquake sequence, *J. Geophys. Res., 119, doi:10.1002/2013JB010612*.

And the Stanford study mentioned at the meeting:

https://www.energyindepth.org/stanford-researchers-forecast-further-decreases-oklahoma-kansas-earthquakes-through-2020/ indicates just as fracking wastewater increases fracking induced earthquakes, reducing fracking wastewater causes those earthquakes to go down. So there is 100% correlation between wastewater injection and earthquakes

Stanford Researchers Forecast Further Decreases in Oklahoma and Kansas Earthquakes Through 2020

“A new Stanford University study released this week predicts induced seismic activity in Oklahoma and southern Kansas will continue to decline over the next three years, further confirming that current wastewater disposal mitigation policies have been effective. Study authors Mark Zoback, Cornelius Langenbruch and Matthew Weingarten note that “even without additional injection rate reductions” their physics-based model indicates “a further decrease of the seismic hazard in 2018, 2019 and 2020.”

The study goes on to note that the research “**underlines the effectiveness of injection rate reductions**, which slow down the rate of pressure increase at seismogenic depth.”