Proposed Stillwater County Beartooth Front District

Reference Materials Regarding Selected Possible Impacts of Oil and Gas Activity

I. Background Regarding Recent Studies

Improvements in drilling technology that have enabled oil and gas booms in eastern Montana, North Dakota and elsewhere have changed the relationship between communities and oil and gas operations. Whereas drilling once occurred primarily in remote areas, these new technologies have brought oil and gas wells into close contact with people. By the summer of 2013, according to the *Wall Street Journal*, "at least 15.3 million Americans live within a mile of a well that has been drilled since 2000".

Because these changes have been recent, scientific research is just beginning to help us understand the impact of putting people close to oil and gas operations. According to a "Compendium of Scientific, Medical, and Media Findings" published by Concerned Health Professionals of New York and Physicians for Social Responsibility, "Our knowledge base is very young. The study citation database…shows that over half of the available studies on the adverse impacts of shale and tight gas development have been published since January 2014. In 2014, 192 peer-reviewed studies on these impacts were published. In the first six months of 2015, 103 studies appeared" (a peer-reviewed document has been reviewed by other professionals in the subject matter area and tends to carry greater authority as compared to a non-peer-reviewed document). (Retrieved from http://concernedhealthny.org/wp-content/uploads/2012/11/PSR-CHPNY-Compendium-3.0.pdf.) What these studies show is that oil and gas development, in close proximity to communities, may cause substantial harm regarding water quality, air quality, and human health.

We believe that such studies are relevant to the consideration by the Stillwater County Commissioners of whether granting the Petition dated September 12, 2014, is in the public interest or convenience.

This document provides a brief listing of recently-published peer-reviewed and other scientific studies identifying the potential for impacts of oil and gas drilling in the following areas:

a. Water quality
b. Air quality
c. Possible consequences of faulty wellpad engineering
d. Noise, light, and related human stress
e. Agriculture and soil quality
f. Other public health issues

II. Water Quality

A. June 16, 2015 – A University of Texas research team documented widespread drinking water contamination throughout the Barnett Shale region in northern Texas. The study, which analyzed 550 water samples from public and private water wells, found elevated levels of 19 different hydrocarbon

compounds associated with oil and gas drilling (including the carcinogen benzene and the reproductive toxicant, toluene), detections of methanol and ethanol, and strikingly high levels of 10 different metals.

Source: Hildenbrand, Z. L., Carlton, D. D., Fontenot, B. E., Meik, J. M., Walton, J.L., Taylor, J. T., Schug, K.A. (2015) "A comprehensive analysis of groundwater quality in the Barnett Shale region". *Environmental Science & Technology,* 49(13), 8254-62. doi: 10.1021/acs.est.5b01526

B. June 5, 2015 – The U.S. Environmental Protection Agency's (EPA) 600-page draft report on the potential impacts of fracking for drinking water resources confirmed specific instances of drinking water contamination linked to drilling and fracking activities. The report also identified potential mechanisms, both above and below ground, by which drinking water resources can be contaminated by fracking. In some cases, drinking water was contaminated by spills of fracking fluid and wastewater. In other cases, "[b]elow ground movement of fluids, including gas ... have contaminated drinking water resources." The EPA investigators documented 457 fracking-related spills over six years but acknowledged that they do not know how many more may have occurred. Of the total known spills, 300 reached an environmental receptor such as surface water or groundwater.

Source: U.S. EPA. (2015). "Assessment of the potential impacts of hydraulic fracturing for oil and gas on drinking water resources" (External review draft). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-15/047, 2015. Retrieved from http://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=244651

III. Air Quality

A. April 15, 2015 – In a review of scientific literature, Colorado researchers demonstrated that four common chemical air pollutants from drilling operations—benzene, toluene, ethylbenzene, and xylene (BTEX)—are endocrine disruptors commonly found in ambient air that have the ability to interfere with human hormones at low exposure levels, including at concentrations well below EPA recommended exposure limits. Among the health conditions linked to ambient level exposures to the BTEX family of air pollutants: sperm abnormalities, reduced fetal growth, cardiovascular disease, respiratory dysfunction, and asthma.

Source: Bolden, A. L., Kwiatkowski, C. F., & Colborn, T. (2015). "New look at BTEX: are ambient levels a problem?" *Environmental Science & Technology*, 49, 5261-76. doi: 10.1021/es505316f

B. March 26, 2015 – Working with citizen volunteers, a team led by Oregon State University researchers installed passive air samplers in the backyard properties of residents living within three miles of petroleum wells in rural Ohio. They found levels of polycyclic aromatic hydrocarbons that surpassed those measured in downtown Chicago, were ten times higher than those found in other rural areas without drilling operations, and exceeded the EPA's maximum acceptable risk level for cancer. Using standard EPA methodologies, researchers determined that the excess lifetime cancer risk for residents living nearest the wells was about 45 percent higher than for residents living farthest from them and three times higher than the EPA's acceptable risk level of 1 in 10,000.

Source: Lockwood, D. (2015, April 8). "Fracking activities pollute nearby air with carcinogenic hydrocarbons". *Chemical & Engineering News*. Retrieved from http://cen.acs.org/articles/93/web/2015/04/Fracking-Activities-Pollute-Nearby-Air.html

C. October 21, 2014 – Using a mobile laboratory designed by the National Oceanic and Atmospheric Administration (NOAA), a research team from the University of Colorado at Boulder, the NOAA Earth System Research Laboratory, and the Karlsruhe Institute of Technology looked at air pollution from drilling operations in Utah's Uintah Basin. The researchers found that drilling and fracking emit large amounts of volatile organic air pollutants, including benzene, toluene, and methane, all of which are precursors for ground-level ozone (smog). Multiple pieces of equipment on and off the well pad, including condensate tanks, compressors, dehydrators, and pumps, served as the sources of these emissions. This research shows that drilling activities are the cause of the extraordinarily high levels of winter smog in the remote Uintah basin—which regularly exceed air quality standards and rival that of downtown Los Angeles.

Source: Warneke, C., Geiger, F., Edwards, P. M., Dube, W., Pétron, G., Kofler, J, Roberts, J. M. (2014). "Volatile organic compound emissions from the oil and natural gas industry in the Uintah Basin, Utah: oil and gas well pad emissions compared to ambient air composition". *Atmospheric Chemistry and Physics*, 14, 10977-10988. doi: 10.5194/acp-14-10977-2014

IV. Possible Consequences from Faulty Wellpad Engineering

A. July 9, 2015 – As part of a larger examination of the potential health and environmental impacts of oil and gas drilling in California, the California Council on Science and Technology (CCST) documented cases of well failures triggered by underground movements that caused well casings to shear. Sheared well casings can allow gas and fluids from the drilling zone to migrate to overlying aquifers. The CCST team identified several mechanisms by which casing shears can occur in California as oil wells age: surface subsidence, heaving, reservoir compaction, and earthquakes. Prolonged drought can also damage the integrity of well casings: as groundwater levels fall, landforms can sink and contribute to casing shear.

Source: Stringfellow, W. T., Cooley H., Varadharajan, C., Heberger, M., Reagan, M. T., Domen, J.K., Sandelin, W., Houseworth, J. E. (2015, July 9). Volume II, Chapter 2: "Impacts of well stimulation on water resources". In: *An Independent Scientific Assessment of Well Stimulation in California*. California Council on Science and Technology, Sacramento, CA. Retrieved from http://ccst.us/publications/2015/vol-II-chapter-2.pdf

B. June 30, 2014 – A study published in *Proceedings of the National Academy of Sciences* by a Cornell University research team projected that over 40 percent of shale gas wells in Northeastern Pennsylvania will leak methane into groundwater or the atmosphere over time. Analyzing more than 75,000 state inspections of more than 41,000 oil and gas wells in Pennsylvania since 2000, the researchers identified high occurrences of casing and cement impairments inside and outside the wells. A comparative analysis showed that newer, unconventional (horizontally fracked) shale gas wells were leaking at six times the rate of conventional (vertical) wells drilled over the same time period. The leak rate for unconventional wells drilled after 2009 was at least six percent, and rising with time. In the state's northeastern counties

between 2000-2012, over nine percent of shale gas wells drilled leaked within the first five years. The study also discovered that over 8,000 oil and gas wells drilled since 2000 had not received a facility-level inspection. This study helps explain the results of earlier studies that documented elevated levels of methane in drinking water aquifers located near drilling and fracking operations in Pennsylvania and points to compromised structural integrity of well casings and cement as a possible mechanism.

Source: Ingraffea, A., Wells, M., Santoro, R., & Shonkoff, S. (2014). "Assessment and risk analysis of casing and cement impairment in oil and gas wells in Pennsylvania, 2000–2012". Proceedings of the National Academy of Sciences. Retrieved from http://www.pnas.org/content/early/2014/06/25/1323422111.abstract

C. June 4, 2015 – As part of a draft assessment of the impact of drilling on drinking water, the U.S. EPA examined cases of water contamination across the United States and concluded that "construction issues, sustained casing pressure, and the presence of natural faults and fractures can work together to create pathways for fluids to migrate toward drinking water resources." Fracking older wells poses additional risks, the draft study notes, because aging itself "can contribute to casing degradation, which can be accelerated by exposure to corrosive chemicals, such as hydrogen sulfide, carbonic acid, and brines"

Source: U.S. Environmental Protection Agency (2015, June 30). Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources, executive summary (draft). Retrieved from http://www2.epa.gov/sites/production/files/2015-06/documents/hf_es_erd_jun2015.pdf

V. Noise, Light, and Related Human Stress

A. July 9, 2015 - As part of its assessment of potential health impacts, the California Council of Science and Technology looked at the impacts of noise and light pollution from oil and gas operations in California. The researchers noted that a number of activities associated with drilling and fracking generated noise levels greater than that considered dangerous to public health. Noise is a biological stressor that can aggravate or contribute to the development of hypertension and heart problems. In California, noise from well stimulation was associated with both sleep disturbance and cardiovascular disease in a dose-response relationship. Exposure to artificial light at night has been linked to breast cancer in women.

Source: Shonkoff, S.B.C., Jordan, P., Hays, J., Stringfellow, W.T., Wettstein, Z.S., Harrison, R., Sandelin, W., & McKone, T.E. (2015, July 9). Volume II, Chapter 6: Potential impacts of well stimulation on human health in California. In: An Independent Scientific Assessment of Well Stimulation in California. California Council on Science and Technology, Sacramento, CA. Retrieved from http://ccst.us/publications/2015/vol-II-chapter-6.pdf

VI. Agriculture and Soil Quality

A. April 24, 2015 – Unconventional technologies in gas and oil extraction facilitated the drilling of an average of 50,000 new wells per year in North America over the past 15 years. An interdisciplinary study

published in Science demonstrated that the accumulating land degradation has resulted in continent-wide impacts, as measured by the reduced amount of carbon absorbed by plants and accumulated as biomass. This is a robust metric of essential ecosystem services, such as food production, biodiversity, and wildlife habitat, and its loss "is likely long-lasting and potentially permanent." The land area occupied by well pads, roads, and storage facilities built during this period is approximately three million hectares, roughly the land area of three Yellowstone National Parks. The authors concluded that new approaches to land use planning and policy are "necessary to achieve energy policies that minimize ecosystem service losses."

Source: Allred, B. W., Kolby Smith, W., Tridwell, D., Haggerty, J. H., Running, S. W., Naugle, D. E., & Fuhlendorf, S. D. (2015). "Ecosystem services lost to oil and gas in North America". *Science*, 348 (6233), 401-402.

B. January 26, 2015 – Two Colorado scientists performed a detailed analysis of vegetative patterns – followed chronologically – over a selected group of well pads in Colorado managed by the U.S. Bureau of Land Management, including two undisturbed reference sites. They documented the disturbance of plant and soil systems linked to contemporary oil and gas well pad construction, and found that none of the oil and gas well pads included in the study returned to pre-drilling condition, even after 20 to 50 years. Full restoration may require decades of intensive effort.

Source: Minnick, T. J. & Alward, R. D. (2015). Plant–soil feedbacks and the partial recovery of soil spatial patterns on abandoned well pads in a sagebrush shrubland. *Ecological Applications* 25(1), 3-10.

VII. Other Public Health Issues

A. July 15, 2015 – A study by University of Pennsylvania and Columbia University researchers found that drilling activity was associated with increased rates of hospitalization in Pennsylvania. During a period of dramatic increase in drilling and fracking activity between 2007 and 2011, inpatient prevalence rates surged for people living near shale gas wells. Cardiology inpatient prevalence rates were significantly associated with number of wells per zip code and their density, while neurology inpatient prevalence rates were significantly associated with density of wells. Hospitalizations for cancer, skin conditions, and urological problems also rose significantly.

Source: Schlanger, Z. (2015, July 15). Living near fracking wells linked to increased hospitalization rates. Newsweek. Retrieved from http://www.newsweek.com/living-near-fracking-wells-linked-increased-hospitalization-rates-354093

B. June 3, 2015 – A University of Pittsburgh study linked drilling to low birthweight in three heavily drilled Pennsylvania counties. The more exposure a pregnant woman had to gas wells, the higher her risk for a smaller-than-normal baby. Exposure was determined as proximity and density of wells in relation to the residence of the pregnant woman. Compared to mothers whose homes had the fewest surrounding gas wells, mothers whose homes were nearest to a high density of wells were 34 percent more likely to have babies who were "small for gestational age," meaning they weighed significantly less

than expected for the number of weeks of pregnancy. Low birth weight is a leading cause of infant mortality.

Source: Preidt, R. (2015, June 3). 'Fracking' linked to low birth weight babies, WebMD. Retrieved from http://www.webmd.com/parenting/baby/news/20150603/fracking-linked-to-low-birth-weight-babies