The impact of natural gas extraction and fracking on state and local roadways [1]

Although this study is from Pennsylvania, the impact on roadways and cost to the state of same for road transport of natural gas from well sights help to identify some of the issue relevant to Virginia.

“A 2014 study published in *Journal of Infrastructure Systems*, “*Estimating the Consumptive Use Costs of Shale Natural Gas Extraction on Pennsylvania Roadways.*” [2] analyzes a less-studied impact of fracking, the damage it imposes on local transportation infrastructure. The researchers, based at the RAND Corporation and Carnegie Mellon University, looked at the design life and reconstruction cost of roadways in the Marcellus Shale formation in Pennsylvania. They note that local roads are generally designed to support passenger vehicles, not heavy trucks, and that “the useful life of a roadway is directly related to the frequency and weight of truck traffic using the roadway.”

The study’s findings include:

- Heavier vehicles cause exponentially greater roadway damage: A single axle with a 3,000- pounds load has a load equivalency factor [3] (LEF) of 0.0011; for an 18,000-pound load, the LEF is 1.0; and for 30,000 pounds, it’s 8.28. “This means that 18,000-pound and 30,000-pound single-axle … do about 900 times and 7,500 times more damage than a 3,000-pound single axle pass, respectively.”

- The estimated road-reconstruction costs associated with a single horizontal well range from $13,000 to $23,000. However, Pennsylvania often negotiates with drilling companies to rebuild smaller roads that are visibly damaged, so the researchers’ conservative estimate of uncompensated roadway damage is $5,000 and $10,000 per well.
While the per-well figure of $5,000-$10,000 appears small, the increasingly large number of wells being drilled means that substantial costs fall on the state: “Because there were more than 1,700 horizontal wells drilled [in Pennsylvania] in 2011, the statewide range of consumptive road costs for that year was between $8.5 and $39 million,” costs paid by state transportation authorities, and thus taxpayers.

“Some external costs, such as air-quality related health problems, are borne by society at large,” the scholars conclude, “but roadway consumption costs accrue directly to the state and local departments of transportation (e.g., PennDOT).” They suggest several potential approaches that the Commonwealth of Pennsylvania could take to reduce these costs, including an additional fee or tax on top of current per-well impact fees, limiting truck size and weight, or encouraging the use of pipelines rather than trucks. “A comprehensive policy design would combine elements of these three approaches, and work in conjunction with other policies to reduce the broader set of external costs from shale gas operations.”

**Investigating the traffic-related environmental impacts of hydraulic-fracturing (fracking) operations**

**Abstract**

“Hydraulic fracturing (fracking) has been used extensively in the US and Canada since the 1950s and offers the potential for significant new sources of oil and gas supply. Numerous other countries around the world (including the UK, Germany, China, South Africa, Australia and Argentina) are now giving serious consideration to sanctioning the technique to provide additional security over the future supply of domestic energy. However, relatively high population densities in many countries and the potential negative environmental impacts that may be associated with fracking operations has stimulated controversy and significant public debate regarding if and where fracking should be permitted. Road traffic generated by fracking operations is one possible source of environmental impact whose significance has, until now, been largely neglected in the available literature. This paper therefore presents a scoping-level environmental assessment for individual and groups of fracking sites using a newly-created Traffic Impacts Model (TIM). The model produces estimates of the traffic-related impacts of fracking on greenhouse gas emissions, local air quality emissions, noise and road pavement wear, using a range of hypothetical fracking scenarios to quantify changes in impacts against baseline levels.”

**1.2. Well drilling and fracking**

The drilling of a well requires the building of a well pad, movement of a rig and related equipment and materials to the site, for example casing, cement and the chemicals required to make up drilling mud. The fracking process is undertaken after the well has been drilled. Rather than one fracking operation, fracking is normally carried out along different sections of a horizontal or vertical well in what is called a multi-stage fracking operation. Total volumes of water used per well vary considerably, from 1500 m$^3$ to 45,000 m$^3$ (e.g. King, 2012) [5]. The process requires water to be pumped down the well along with chemicals and proppant (usually ceramics or sand). After pumping has finished, the fracking fluid (including natural contaminants) returns to the surface. As with initial water demand, flowback
volumes are variable. In US operations the volumes returning can be 5–50% of the injected volume (King, 2012) [5]. Over a period of a few days to a few weeks flowback decreases and gas production commences. A production well pad could include 12 or more wells, which may be re-fracked several times, once production has declined. It subsequently becomes necessary to remove flowback water from those sites both during and after fracturing. If this transportation is done by road, as has typically been the case in the US and Canada, then considerable volumes of HDV (i.e. tanker) traffic may be generated, albeit for relatively short periods (i.e. weeks) of time.

1.3. Traffic impacts
This section discusses several different ways in which “transportation” of materials can have a harmful impact:

1. Congestion, particularly where the roadways used are designed for light traffic in rural areas, or at times of day when the road ways are already at high usage.
2. Noise: The types of vehicles used tend to be large and diesel powered. The noise generated by these vehicles can have a significant impact on a community.
3. Air: Diesel engines are considered “dirty” due to the Oxides of Nitrogen and particulate matter discharged into the environment. Their exhausts are considered worse than standard lighter weight vehicles.
4. Damage to infrastructure: When road usage changes, so does the affect on the road surface and subsurface. Increased traffic often leas to an increase in the number of accidents, and when carrying “hazardous wastes” the likelihood of an accidental spill s increased. The costs for the repair to these roadways is often put on the shoulders of taxpayers rather than the company doing the drilling and pumping.

1.4. Traffic volume & intensity
(cl notes) Estimation of the anticipated volume of traffic at any given drill site is highly variable. In large part, this is due to the evolution of horizontal drilling which allows for multiple drill pads to be located on one site. The authors note that there appears to be evidence that 6 to 12 well pads are now standard in the US. Each of the drilling pads require their own land clearing and structure; and, each of the rigs will require their own water and produce their own waste water. They also require their own additives to each well. There is a high rate of variability in the reported waste water that is generated by each well.

These wells are not simply drilled, filled, pumped, and closed. It is highly likely that they will be refracked at some point in the future, so at least part of the process (filling, pumping, and removal of waste water) will be repeated over time. The authors note:

“Finally, aside from the actual fracking and waste disposal transport demands, there will also be vehicle movements associated with: construction of access roads and site facilities, excavation and concrete pouring for the pad, transportation of drilling equipment, well casings, water tanks and pump equipment to site, excavation equipment used to dig waste pits, completion and capping material transport, and general movement of workers to and from a site.” [5]
“However, the vast majority of movements (typically 70% or greater) are associated with the fracking and flowback processes. Table 1 presents data from NYC DEP (2009), cited by Broderick et al. (2011), illustrating total truck movements associated with a fracking operation requiring between approximately 12,500 m³ (low) and 18,750 m³ (high) of water and proppants per well, with approximately 50% flowback of fluid waste.”[5]

**Transportation of Products of Hydraulic Fracturing**

Natural gas and oil are primarily transported across land masses and small bodies of water via three methods: (1) pipelines and/or (2) trucks and/or (3) rail. Before it gets to your home for use, it may have traveled via more than one such mode of transportation with pipelines being the most common. Gas and oil from a well must be transported to a facility for cleaning, then it transferred to a storage facility from which it is distributed for further storage or processing, or to the end user.

With all three of these methods of transport, there is a degree of risk. There is risk in everything, nothing in life is “risk free”. Public health and safety demands that transportation of any hazardous materials such as waste of product of extractive industries such as hydraulic fracturing be evaluated for the potential for risk and that the least “risk prone” option be utilized. It is simply a matter of determining the level or risk and if that level of risk is acceptable.

**Pipelines**

“There are approximately 2.6 million miles of pipeline networks in the United States of which 304,725 are natural gas transmission lines. The network includes the "gathering" lines (the ones that transport oil and natural gas from well sites to compressor stations and other processing facilities), the 20- to 42-inch transmission lines (that carry oil and gas long distances), and distribution lines as small as 2 inches that carry gas into homes and businesses.” [8]

A powerpoint presentation by Ian Duncan, Bureau of Economic Geology, University of Texas, “Understanding Risks of Natural Gas and Oil Pipelines” [6] provides an overview of the risks associated with pipelines and the importance of making a realistic evaluation of the risk involve when developing opinions on pipeline usage for oil and gas transportation. On his 28th slide it is important to note the chart showing the “Causes for Oil Pipeline Failure”. Corrosion, both external and internal are the most frequent causes of oil pipeline failure.

The analysis of gas pipeline failure is problematic at best. Much of the “evidence” that would show the reason for a failure are destroyed in the explosion/fire. The evidence available does show that “Over half of all in-servie pipeline failures result from some externally applied mechanical force”. [7] In direct counterpoint to the previous article discussed, this author notes that: “Corrosion can cause failures by thinning the wall over a large area or localized pitting. Both external and internal corrosion can lead to failures, but the widespread use of cathodic protection has greatly reduced external corrosion.” [7] Note that this safety feature does not apply to internal corrosion.

Other forms of damage that can result in pipeline failure discussed are:

- “transit fatigue”: damage to pipe due to handling and transport when shipping to site
- “stress-corrosion cracking”: due to corrosive materials in the moisture building up on any imperfections on the pipe surface coating
- “material defects” defects that occur during the production of the pipe, particularly at weld seams (7)

Sixty-one (61) percent of major tragic natural gas incidents have been due to corrosion, faulty material, or faulty welding. [8] Age of pipeline is a significant contributing factor as many have been in the ground since the 1950’s and 1960’s. Current safety standards were not in place at that time and therefore incidents are more likely to occur with older lines.

“Based on the hazardous liquid pipeline incidents reported to the PHMSA across the United States between January 2002 July 2012, there were 1,692 incidents, of which 321 were pipe incidents along the mainline and 1,027 were involving different equipment components such as tanks, valves, or pumps.” [8] In discussing “Failure Modes of Gas and Liquid Pipelines” the author provides images and data, and discussions for each of these types of failure: [8]

- Physical (mechanical) damage (approximately 11% of incidents)
- Corrosion (internal, external or stress corrosion cracking (approximately 25% of incidents)
- Equipment and material defects and/or weld failures (approximately 36% of incidents)
- Incorrect or negligent operation or inspections (approximately 11% of incidents)
- Damage due to natural forces (approximately 6% of incidents)
- Other outside force damage (approximately 3% of incidents)
- All other causes (approximately 8% of incidents)

Corrosion was the most common cause found in the 370 significant safety incidents involving natural gas pipelines between 2008 and 2012. [11] Despite all of these issues/potential risks, pipelines are considered the safest method of transporting natural gas. In large part, this appears to be due the measures taken to monitor pipelines over time.

**Rail Transportation**

The transport of liquid natural gas by rail is being pushed in some areas of the country as a means for delivering large quantities of natural gas to more rural areas. In particular, this addresses product needs in areas where pipelines may be built in the future, but rail offers a reasonable substitute for the time being.

It is 4.5 times more likely that a major event will occur in rail transport of natural gas than in pipeline transmission. The majority of pipeline incidents occur within facilities where additional safety measures are in place. This does not hold true for rail transportation. [12]
Truck Transportation

Despite the fact that the majority of oil and natural gas are transported by pipeline or by tanker (ship transport), trucks have a significant role in the movement of both oil and gas. This can be the transport method of choice when the wells are located in remote areas. Pipelines and railroad tracks take a long time to construct, so unless they already exist within a given area, trucks are the next option for moving the raw product to processing facilities. For waste products, trucks are often used to transport fluids short distances to settling ponds or other storage facilities.

Compressing natural gas and then transporting by truck creates a “virtual pipeline”. Despite the truck transport of gas being more costly than piped in options, when companies switch from oil to gas, fuel costs are low enough to offset the expense, reduce sales price, and hire more employees. [9] Again, by providing a service to rural areas that are not supplied by pipelines, this can create a significant economic advantage.

Transportation of Hydraulic Fracturing Wastewater

The most significant forms of waste from the beginning to the end of the process is water. The greatest potential hazard comes from when fluids used in the drilling, stimulation, or production of the well produces “flowback”. Horizontal drilling, when used in conjunction with hydraulic fracturing may result in volumes of this “flowback” water that far exceeds wastes generated by other extractive forms and require larger storage capacity at the site of the wastewater in the form of tanks or pits. In 2014, the EPA conducted a survey of 26 of 33 gas producing states for wasterelated provision of state regulations. [13] They found that:

All 26 reviewed states have oil and gas regulations.

- State regulations vary greatly in scope and detail.
- Regulatory programs can include regulatory parameters such as liner requirements, clear definitions of waste fluids and characterization requirements, operational controls, maintenance, closure, and financial assurance requirements.
- Several areas do not appear to have specific requirements; for example, groundwater monitoring, air monitoring, or post closure monitoring.
- Numerous states have recently updated regulations to include disclosure requirements for the chemicals used in the practice of hydraulic fracturing. [13]
Wastewater from hydraulic fracturing is usually handled in one of 3 ways:

- Treatment of waste water to remove contaminants then discharge into surface water-based
- Recycle through the hydraulic fracturing processed
- Underground injection into special wells for long-term storage

Most of the waste water is re-injected into the ground. One of the most common was of managing this water is to store it onsite until such time as it can be transported, usually by truck for long term storage in wells that are no longer functioning. Fracking waste water is but a very small portion of the water handled in this fashion. The the average oil well, 88% of the material brought to the surface is brine water. [14] The recycling of this wastewater is not covered under federal regulations and is therefore regulated only at the state level. [15] Underground injection of the water requires that the water be transported to the injection site.

In between the well and the final resting place of wastewater is the truck and the public roadways and communities. The temporary storage and transportation of these fluids fall under the purview of the state since oil and gas wastes are not covered by the federal Resource Conservation and Recovery Act. These state regulations vary significantly from state to state. The regulations for Virginia are currently in development for fracking waste fluids. [15] If these fluids are untreated and are being transported for in ground storage, the actual components of the water could include all of the chemical additives. This becomes problematic if there is an accident involving one of the vehicles hauling the fluid or if there is an equipment failure on the vehicle that a results in leakage.

The landscape of chemicals used in the process of hydraulic fracturing is highly variable. Companies are working diligently to protect their “proprietary information” by not being required to release the names of the chemicals used in fracking waters to the public. In Virginia, this has brought us to the point where the companies are requesting the Dept. of Mines, Minerals, and Energy not release their proposed regulations for hydraulic fracturing until such time as the companies can attempt to get transparency laws changed.

What is problematic in this partial or lack of transparency is the inability of first responders to be adequately prepared to deal with an accident involving such fluids. Without knowledge of what the contents of the liquid are, there is no way for first responders to have the necessary protective clothing or gear required to be able to access any victims within the accident zone. First responders to a loss of these fluids near surface waters will not know the precise methods of containment to use or the warnings to distribute to affected homes/communities. Furthermore, there may be an issue of who is responsible for providing any special training and equipment to first responders. In the more rural areas, where hydraulic fracturing has historically occurred, these response agencies are frequently volunteers. They may or may not be able to afford the costs of additional equipment and supplies needed. If the potential hazards are clearly identified, then the costs of managing an accident could be more fully evaluated and steps taken to insure that the public health, safety, and welfare is insured.

Sources cited:


[5] Investigating the traffic-related environmental impacts of hydraulic-fracturing (fracking) operations. (n.d.).


**Additional Resources:**


Companies providing “virtual pipeline” for natural gas. (n.d.).


