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Hydraulic Fracturing and Public Health

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Disposal of Hazardous Wastewater from Hydraulic Fracturing

Charlotte Weisberg. Fall 2015

Introduction:

The process of hydraulic fracturing to obtain natural gas from shale is a currently booming field in the United States energy industry and offers a promising outlook to those looking for a "cleaner" energy source. Hydraulic fracturing or fracking, as it is often referred to, involves drilling deep into Earth's rock layers and blasting a mixture of chemicals and water down at high pressures to obtain natural gas. Although this technology offers a seemingly more environmentally friendly way to fill the extreme energy demands of our nation, it brings along with it an enormous amount of unregulated waste.

With this waste being an issue of serious environmental and economic concern, many individuals have taken a strong stance on the topic of fracking as a whole. The large area of concern over this waste is simply the lack of federal regulation on disposal of it. If the federal government could impose stronger regulations or look for alternative methods of disposal, the topic of fracking and its waste could become much less controversial. With waste more strongly regulated, the environmental concerns over fracking in general might lessen as well.

Here in the Lehigh Valley, many citizens or students at Lehigh University would consider themselves to be free from these issues of fracking because fracking does not occur within the area. Yet, these individuals are far from clear of the issues of fracking, as waste disposal from fracking occurs in almost every corner of the country. Many forms of wastewater disposal that are currently used have been shown as having grave environmental and health impacts in the areas which they are implemented. So although Lehigh Valley residents may be free of the dangers of fracking currently, it is still an issue to care about beyond our backyards. It is important to become aware of the facts of waste management from fracking so that we can assist in pushing for more regulation for the entire state and potentially the country.

This issue comes to the forefront on a global scale as well. With both developing and developed countries across the world facing issues of severe drought and water shortages, any practices that can aid in conserving water are essential. Fracking currently uses approximately two to eight million gallons of fresh water to frack a single well (Schmidt 2013). These wells can be fracked multiple times over their usage lifetime as well and almost all of the water ends up being disposed of. For this reason alone, the topic of reforming wastewater disposal methods should be in everyone's interest. If technology can be improved in a way which would lessen the amount of water being used to frack these wells, or create a method to recycle a portion of the water, it is worth investing in.

Major Discussion:

What waste is being created?

From the sheer number of anti-fracking organizations and grassroots movements that exist today, it is evident that hydraulic fracturing is a widely controversial topic in the United States and beyond. An integral part of this argument is the issue of waste disposal from the fracking process and the environmental impact that waste may be creating. The fracking process uses many harmful chemicals and an enormous amount of water, along with many other substances which are unrevealed by energy companies. The process alone creates both solid waste, which includes a mixture of sand, sludge, and various harmful or radioactive chemicals, as well as waste water which contains any number of chemicals for disposal.

The waste water can be broken down into two major categories; flowback water and produced water [brine]. The first is a result of water and chemicals flowing back up to the surface after a well is drilled, and hence is referred to as "flowback fluid" (Hansen 2014). Flowback fluid makes up the majority of the waste created from fracking and is most critics' biggest concern. Up to 60% of the water used for fracking at a single well will return as flowback water, with a single wellhead likely to produce more than 100,000 gallons of flowback fluid over its lifetime (Easton 2015). The brine water is of a slightly lesser concern because treatment and disposal usually involves simply diluting the intense salt concentrations before the water can be placed anywhere.

Table 3. Chemicals Components of Concern: Carcinogens, SDWA-Regulated Chemicals, and Hazardous Air Pollutants

Chemical Component	Chemical Category	No. of Products
Methanol (Methyl alcohol)	HAP	342
Ethylene glycol (1,2-ethanediol)	HAP	119
Diesel[19]	Carcinogen, SDWA, HAP	51
Naphthalene	Carcinogen, HAP	44
Xylene	SDWA, HAP	44
Hydrogen chloride (Hydrochloric acid)	HAP	42
Toluene	SDWA, HAP	29
Ethylbenzene	SDWA, HAP	28
Diethanolamine (2,2-iminodiethanol)	HAP	14
Formaldehyde	Carcinogen, HAP	12
Sulfuric acid	Carcinogen	9
Thiourea	Carcinogen	9
Benzyl chloride	Carcinogen, HAP	8
Cumene	HAP	6
Nitrilotriacetic acid	Carcinogen	6
Dimethyl formamide	HAP	5
Phenol	HAP	5
Benzene	Carcinogen, SDWA, HAP	3
Di (2-ethylhexyl) phthalate	Carcinogen, SDWA, HAP	3
Acrylamide	Carcinogen, SDWA, HAP	2
Hydrogen fluoride (Hydrofluoric acid)	HAP	2
Phthalic anhydride	HAP	2
Acetaldehyde	Carcinogen, HAP	1
Acetophenone	HAP	1
Copper	SDWA	1
Ethylene oxide	Carcinogen, HAP	1
Lead	Carcinogen, SDWA, HAP	1
Propylene oxide	Carcinogen, HAP	1
p-Xylene	HAP	1
Number of Products Containing a Component of Concern		**652**

Figure 1: This Table demonstrates the various chemicals used by energy companies which could potentially appear in residual flowback fluid and brine from Hydraulic Fracturing. (U.S. HOR 2011). Retrieved from http://conservationco.org/admin/wp-content/uploads/2013/02/Final-Rebuttal-Exhibits.pdf-Adobe-Acrobat-Pro.pdf

Each truckload of flowback fluid from a fracking site contains a variety of chemicals which may include anything from simple table salt to the chemicals used in antifreeze for motor vehicles. Although each chemical occurs at different levels in each sample of wastewater, many of them become toxic even at the lowest dosages. Many of the chemicals used are known cancer-causing agents, such as naphthalene, benzene, and acrylamide, and are used at considerably high levels (Ridlington et al. 2013). For example, naphthalene is a chemical used in mothballs, a common household item, that when ingested can cause anemia and liver damage in humans at even the lowest levels of exposure (NPIC 2010). In a report by the U.S. House of Representatives Energy Committee in 2011, it was noted that over

600 other chemicals appearing in fracking wastewater are hazardous or potentially harmful to humans (U.S. HOR 2011). From this data alone it becomes evident that a proper disposal system and regulations are necessary for dealing with this many dangerous or potentially harmful chemicals.

How do we regulate this waste and disposal?

With over 1.1 million active oil and gas wells in the United States, the amount of waste being produced from fracking in these wells is hard to imagine. Roughly 280 billion gallons of wastewater were produced nationwide from fracking wells in the year 2012, according to a report by Environment America, a national environmental advocacy organization (Ridlington & Rumpler 2013). This 280 billion gallons of wastewater per year is comparable to about 76 million gallons per day, or in simpler terms, roughly 40,000 backyard swimming pools filled with fracking wastewater every single day. If we consider that fracking wells are increasing across the country every year and still producing wastewater at this rate, there is an alarming amount of harmful waste being produced daily with almost no regulation.

Regulation of flowback fluid from fracking falls under the U.S. Environmental Protection Agency (EPA) and the Safe Drinking Water Act of 1974. The SDWA protects all water sources in the U.S. by holding them up to certain minimum standards for what is considered "safe" to drink. When the Act was initially created, it stated that "State programs must require a permit for any underground injection, mandated inspection, monitoring, record keeping, and reporting" if the injection endangers drinking water sources (SDWA). Under these initial conditions, fracking wastewater was exempt from regulation due to the EPA's definition of underground injection sites. In 1997, though, that definition was overruled and the U.S. Court of Appeals determined fracking to be a form of underground injection (Brady 2012). Under this new ruling, all state programs and the EPA itself had to regulate fracking waste and the disposal of flowback fluid. As expected, there was a considerable amount of opposition to this ruling by the energy companies and the EPA was required to do their own study on the dangers of contamination to water sources. The EPA released this study in 2004 and determined that hydraulic fracturing brings almost no danger to drinking sources and therefore the SDWA was amended a year later (U.S. EPA 2004).

The SDWA was reexamined and passed with the caveat that underground injection for fracking purposes would be exempt unless diesel fuels were involved in the process (U.S. HOR 2011). This exemption, passed in 2005 under the Energy Policy Act is often called the "Halliburton Loophole" due to Vice President Dick Cheney's involvement as a past CEO of Halliburton; a multinational energy company. The Halliburton loophole is what currently allows billions of gallons of fracking wastewater to go unregulated every year. Fortunately, since the loophole appeared, revisions have been considered and in 2011, the EPA began developing new standards for wastewater from natural gas extraction (Brady 2012). Currently, regulation of fracking wastewater remains in the hands of each state's environmental protection department, which allows for much variation across the nation. Due to the lack of federal regulation on fracking wastewater, the existing options for disposal are limited and often questionable in practice.

Ways of Disposing of Flowback Water

Fracking companies across the nation use a multitude of methods for disposing of the flowback water they produce. Dependent on each state's regulations for disposal, energy companies often have three different methods to choose from; deep well injection, open air pits, or treatment and reuse of the water.

Deep Well Injection of Wastewater

Similar to the hydraulic fracturing process, deep well injection involves blasting of fluids deep into the earth's core at tremendous pressures. Injection wells are structurally quite similar to natural gas wells with cement casings and pipe that run thousands of meters down into rock layers. Injection wells serve the purpose of disposal rather than acquiring gas. As gallons of flowback water or brine are collected from fracking wells every day, they are often transported to these deep injection wells which blast the water down with powerful force and then allow the water to seep into spaces left between the rock, well beneath Earth's surface (Lustgarten 2012). This process is demonstrated in the following image as it outlines the process in Class II wells; the same ones into which fracking waste is injected. Well injection is a popular method in any area that is also home to fracking wells as it presents a relatively inexpensive route for dumping the hazardous waste that companies are no longer allowed to dump into surface water (EPA 2012). Well injection of flowback fluid is regulated more extensively than the fracking process itself, yet still allows for a wide margin of error.

The injection process came into use as an alternative to keeping liquid waste in surface ponds or dumping it into rivers and ponds. Yet waste injection initially was not regulated and resulted in hundreds of reports of toxic waste bubbling up in backyards and public areas. In 1980, to fix the problem, the EPA set up a classification system for wells and required that only certain types of wells could be used for waste injection and that those types could only be constructed in areas a minimum

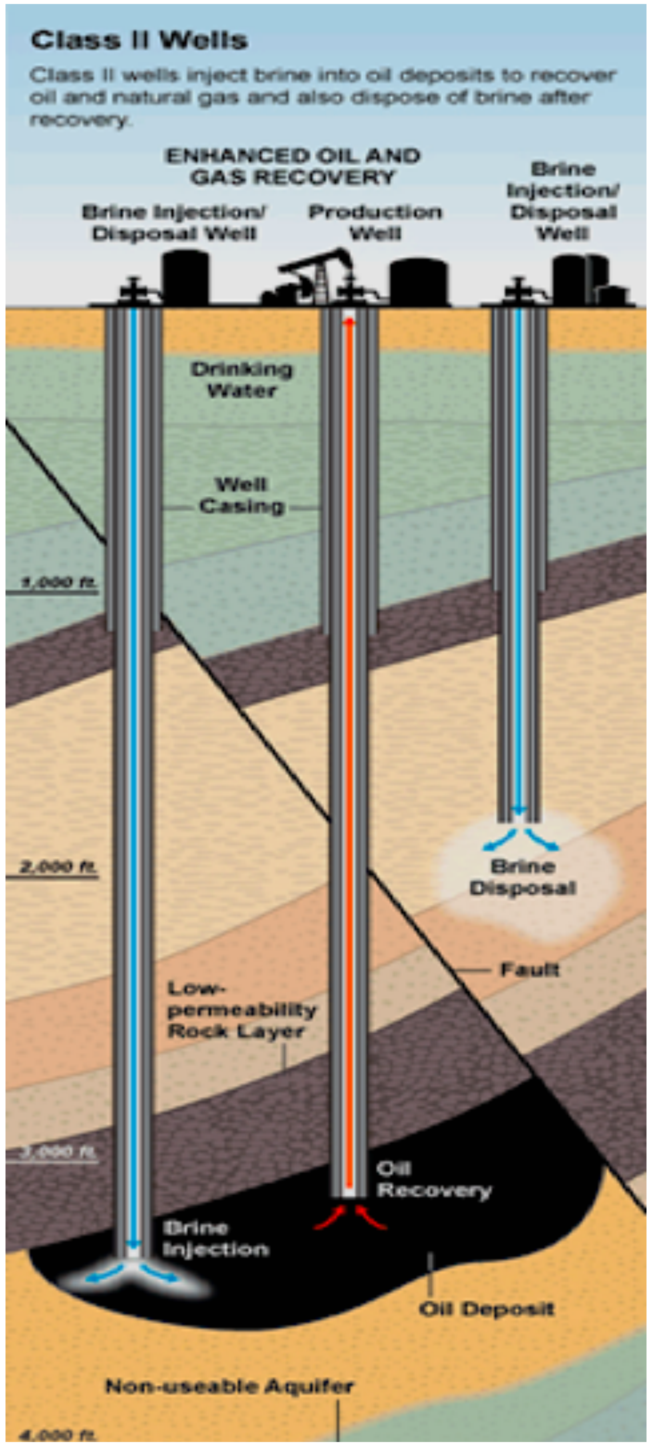

Figure 2: This graphic illustrates the use of Class II Underground Injection Wells for brine disposal. This is different from the other class II wells which can be used for obtaining oil from underground layers. (Lustgarten 2012). Image retrieved from http://www.propublica.org/article/injection-wells-the-poison-beneath-us

distance from drinking water sources (Hasemyer & Hirji 2014). This is now called the Underground Injection Control (UIC) program under the SDWA (Hammer et al. 2012). Regulations became even stricter in 1988, mandating that fracking companies had to be permitted and conduct numerous tests verifying that their waste would not travel near water supplies (Lustgarten 2012). Energy companies lobbied heavily against these strict regulations and eventually won when the Halliburton loophole was created in 2005, declaring all fracking waste non-hazardous (Drouin 2014).

Deep well injection is a favorable process for wastewater disposal in the fracking industry because it deals with waste in an "out of sight, out of mind" approach and is typically less expensive than other methods. The cost to transport wastewater from a fracking site for deep well injection is approximately $3-$7 per barrel and only increases with the distance it is transported (Easton 2015). At the rate which most fracturing wells are creating flowback, this can easily cost thousands of dollars over the course of a day for a single fracking site. While the cost appears extensive, it remains a cheaper option for disposal in comparison to recycling or treating the fluids. Although deep well injection appears to be a harmful option, the disposal of wastewater "has been and will remain a chronic problem because it is produced in such large quantities," said Anthony Ingraffea, a research professor at Cornell University (Drouin 2014). Deep well injection is not the only existing solution for the immense amount of wastewater which needs to be disposed of.

Open Air Pits; Landfills for Wastewater

Soon after wells are injected and natural gas is obtained from the shale underneath, flowback fluid is collected and often sent through pipelines to bodies of water which would appear to be man-made ponds to the untrained eye. Yet upon closer inspection, these "ponds" contain a thick surface coating, noxious odors, and in many cases, no inner lining preventing the liquid from seeping into the ground below it. These "ponds" and reservoirs are open air pits and represent a large portion of where the fracking industry's waste ends up (Hasemyer & Hirji 2014). Open air pits pose a serious threat to human and environmental health, particularly when they are not regulated.

In 2014, Clean Water Action, a national environmental organization, conducted research on open air pits in Center Valley, California, and found just how common and unregulated they are. The study found that wastewater from unlined pits had travelled over 4,000 feet toward major drinking water sources and only 20 of over 400 active pits had been inspected by the state (Grinberg 2014). Other states, such as Ohio have banned open air pits due to the air and water pollution they cause. Pennsylvania is currently working toward banning disposal pits for fracking wastewater, as the DEP states that "Open pits may only be used for temporary storage" and must have "a liner of minimum thickness and tested prior to use" (PA DEP 2014). Although this ban is evidence of some state governments requiring the industry to move toward safer methods of disposal, there still remain thousands of active and unregulated open pits full of toxic flowback fluid nationwide.

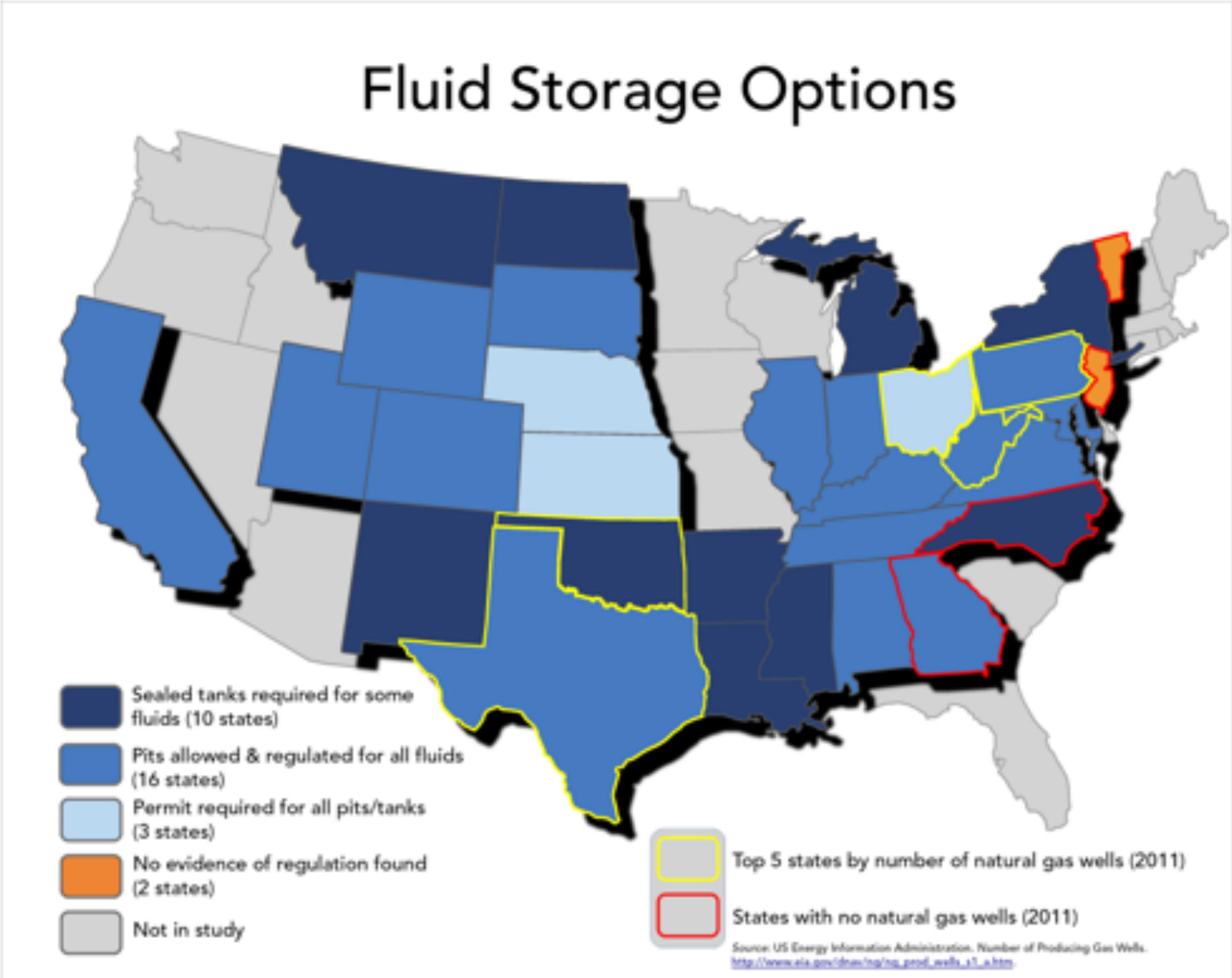

Figure 3: This graphic displays the distribution of open air pit disposal regulation by state across the United States. This data was recorded in 2011 and regulations may have changed in more recent years. (Schailby 2014). Retrieved from http://www.shaleplaywatermanagement.com/2014/02/water-storage-regulations-state-level-level/

Treatment and Reuse: A Growing Yet Expensive Option

Another route to handle flowback fluid is through a wastewater treatment system. These exist in the form of both state- or publicly owned treatment works (POTWs) and privately owned centralized waste treatment facilities (CWTs), which are both regulated by the federal Clean Water Act (Hansen 2014). If the fluid that is treated at these plants is going to be released back into surface waters, the facilities must obtain permits from the EPA. Surface waters simply refers to any body of water including ponds, lakes, rivers, and reservoirs. These permits for surface water release require the treatment facilities to report every instance of discharge, their method of treatment, and what type of waste will be discharged (Steinzor & Baizel 2015). In Pennsylvania, stricter regulations have been implemented and require each fracking company to outline its plans for maximizing reuse of its waste and impose new limits on contaminants from shale gas wastewater specifically (Hansen 2014). The treatment of fracking wastewater is potentially the industry's best solution for dealing with disposal that currently exists.

Treatment at either type of facility remains an extensive and sometimes costly procedure depending on the quality of the wastewater. Treatment involves the removal of any solids and dissolved inorganic substances, desalination, and special procedures for any radioactive or carcinogenic materials (Hammer et al. 2012). Yet some form of treatment must be done for almost every method of disposal that exists. When flowback fluid is sent to be injected into class II wells it must first receive partial treatment to remove solids and minimize clogging risks. Recycling methods require some form of treatment as well to develop a water source which is clean enough to be used. Hence, no form of wastewater disposal from fracking can be successful without some treatment of the water.

The reuse and recycling of flowback fluid is a newer and more expensive method, yet is gaining in popularity and use among the fracking industry. To be reused or recycled, the wastewater must be treated initially and then combined with water to balance out the high salt concentrations (Easton 2015). Wastewater that is intended to be reused is not under federal regulation by the EPA, and therefore the states have sole responsibility for regulating it. Yet any water that is going to be reused for the intended purpose of fracking, only has to meet the requirements of the fracking company which is planning to use the water. Although the treatment process can be somewhat elaborate, this recycling provides energy companies with an on-site, replenishing, source of water for their operations.

The recycling method is a point on which both the fracking companies and anti-fracking campaigns agree is a step in the right direction. Economically, recycling of wastewater is not a feasible option for most companies due to the high cost of building pipelines, treatment equipment, and property rights (Rahm et al. 2013). Yet the recycling method continues to gain in use nationwide.

So why exactly are energy companies moving toward recycling and reuse methods when the other existing methods (deep well injection, open air pits) are simpler and less costly? Kevin Sunday from the Pennsylvania Department of Environmental Protection (DEP) noted that “about 70% of flowback water gets reused…recycling has never been higher” (Schmidt 2013). One of many reasons for this is that the standards for surface discharge have become increasingly strict and driven the price of wastewater treatment up. A scarcity of injection wells has also driven fracking industries into methods of reuse and treatment as the transport of fluids to the closest well sites can be extremely costly. At a time where water scarcity is becoming an increasing problem in the United States, reuse of fracking fluids is rising in appeal for the fracking industry as the process itself requires an immense amount of water. Fracking companies that have employed wastewater recycling systems have been reported that “it may be more expensive than buying fresh water, but not by much” and that they worry about “how much water is left” on their land (Osborne 2014). Although it is a slowly building campaign for flowback fluid recycling, it is likely in the fracking industry’s and the environment’s best interest to pursue using this method. Once in place, the recycling systems are likely to reduce expenses and cause fracking to surpass coal and oil in terms of “clean” energy.

Conclusion:

The majority of wastewater disposal methods that exist currently lack in necessary regulation and that is truly what makes the process so environmentally and economically damaging. In reality, methods such as open air pit disposal should no longer be an option for energy companies due to the vast number of issues that have resulted from them. Underground injection is becoming an inviable option to these companies as well due to the bad press they have gotten for causing seismic activity and countless impacts on ecosystems. With North America beginning to look like a pin cushion when underground injection wells are mapped out, companies are likely going to begin feeling pressure to come up with new solutions and new technology. Unless wastewater from fracking becomes subject to stricter regulations or these disposal methods undergo renovations, the energy companies will be incapable of continuing at this rate of disposal. It becomes evident that water reuse and recycling is an option which needs to be more carefully explored. Companies should begin looking towards these types of methods to ultimately save on cost and drive fracking toward being the clean energy source that America needs.

Important Resources:

1. John Quigley

John Quigley is the current Pennsylvania Department of Environmental Protection (DEP) secretary. The PA DEP is the primary regulator of wastewater disposal and all fracking waste for Pennsylvania. Quigley has extensive experience in the field. He worked as secretary of the Pennsylvania Department of Conservation and Natural Resources (DCNR) for two years prior to being appointed secretary of the PA DEP. He has worked with the top leaders in gas, timber, and coal industries and has helped lead PA to a top spot nationally in the energy producing industry. Quigley is typically noted as having a pro-fracking viewpoint and is pushing to make Pennsylvania a leader in shale gas production. However, he has pushed for new stricter regulations on open air pit disposal in Pennsylvania, making it a very difficult option for fracking companies to use. To contact him, fill out an online contact form at http://www.dep.pa.gov/About/Contact/Pages/default.aspx#.VmeBjoShjzI under the category in which you are interested.

2. Environmental Protection Agency- Safe Drinking Water Act

The EPA's SDWA controls almost all regulation of fracking waste at the federal level. All state regulations must at the very least meet the requirements of the SDWA. All wastewater underground injection is part of the Underground Injection Control (UIC) program; a party of the SDWA. Therefore all disposal through underground injection must meet the SDWA requirements as well.

There is minimal federal regulation under the SDWA due to the Halliburton Loophole which classifies all wastes from natural gas production to be non-hazardous. Yet the SDWA is the strongest form of regulation that some states have and therefore is an important act to understand when considering wastewater disposal methods. To contact the EPA about the SDWA, email Kenneth Schefski, director of the waste and chemical enforcement division, at schefski.kenneth@epa.gov. Or contact Mark Pollins, director of the water enforcement division at pollins.mark@epa.gov

3. Clean Water Action

Clean Water Action is a large non-profit organization which works to protect the environment from pollution of water resources as well as enhance human health and quality of life. Made up of thousands of members, Clean Water Action has been successful in organizing grassroots organizations and campaigns across the country targeted toward environmental issues both on a global and national scale.

Clean Water Action is an important resource in understanding the controversial methods of wastewater disposal because they have contributed many studies and research to the subject. A group from Clean Water Action completed a study on open air pits in California in 2014 which exposed hundreds of unknown pits to the public and drove awareness of the company's followers and many others to the issue of unregulated disposal. To contact Clean Water Action's President and CEO Robert Wendelgass: (215)-545-0250; or contact John Noel, Clean Water Action's National Oil and Gas Campaigns Coordinator at (202)-895-0420.

4. Brian G. Rahm

Brian Rahm is a researcher at Cornell University's New York State Water Resources Institute. Dr. Rahm has a Ph.D from Cornell University in groundwater contamination and an environmental engineering degree from University of California at Berkeley. His research primarily focuses on greenhouse gas emissions from wastewater treatment plants. Dr. Rahm is a notable resource in the field of wastewater management and has spoken at various conferences on issues involving fracking waste. At the NY State Water Resource Institute, he works toward improving the management of water resources in NY and increasing awareness of wastewater management issues. To contact Dr. Rahm, his e-mail address is bgr4@cornell.edu

5. United States House of Representatives—Committee on Energy and Commerce

Led by congressman Fred Upton, the committee focuses on issues such as health, environment, commerce, energy, and technology. While the committee covers a wide array of issues, they offer important regulatory information about what is happening with the energy industry at the federal government level. The Committee oversees the EPA's SDWA and the UIC program and any other regulations of hazardous waste from oil and gas production. The E & C Committee is the best resource for all federal regulation information other than the EPA. The Committee can be reached directly at (202)-225-2927. All fact sheets and information posted by the committee can be found at http://energycommerce.house.gov/news/fact-sheets

Go-To Websites:

1. http://www.nrdc.org- National Resources Defense Council
This website is run by NRDC; one of the nation's largest environmental action groups with over two million members and activists. The website is well-designed and offers constant updates on global and local environmental issues which are trending and pertinent. There are 16 different "Issues" sections which are available to navigate with graphics and content for further understanding in each area. This is a very widely-cited and reliable source, although is heavily environmentally biased; offering primarily anti-fracking type stories and coverage.

2. https://www.earthworksaction.org- EarthWorks
This website is essential in understanding exactly all the issues surrounding hydraulic fracturing.

The home page offers a constant stream of the latest issues in the U.S. surrounding environmental impacts of fracking, and immediately connects you to “Fracking 101” and “Mining 101” in just one click. The Fracking 101 section is extensive and outlines all aspects of fracking, citing information from US Geological Surveys, ProPublica, and even state health departments. Although EarthWorks is biased towards pro-environmental viewpoints, it offers a much more balanced and non-biased stream of information than most websites of its kind.

3. http://www.waterworld.com/index/about-us.html- WaterWorld International
This website is an online news source by WaterWorld that covers water resource issues on a global scale. The International sector comprises all of the latest news on emerging technology and projects as well as information on the industrial wastewater process. The website offers years of archives of WaterWorld Magazine articles as well as a list of over 100 resources for those looking for more information about companies involved in the water industry.

4. https://stateimpact.npr.org/pennsylvania/tag/deep-injection-wells/- NPR StateImpact Reports
This is a website run by National Public Radio journalists who provide an array of stories on hydraulic fracturing and waste disposal. Upon entering the site, four tabs are available which provide information on the topic you have searched; Regulation, Economy, Influence, and Impact. These tabs are very useful in understanding a topic such as “Deep Injection Wells”, as they guide the user to the most recent stories related to the topic in all four areas. A very helpful website and extremely reliable source.

5. http://fracfocus.org- FracFocus Chemical Disclosure Registry
This website is the primary registry for all hydraulic fracturing companies to offer public access to reports of chemicals used in their processes. The site offers an interactive map in which the user can find where fracking wells exist across the U.S. and what kind of regulation is in place in each state. Also offered is a map that users can access direct contact information for their state’s regulatory office. This site is very visually attractive and user-friendly, which offers a very non biased viewpoint.

6. http://www.weatherford.com/about-us- Weatherford International Energy Company
This site is particularly useful in gaining a perspective on the industrial side of waste disposal from fracking. Although this site is highly biased toward a pro-fracking viewpoint, as Weatherford is one of the top energy producers from natural gas in the world, it remains one of the more useful industrial company’s websites. The website offers video and interactive maps outline all the services offered. Their tab for “sustainability” offers a unique look into new technology that the company is offering worldwide and how they are working towards decreasing environmental impacts from the wastewater produced by their shale plays.

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