Report of David O. Carpenter, MD

Institute for Health and the Environment, University at Albany

Concerning Zoning and Land Use Request to Allow Hydraulic Fracturing

in 90+ % of Middlesex Township

14 January 2015

As a public health physician and former Dean of the School of Public Health at the University at Albany, my research and activities are focused on attempts to prevent human disease, especially those diseases that are caused by exposure to environmental pollutants. My publications and research studies have investigated human health hazards resulting from exposure to a variety of chemicals as well as radiation. Many of these studies have investigated effects of exposure to organic chemicals, both those that are persistent in the environment and those that are more volatile, where inhalation is a major route of exposure. I have extensive experience in the study of the effects of ionizing radiation on human health. I have published more than 380 articles in peer-reviewed scientific journals, and have edited six books and written a number of book chapters on various subjects. In 2014, my colleagues and I published a report on the air concentrations of volatile organic compounds in five states, including Pennsylvania, near unconventional oil and gas sites and infrastructure, such as compressor stations. It is based on these experiences that I have a basis to comment on the pending case regarding land use and zoning in Middlesex Township. The opinions expressed in this report are stated to a reasonable degree of scientific and professional certainty.

The attorneys for residents, the Clean Air Council and the Delaware Riverkeeper Network, have asked me to review a number of documents, including the risk assessment report prepared by Ms. Birnbaum and maps of the Township. I am very familiar with the scientific literature published from around the country by different scientists, and know well the reports prepared by the New York State Department of Health and the University of Maryland. I have worked on air sampling around unconventional oil and gas sites in five states. On the basis of these experiences and the knowledge gained from the studies that have been conducted at other locations, I conclude that it would be unwise and unsafe to allow development of natural gas resources in over 90% of Middlesex Township, especially locations in close proximity to schools and residences. To do so would impose significant adverse health effects upon residents of the Township. The justification for this conclusion is summarized below.

Health effects of air pollution resulting from hydro-fracturing (fracking) activities

Every investigation that has been done has reported that the levels of volatile organic compounds (VOCs) are elevated around fracking sites. The major compound is methane, which is the primary component of natural gas. But other VOCs are found along with the methane, including hexane, benzene, ethylbenzene, pentane, xylene and many more. Of these, the most dangerous is benzene, which is a known human carcinogen. As with most carcinogens, benzene will not result in elevations in rates of cancer immediately, but rather increased cancer rates will occur with a latency of 5-20 years. The cancers of greatest concern are leukemia, lymphoma and liver cancer.

In addition to cancer, VOCs in air will be inhaled by all residents living near the sites, and this is known to cause effects on the respiratory system in individuals living within 1 km of a gas well (Rabinowitz et al., 2015). Individuals living near unconventional oil and gas sites have reported continuous sore throats, increased coughs, nosebleeds and asthma attacks (Earthworks, 2012). Studies of workers in occupational settings have demonstrated that chronic exposure to VOCs results in impaired memory, headaches and other indications of reduced mental ability (Verberk et al., 2012), and similar symptoms have been reported among individuals living near to fracking sites (Earthworks, 2012). There are also widely reported effects on the skin, with the development of rashes and hair loss (Rabinowitz et al., 2015).

Another air pollutant coming from natural gas is hydrogen sulfide, the substance that smells like rotten eggs (Eapi et al., 2014; Macey et al., 2014). Hydrogen sulfide is produced whenever organic material containing sulfur degrades, and this is the basic process of natural gas generation from primeval plant life. Our study of air pollutants near unconventional oil and gas sites in five states found elevated hydrogen sulfide near well pads, rigs, separators and especially near discharge canals (Macey et al., 2014). Hydrogen sulfide causes headaches and respiratory irritation and also interacts with water in the respiratory system and eyes to form a weak acid, which is irritating (Birnbaum, 2014). Exposure to concentrations of hydrogen sulfide greater than 4 $\mu g/m^3$ has been associated with increased rates of spontaneous abortion (Hemminki and Niemi, 1982).

In addition to wells, there are particular problems associated with dehydration units, condensate tanks and compressor stations. Because Middlesex Township is a region with wet gas, dehydration units will have to be used. Dehydration units are known to generate up to 40% of air pollutants at production sites (Field et al., 2014).

Other air pollutants are products of above-ground activity around fracking sites. One of the most concerning pollutants is formaldehyde, another known human carcinogen. Formaldehyde is a product of incomplete combustion and is formed especially from truck traffic and natural gas combustion at compressor stations. It is also formed by the reaction that occurs when methane is exposed to sunlight. In our study, formaldehyde was found to be particularly elevated near

compressor stations in Pennsylvania and Arkansas (Macey et al., 2014). Our sampling showed that in Pennsylvania formaldehyde near compressor stations can reach concentrations that exceed federal standards and the 1/10,000 cancer risk level. The frequent nosebleeds reported in individuals living near fracking sites is likely due to formaldehyde, which is embalming fluid, pickling the epithelium in the nose. Compressor stations often burn unrefined natural gas, and will release other hazardous substances such as carbon monoxides and oxides of sulfur and nitrogen as well as formaldehyde (Birnbaum, 2014; Field et al., 2014). The oxides of nitrogen interact with sunlight and VOCs like methane to form ozone, which is also a respiratory toxicant.

Other dangerous categories of air pollutants include polyaromatic hydrocarbons (PAHs) which are often found on particulate air pollution. PAHs are a variety of different chemicals containing only carbon and hydrogen, some of which are known human carcinogens. These arise around fracking sites primarily because of combustion, often coming from trucks and compressors. Particulate air pollution comes in various sizes, ranging from visible soot that is usually trapped in the respiratory tract and removed, down to small particles that can penetrate deep into the lung and cause lung cancer (Hamra et al., 2014), respiratory diseases, especially in children (Sheffield et al., 2011), and heart disease (Ito et al., 2011). A major source of small particulates is diesel exhaust. Birnbaum (2014) reported that operating a typical well pad will involve 13,000 truck round trips, which will generate an enormous amount of particulates containing PAHs.

Studies from Colorado have reported elevated rates of some forms of birth defects (congenital heart disease and neurotube defects) and low birth weight and premature birth in infants born to mothers living within a 10-mile radius of fracking sites (McKenzie et al., 2014). Both the birth defects and low birth weight rates decreased with distance from the wells beyond the 10-mile radius. Studies from Pennsylvania show similar effects on birth weight. Hill (2014) found increased rates of low birth weight and lower average birth weight in infants born to women who lived within 2.5 km of a fracking well as compared to women living further than 2.5 km. Infants born to mothers living closer than 2.5 km from the well pads were more likely to be small for gestational age and have poorer APGAR scores. It should be noted that substances that cause cancer often are also found to cause birth defects. There is strong evidence that low exposure to benzene is associated with increased rates of leukemia (Glass et al., 2003).

Animals, whether farm animals or pets, will be subject to the same—and probably more intense—exposures than humans. Animals will develop the same diseases found in humans as a result of exposure. Bamberger and Oswald (2012) have documented reproductive, neurological, gastrointestinal and other adverse health effects in wild and domestic animals near fracking sites. Bechtel et al. (2009) reported altered immune function in beef cattle resulting from air emissions of VOCs and hydrogen sulfide from oil and gas facilities.

A final air pollutant is silica or silicon dioxide, arising from the high pressure injection of sand into the well to open the shale. Workers at fracking sites have been found to be exposed to ten or more times the OSHA standard for silica (Esswein et al., 2013). While this is an issue of

considerable importance to those working at fracking wells, the exposure to nearby residents will be limited primarily to those who are very close to the site. Silica causes a disease known as silicosis, which results in fibrosis of the lung and is often fatal.

Health effects of fracking activities on vulnerable populations

A major concern is the proximity of proposed fracking sites to schools (see attached map). Increases in birth defects and adverse impacts on birth weight have been detected within 10 miles (McKenzie et al., 2004) and 2.5 km (Hill, 2014) of fracking sites. All of the four schools in Middlesex Township are at closer distances than these. In addition, there is the potential for a well pad will be located within just 910 feet from the Centennial School. Children are more vulnerable than adults to diseases resulting from many different environmental exposures (Sly and Carpenter, 2012) because their bodies are growing, which means they eat, drink and breathe more than adults per unit body weight. This is true whether the child is near a fracking site at home or at school. Because children are more concentrated in schools, the proximity of fracking sites to schools is of particular concern. Fracking should never be allowed anywhere near to a school. Other vulnerable populations include people with existing asthma or respiratory disease and the very old, who are often infirm and unable to tolerate exposures that would not have the same degree of adverse impact on a younger, healthy adult. The studies mentioned above (McKenzie et al., 2014; Hill, 2014) reporting birth defects, low birth weight and small for gestational age are consistent with the expectation that the fetus is very vulnerable to fracking activities.

Health effects of water pollution resulting from fracking activities

There is clear evidence that unconventional deep shale gas development has caused methane contamination of drinking water in Pennsylvania (Osborn et al., 2011). This poses not only the risk of explosion but also of exposure from both ingestion of methane-contaminated water and inhalation of methane that escapes to air. Ingestion of methane will primarily affect the central nervous system (Verberk et al., 2012), whereas inhalation will alter both the central nervous and respiratory systems (Rabinowitz et al., 2015). Fracking involves injection of many chemicals into the shale at high pressure to facilitate the release of the natural gas. There is widespread concern about contamination of ground water with these chemicals, especially arising from spills, leaks from casings or fractured rock, improper disposal of flow-back water and collapse of pits containing waste water (Rozell and Reaven, 2011; Vengosh et al., 2014). This is a reasonable concern especially for individuals who derive drinking water from wells. While many residents of Middlesex Township are on municipal water, conventional drinking water treatment facilities are often not capable of removing all chemicals. This is a special concern since not all of the chemicals used are known as they are proprietary. Colburn et al. (2011) have identified many of these chemicals and have documented toxic actions on many different organ functions. For example, of the 353 chemicals with Chemical Abstract Service numbers known to be used in fracking, more than 80% of them have skin, eye and sensory organ as well as

respiratory effects. They report that about 37% of the chemicals identified are volatile. Other adverse effects were documented for some of the chemicals and for VOCs on the gastrointestinal system, brain and nervous system, immune system, kidney, cardiovascular system, as well as creating increased cancer risks. Many chemicals and VOCs are also mutagenic and are endocrine disruptors, as well as having adverse ecological effects.

Health effects of radioactive substances

The Marcellus Shale contains high concentrations of naturally-occurring radioactive elements, including radium, thorium and uranium (USGS, 2011). While thorium and uranium are not very water soluble, radium is, and the concentration of radium in flow-back water is often high. Conventional drinking water treatment plants are not equipped to remove most radioactive substances, raising the risk of radioactivity in the municipal water supply. In addition, there is the problem of what to do with the flow-back water that contains chemicals as well as radioactivity. In some circumstances the flow-back water is injected deep into the earth, which may solve the radioactivity problem but has been found to cause earthquakes. More often, the flow-back water is stored on pond impoundments, which may leak or overflow, contaminating the surrounding environment. Because the flow-back water usually contains high concentrations of salt it has even been used on roads in Pennsylvania for ice control in the winter, which will clearly spread radioactivity. If ingested, radium will deposit in the bones and increase risk of bone cancer and leukemia (Canu et al., 2011).

Radium decays to radon gas, which has a half-life of 3.8 days, and there certainly will be radon in the natural gas coming from wells which will be inhaled by nearby residents. While the concentration of radon is unlikely to be high, radon is known to cause lung cancer in humans and if inhaled, will decay to other heavy metal isotopes that will be deposited in the lung.

Health effects resulting from noise and light contamination

Fracking activities occur 24/7. Fracking operations are accompanied by loud noise and constant light when the wells are being drilled and by heavy truck traffic during operation (Birnbaum, 2014; Concerned Health Professionals, 2014; University of Maryland, 2014). The setback standard in Pennsylvania is only 500 feet from the well to an existing building. Therefore, a person living near to a fracking well during the drilling and fracking phases will be subjected to almost constant noise day and night, and light pollution all night long. These factors will cause stress and loss of sleep. The result will be irritability, reduced immune system function and excessive fatigue that will interfere with normal functioning.

Dangers arising from emergency events at sites with unconventional oil and gas operations

It is essential to anticipate that unconventional deep shale gas development will be associated with unintended events that pose significant danger to local residents, including explosions, spills, leaks, fires and the collapse of holding ponds. Such incidents have occurred in areas that

already allow fracking (Birnbaum, 2014). If fracking is to be allowed in residential, institutional or commercial neighborhoods there must at least be detailed planning for dealing with these emergencies, including evacuation of residents as well as workers. This necessitates knowledge in advance of all individuals living, working and attending school in the area near each well. In Monroe County, Ohio, evacuation was required of all individuals within one and a half mile of a well accident (Monroe County Emergency Management, 2014). Personal protective equipment must also be available, especially for protection from exposures to formaldehyde, hydrogen sulfide and benzene.

Conclusions

For all of these reasons I conclude that a zoning ordinance that allows unconventional deep shale gas development to occur in over ninety percent (90%) of Middlesex Township, including in close proximity to schools and residences, is at the present time and with current technology not protective of the public health, safety and welfare. Residents and those who regularly visit the Township for work or school will be vulnerable to exposures to chemicals in the air and water. These chemicals will also get in food sources, especially those raised in local farms and gardens, and the exposure will result in increases in rates of cancer, nervous and respiratory system effects, as well as an overall reduction in the quality of life. A similar conclusion was reached after extensive review by the New York State Department of Health (2014), which resulted in a decision to prohibit fracking throughout New York State. Much more research is needed to improve the safety of unconventional deep shale gas extraction and perhaps someday technical advances will allow extraction of shale gas in a fashion that does not cause significant threats to human health. However, that is not the case today. For the sake of the health of the residents of Middlesex Township, especially its children, zoning a community so that unconventional deep shale gas development can occur within less than two miles of schools and close to significant residential development poses a particularly significant public health risk.

David O. Carpenter, M.D.

January 14, 2015

References

Bamberger M and Oswald RE (2012) Impacts of gas drilling on human and animal health. New Solutions 22: 51-77.

Bechtel DG, Waldner CL, and Wickstrom M (2009) Associations between immune function in yearling beef cattle and airborne emissions of sulfur dioxide, hydrogen sulfide, and VOCs from oil and natural gas facilities. Arch Environ Occup Health 64: 73-86.

Birnbaum L (2014) Risk assessment for ambient air exposure near natural gas drilling operations. Report prepared for Middlesex Residents, Clean Air Council, and Delaware Riverkeeper Network.

Canu IG, Laurent O, Pires N, Laurier D and Dublineau (2011) Health effects of naturally radioactive water ingestion: The need for enhanced studies. Environ Health Perspect 119: 1676-1680.

Colburn T, Kwiatkowski C, Schultz K and Bachran M (2011) Natural gas operations from a public health perspective. Human Ecol Risk Assess 17: 1039-1056.

Concerned Health Professionals (2014) Compendium of scientific, medical and media findings demonstrating risks and harms of fracking (unconventional gas and oil extraction).70 p.

Eapi GR, Sabnis MS and Sattler ML (2014) Mobile measurement of methane and hydrogen sulfide at natural gas production site fence lines in the Texas Barnett Shale. J Air Waste Manage Ass 64: 927-944.

Earthworks (2012) Gas patch roulette: How shale gas development risks public health in Pennsylvania. 50 p.

Esswein EJ, Breitenstein M, Snawder J, Kiefer M, and Sieber WK (2013) Occupational exposures to respirable crystalline silica during hydraulic fracturing. J Occup Environ Hyg 10: 347-356.

Field RA, Soltis J and Murphy S (2014) Air quality concerns of unconventional oil and natural gas production. J Roy Soc Chem DOI: 10.1039/c4em00081a.

Glass DC, Gray CN, Jolley DJ, Gibbons C, Sim MR, et al. (2003) Leukemia risk associated with low-level benzene exposure. Epidemiol 14: 569-577.

Hamra GB, Guha N, Cohen A, Laden F, Raaschou-Nielsen O, et al. (2014) Outdoor particulate matter exposure and lung cancer: A systematic review and meta-analysis. Environ Health Perspect 122: 906-911.

Hemminki K and Niemi ML (1982) Community study of spontaneous abortions: Relation to occupational and air pollution by sulfur dioxide, hydrogen sulfide and carbon disulfide. Int Arch Occup Environ Health 51: 55-63.

Hill EL (2014) Shale gas development and infant health: Evidence from Pennsylvania. Cornell University WP 2012-12.

Ito K, Mathes R, Ross Z, Nadas A, Thurston G and Matte T (2011) Fine particulate matter constituents associated with cardiovascular hospitalizations and mortality in New York City. Environ Health Perspect 119: 467-473.

Macey GP, Breech R, Chernaik M, Cos C, Larson D, Thomas D and Carpenter DO (2014) Air concentrations of volatile compounds near oil and gas production: a community-based exploratory study. Environ Health 13: 82.

McKenzie LM, Guo R, Witter RZ, Savitz DA, Newman LS and Adgate JL (2014) Birth outcomes and maternal residential proximity to natural gas development in rural Colorado. Environ Health Perspect 122: 412-417.

Monroe County Emergency Management (2014) https://facebook.com/Monroe CountyEmergencyManagemtn/posts/377922009049793.

New York State Department of Health (2014) A public health review of high volume hydraulic fracturing for shale gas development. 56 p.

Osborn SG, Vengosh A, Warner NR and Jackson RB (2011) Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing. PNAS 108: 8172-8176.

Rabinowitz PM, Slizovskly IB, Lamers V, Trufan SJ, Holford TR, et al. (2015) Proximity to natural gas wells and reported health status: Results of a household survey in Washington County, Pennsylvania. Environ Health Perspect 123: 21-26.

Rozell DJ and Reaven SJ (2011) Water pollution risk associated with natural gas extraction from the Marcellus shale. Risk Analysis DOI: 10.1111/j.1539-6924.2011.01757.x.

Sheffield P, Roy A, Wong K and Trasande L (2011) Fine particulate matter pollution linked to respiratory illness in infants and increased hospital costs. Health Affairs. DOI:10.1377/hlthaff.2010.1279.

Sly L and Carpenter DO (2012) Special vulnerability of children to environmental exposures. Rev Environ Health 27: 151-157.

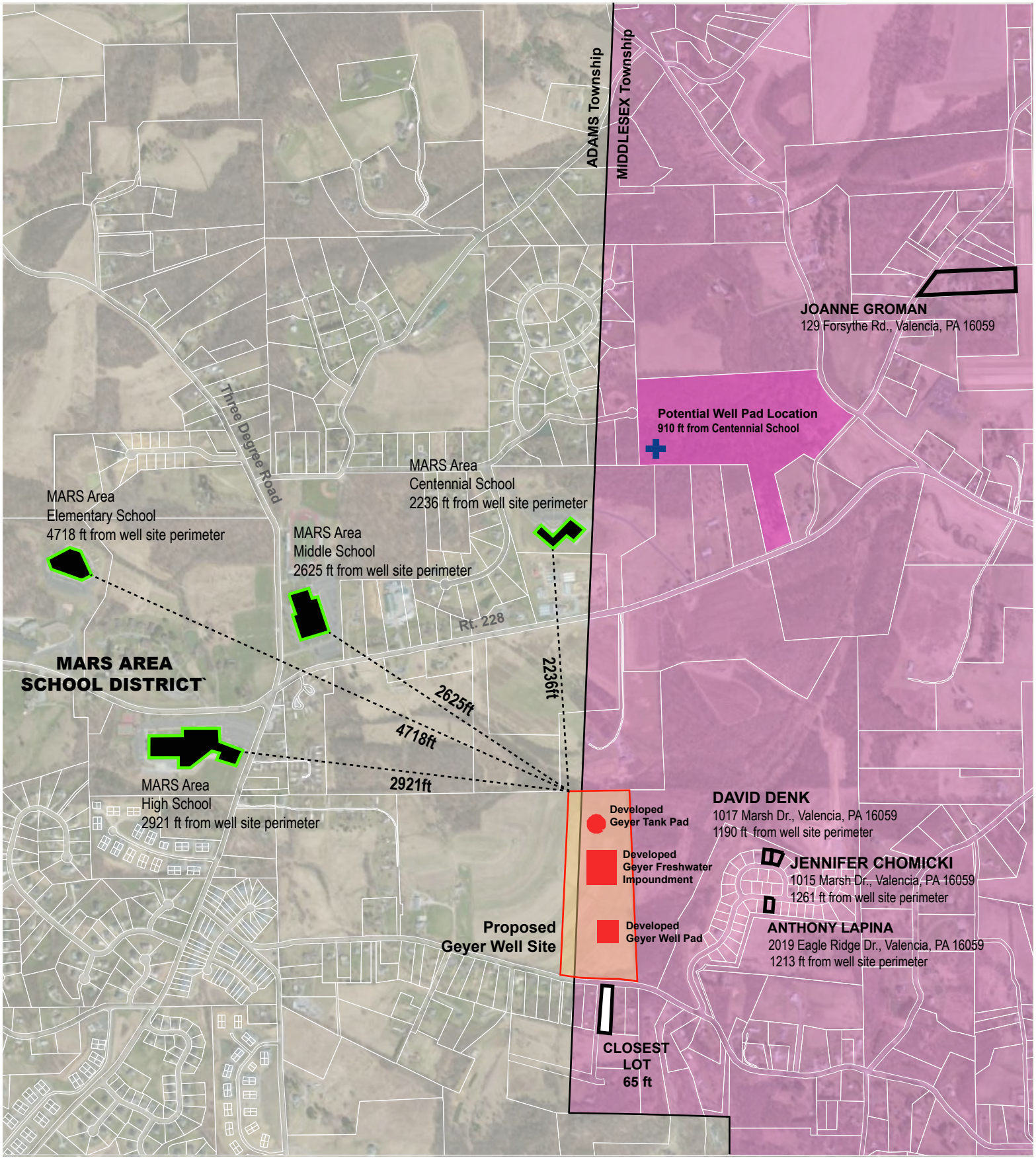
Vengosh A, Jackson RB, Warner N, Darrah TH and Kondash A (2014) A critical review of the risks to water resources from unconventional shale gas development and hydraulic fracturing in the United States. Environ Sci Technol 48: 8334-8348.

Verberk MM, van der Hoek JAF, van Valen E, Wekking EM, van Hout, et al. (2012) Decision rules for assessment of chronic solvent-induced encephalopathy: Results in 2370 patients. NeuroToxicology 33: 742-752.

University of Maryland (2014) Potential public health impacts of natural gas development and production in the Marcellus shale in Western Maryland. Prepared for the Maryland Department of the Environment and the Maryland Department of Health and Mental Hygiene. 173 p.

USGS (2011) Radium content of oil and gas-field produced waters in the Northern Appalachian Basin (USA): Summary and discussion of data. US Department of the Interior, 31 p.

ATTACHMENT



Proposed Parcels Available for Drilling (Middlesex Township)

MARS Area School District Schools

PROPOSED GEYER WELL SITE AREA MAP
1.13.2015

Clean Air Council

Prepared for: Clean Air Council, Philadelphia, PA
Prepared by: Sean M. Eno, Geospatial and Cartographic Consultant

0 500 1,000 2,000 Feet