Out of Sight, Out of Mind

New York's Failure to Track or Treat Fracking Waste Endangers Public Health & the Environment

ENVIRONMENTAL
ADVOCATES OF NEW YORK
YOUR GOVERNMENT WATCHDOG

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Environmental Advocates of New York's mission is to protect our air, land, water, and wildlife and the health of all New Yorkers. Based in Albany, we monitor state government, evaluate proposed laws, and champion policies and practices that will ensure the responsible stewardship of our shared environment. We work to support and strengthen the efforts of New York's environmental community and to make our state a national leader. A tax-exempt 501 (c) (3), Environmental Advocates is the New York affiliate of the National Wildlife Federation.

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EXECUTIVE SUMMARY

New York State Governor Andrew Cuomo is contemplating whether to allow drilling for natural gas in the Marcellus and Utica Shales using high-volume hydraulic fracturing, or high-volume "fracking." If this process is permitted, how New York requires drillers to handle, treat, and dispose of high-volume fracking's toxic wastes will be among the administration's greatest challenges.

While New York's pending decision on high-volume fracking has generated intense public concern, less attention has been paid to the state's existing gas drilling operations.

As of 2009, New York was home to 6,628 active gas wells, approximately 90 percent of which are fracked (although drillers use less water than the amounts proposed for high-volume fracking).

To better understand how wastewater from fracking operations is disposed of today, and to shed light on how the anticipated influx of wastes from the high-volume fracking operations being proposed could affect New York tomorrow, Environmental Advocates of New York took an in-depth look at the state's current oversight of drilling wastes.

We set out to learn what happens to fracking wastewater from existing operations, and how and where such wastes are disposed. We also attempted to find out if New Yorkers and our shared environment are at risk from existing drilling operations.

Our review yielded disturbing results.

Existing state laws and regulations do not require oil and gas companies to report with any specificity how much waste is being created, its chemical components, or how drilling waste is being disposed. We also discovered that much of fracking's waste would likely be classified as hazardous waste if it were not exempt under flawed state regulations.

Whether they originate from large or small fracking operations, all fracking wastes share similar toxic properties. Both low- and high-volume fracking wastes are laden with toxic chemicals used to extract gas. Fracking waste is also two to six times as salty as seawater. And although the precise toxicity of fracking waste differs from well pad to well pad, none of it is subject to the strict tracking, treatment, and disposal requirements of hazardous wastes.

Governor Cuomo and the New York State Department of Environmental Conservation (DEC) are proposing new policies to govern the disposal of wastewater from high-volume fracking, but the state's proposals do not address waste disposal from smaller fracking operations.

Fracking is fracking. Put simply, unequal treatment of potentially toxic and hazardous drilling wastes puts New York's waters and communities at risk.

> *... much of fracking's waste would likely be classified as hazardous waste if it were not exempt under flawed state regulations.*

Governor Cuomo should ensure all New Yorkers are protected under state law from the potential dangers of fracking—meaning any new measures to regulate fracking waste treatment and disposal should apply to all fracking operations, regardless of size.

The Governor should also close the loophole that makes fracking waste exempt from the storage, handling, and treatment requirements for other hazardous substances. In addition, facilities not designed to dispose of toxic wastes, such as municipal sewage treatment plants, should be prohibited from accepting such waste, and fracking waste should never be spread onto roads.

INTRODUCTION

New York State Governor Andrew Cuomo is contemplating whether to allow drilling for natural gas in the Marcellus and Utica Shales using high-volume hydraulic fracturing, or "fracking." If the Governor decides to permit fracking, one of the biggest challenges facing his administration will be safely and responsibly handling, treating, and disposing of fracking's toxic wastes.

While the pending decision on high-volume fracking has generated intense public concern, less attention has been paid to New York's current low-volume fracking operations.

In 2009 (the most recent year for which data is available), New York had 6,628 active gas wells, most of which are located in Western New York and the Finger Lakes.[1] Ninety percent of these wells are fracked, although drillers use less water than the amounts proposed for high-volume fracking.

But drilling waste from all fracked wells is similar. In general, fracking waste from high- or low-volume operations is comprised of salts, heavy metals, and the toxic chemicals injected into the wells during drilling. Depending on the rock formation being drilled, these wastes may also include significant amounts of naturally occurring radioactive materials.

Based on its chemical makeup, this toxic cocktail of drilling waste would likely be considered hazardous waste if not for a loophole in existing state regulations.

What is Hydraulic Fracturing, or "Fracking?"

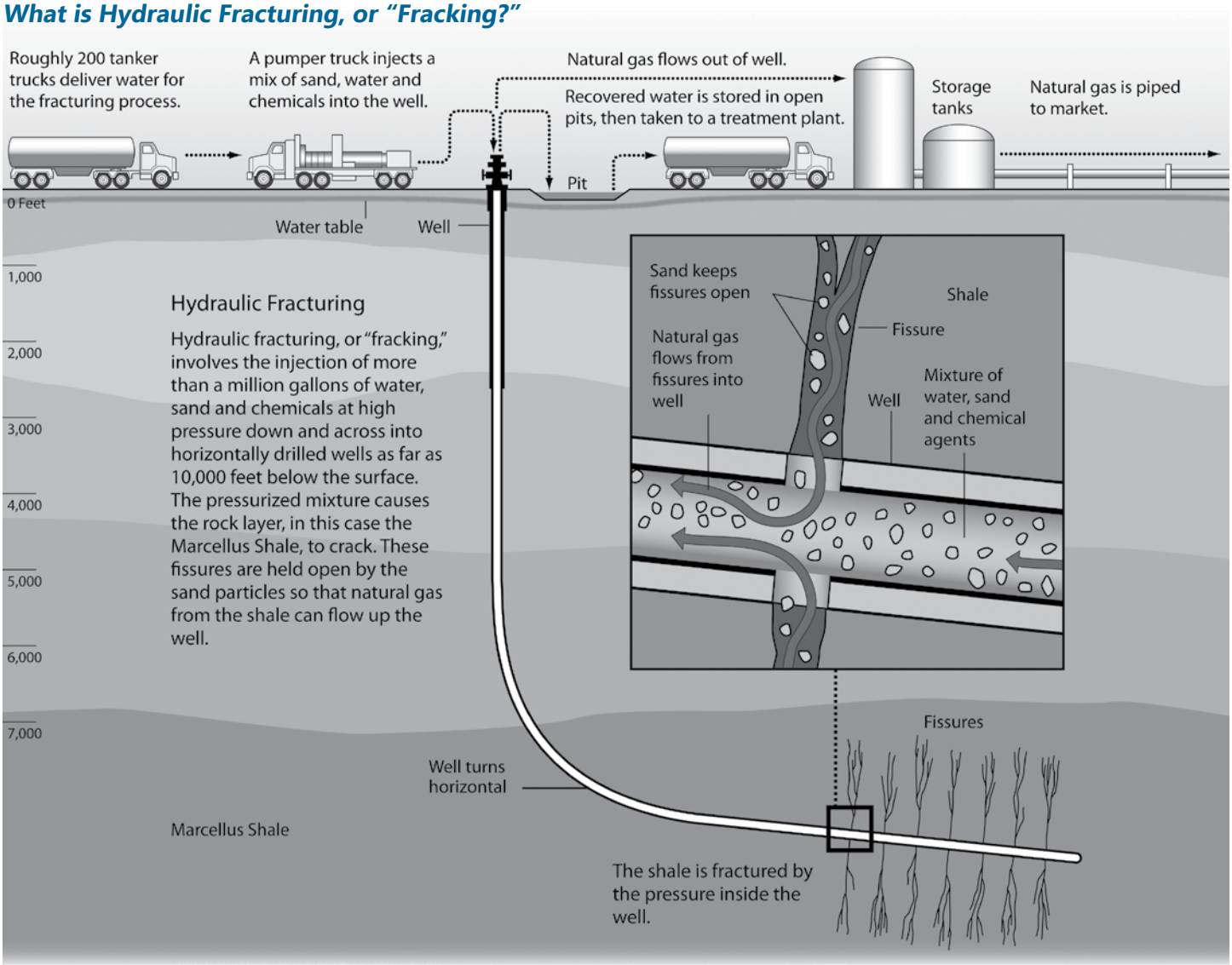


Diagram of fracking process

Graphic: Al Granberg / ProPublica

As with any hazardous waste, if improperly treated or disposed of, fracking waste can enter waterways and underground aquifers and wreak havoc on ecosystems and drinking water.

In states where the drilling technique has proliferated, including Wyoming, Colorado, Pennsylvania, and Texas, fracking has led to ground and surface water pollution and may be responsible for a range of public health problems.

As the state's passionate debate about fracking continues, Environmental Advocates of New York set out to better understand how fracking wastes are from low-volume operations are disposed of today. We analyzed data from nearly 100 permit applications to see how state regulators currently oversee fracking wastewater disposal.

Instead of shedding light on where fracking wastewater goes, our analysis shows cause for alarm.

This report describes:

1. the state's flawed process for permitting existing drilling operations;

2. the makeup of fracking wastewater and its environmental hazards; and

3. a discussion of the likely ways fracking wastewater is disposed of today.

> *In short, the DEC does not know how much drilling waste is being produced or where it is going. Only the gas companies know, and they're not talking.*

Our research also uncovered that, based on testing results from other states included in the New York State Department of Environmental Conservation (DEC) report, fracking waste would indeed be classified as hazardous waste if it were not exempt from such classification under state regulations.

In short, the DEC does not know how much drilling waste is being produced or where it is going. Only the gas companies know, and they're not talking.

NEW YORK'S FLAWED PERMITTING PROCESS

For a better understanding of how the state might deal with a glut of high-volume fracking wastes, Environmental Advocates requested documents filed by the oil and gas industry for 100 active wells in the state's gas producing counties permitted since 2005.

During our investigation, we uncovered that the DEC asks drillers only two questions during the application process about how they intend to dispose of waste:

1. How will drilling fluids and stimulation fluids be contained and disposed of?

2. If brine will be stored onsite, how will it be stored and disposed of?

Drillers' Responses

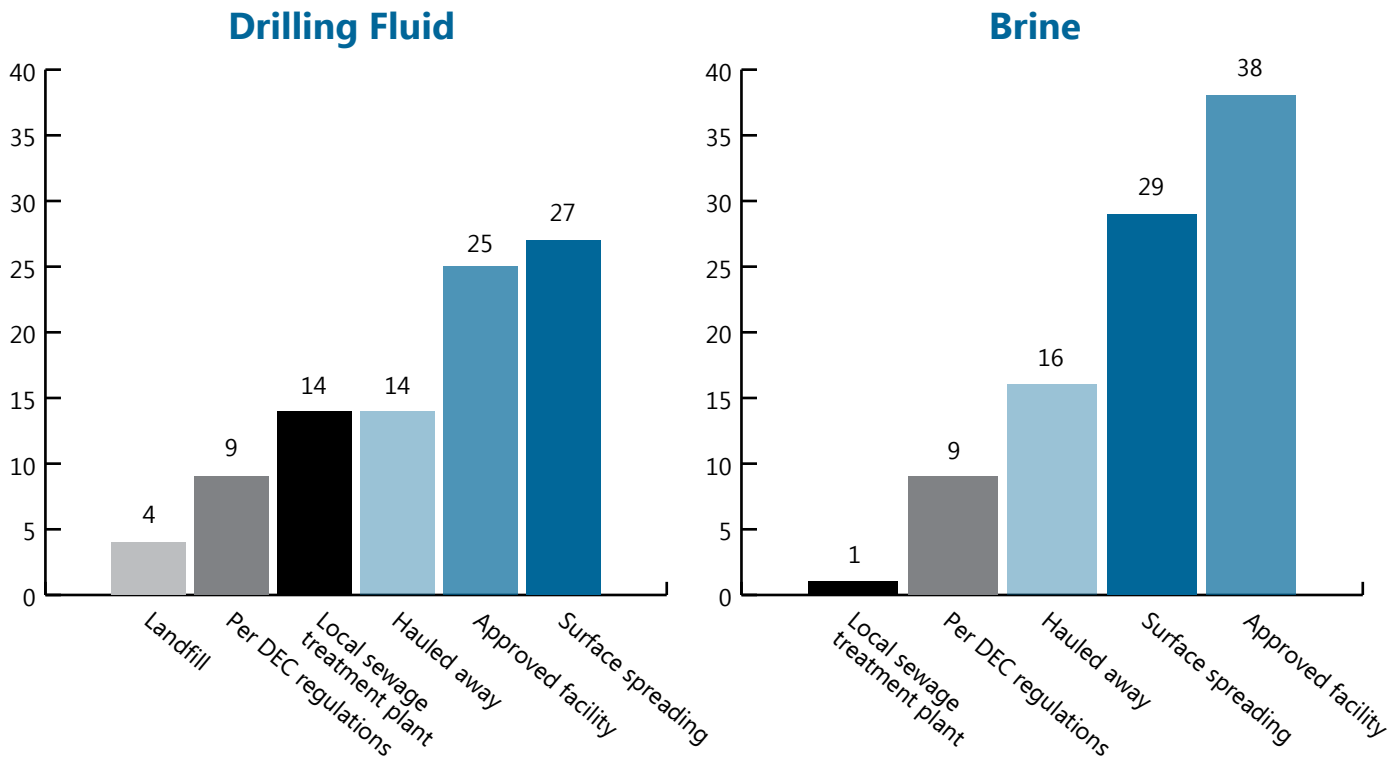
As shown in the bar graph on page 5, responses by industry to the two questions listed above are unacceptably vague. The responses provide little detail on where the wastes actually went, shed no light on whether the waste got there, and raise more questions for further inquiry.

For example, in 16 cases, drillers simply responded that their brine was "hauled away." Where did it go? Did they send it to another state? How was it disposed after it was hauled?

In four cases, drillers responded that their drilling fluids may have been sent to a landfill. How was predominately liquid waste disposed in a solid waste landfill? Did they mix it with something first? Did they just dump it?

On 25 forms, oil and gas companies simply stated that they dispose of their wastes at "approved" facilities. Similarly, in nine cases, drillers said their waste was

INDUSTRY WASTEWATER DISPOSAL RESPONSES



Note: The categories listed above capture the types of responses included in the forms, not verbatim responses (see www.eany.org for a table with complete responses).

disposed of per DEC regulations. Which ones? What does this mean?

Additionally, on some applications, drillers identified more than one disposal option, which means that even among the vague answers provided, further ambiguities abound (e.g., 27 drillers responded that they would dispose of drilling fluids by hauling them to an approved disposal facility and/or by approved surface spreading).

Based on DEC's process, following the waste stream from a well to ultimate disposal is nearly impossible. And some of the disposal options, such as road spreading or disposal in treatment plants, raise their own serious environmental concerns.

Unanswered Questions

In reviewing drillers' responses, Environmental Advocates was left with some unsettling questions.

- How are liquid wastewaters landfilled (as indicated in four responses)?
- When a driller indicated that wastewaters were hauled offsite, how were the wastes ultimately disposed?
- What does it mean when drillers reported that wastes would be handled according to DEC regulations?
- How is it possible that the state's environmental agency accepted these responses as complete?

WASTEWATER HAZARDS

Throughout this report the term "wastewater" is used to describe flowback and produced waters, both of which can be harmful to human health and the environment.

There are varying estimates of the amount of wastewater produced by a fracked well. According to a 1992 study (the most recent state data we could find that estimated the amount of wastewater from the types of wells currently being drilled), the DEC documents estimate that each well currently fracked in New York may produce 42 to 210 gallons of wastewater per day, depending on well-specific conditions.[2] The amount of wastewater produced increases the longer the well stays in production.[3]

It's important to keep in mind that high-volume fracking in the state's shale formations would require drillers to use volumes of water and chemicals far greater than those currently used for smaller wells.

High-volume wells will generate significantly more waste. For instance, based on information from Pennsylvania, high-volume fracked gas wells produce between 216,000 gallons and 2.7 million gallons per well as flowback, and roughly 100 gallons of produced water per day for a well's producing life.[4]

The composition of wastewater from New York's existing wells was last analyzed by the DEC in 1988, although drillers have provided some updated information since then. But as mentioned previously, drillers are not required to test waste from each well, which can vary from well to well.

In general, fracking wastes have three main components: the chemicals used during the drilling process, naturally occurring salts and heavy metals released during drilling, and, in some cases, significant amounts of radioactive material. Each of these components and their environmental hazards are described below.

Chemicals

A portion of the wastewater includes the chemicals used during the fracking process. The exact composition of fracking fluids differs from product to product. The industry regards fluid composition as a trade secret and refuses to publicly disclose its makeup.

However, the DEC requested the chemical constituents that may be used in fracking fluids in the context of permitting high-volume fracking. In response, the oil and gas industry revealed that fracking fluid may contain 300 distinct chemicals and at least 22 additional compounds.[5]

These chemicals vary in impact on human health and the environment from the toxic to the benign. But some chemicals disclosed include known carcinogens benzene and formaldehyde, etholene glycol (a.k.a. antifreeze), potential carcinogens xylene and monoethanolamine, and the endocrine disruptor precursor nonylphenol polyethoxylate.

Fracking wastewater storage pit Photo: Flickr

Salts

Fracking wastewater can be up to six times as salty as seawater, depending on the rock formation drilled and the amount of time water spends in the well before returning to the surface.[6]

Salts found in fracking wastes can become a human health concern when the wastes are treated at municipal treatment plants. Fracking can contain certain salts known as bromides. Bromides react with disinfectants used by sewage plants, creating brominated trihalomethanes (THMs). Studies show a link between ingestion of and exposure to THMs and several types of cancer and birth defects.[7] People can be exposed to THMs when treated wastes are discharged into waterways that serve as water supplies.

Radiation

Fracking may also bring naturally occurring radioactive materials to the surface in drilling wastes. The DEC published data received from high-volume fracking wastewaters from the Marcellus Shale formation in Pennsylvania. The wastes contained radioactive elements, including radium-226, a derivative of uranium. In some waste samples, the levels were recorded at more than five times federal drinking water limits.[8] Very few water treatment plants across the nation are capable of treating radiation, so disposal of fracking wastewater in most plants could potentially release unsafe levels of radiation into lakes, rivers, and streams that serve as drinking water sources.

The New York Times conducted its own investigation of wastewater produced by high-volume fracked wells in the Marcellus Shale formation and reported that the level of radioactivity in the waste "has sometimes been hundreds or even thousands of times the maximum allowed by the federal standard for drinking water."[9]

A Toxic Cocktail

Fracking waste is a toxic cocktail should be handled with great care. Although the chemical composition of the waste will vary from well to well, our research shows that in at least one case, drilling waste would be considered "hazardous waste" and should be subject to rigorous handling and disposal standards.

THE DRILLING WASTE LOOPHOLE: A CASE STUDY

New York State regulations exempt the waste produced by gas and oil drilling or operations from the hazardous waste treatment, disposal, and handling requirements required of every other industry.[10]

Under New York Environmental Conservation Law (ECL) § 27-0901 3(b), hazardous waste is broadly defined as a waste or combination of wastes that pose

> *"a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed, or otherwise managed."*

It is the responsibility of the DEC, under ECL § 27-0903, to promulgate regulations to further define hazardous waste.

Under 6 NYCRR section 371.3(e), wastes qualify as hazardous if they contain certain contaminate concentrations above the values listed in the regulations. Barium is included in the list at a concentration of 100 milligrams per liter (mg/l). Therefore, any waste that includes barium at more than 100 mg/l would be considered hazardous.

According to an industry study of eight Marcellus Shale wells in northern Pennsylvania with comparable character to New York's Marcellus Shale, the amount of barium detected in flowback fluid the first day it was pumped out of the well varied from 37 mg/l to 1,450 mg/l (the median level detected was 387 mg/l). On day 14/15, the amount of barium detected varied from 105 mg/l to 12,500 mg/l (the median level detected was 1,835 mg/l).[11]

> *If produced by any other industry, such wastes would be classified and treated as hazardous based on barium levels alone.*

According to a separate analysis by the DEC, wastes from 48 wells in Pennsylvania and West Virginia were tested for barium. Forty seven of the 48 wells tested positively, and ranged from .553 mg/l to 15,700 mg/l (the median level detected was 1,450 mg/l).[12]

If produced by any other industry, such wastes would be classified and treated as hazardous based on barium levels alone.

Although the Governor and the DEC have proposed requiring the oil and gas industry to submit a drilling waste disposal plan for high-volume fracking, these requirements are still far short of the publicly available cradle–to-grave tracking, handling, and disposal measures required for other hazardous wastes.

But for smaller fracking operations, only the industry would know exactly how much wastewater a well is producing, how toxic or hazardous these wastes may be, where they are going, how they got there, or if wastes reached their destination.

LIKELY DISPOSAL OPTIONS

Based on Environmental Advocates' analysis, there is no way to know where waste produced by any one well is going. But there are several potential disposal options for New York's existing fracking waste that are currently permitted by law, several of which were cited on drillers' applications.

Municipal sewage plant Photo: Adrian Jones / IAN–UMCES

Municipal Sewage Plants

Under state and federal law, municipal sewage plants (also known as publicly owned treatment works, or POTWs) are legally allowed to accept fracking wastes provided that such wastes will not exceed the plant's permitted pollution limits when discharged into a water body.[13] Legal or not, sewage plants were not designed to remove fracking chemicals, high levels of salts, and naturally occurring radioactive materials from wastewater.

The New York Water Resources Institute at Cornell University came to the same conclusion. In testimony before the New York State Senate Environmental Conservation Committee, researchers said that

> *"treatment of most shale gas wastewaters is not appropriate at POTWs utilizing biological processes (almost every POTW in New York)."*

And,

> *"existing or new POTWs that utilize physical/chemical treatment processes may have the ability to successfully treat specific shale gas wastewaters. However, only two such systems currently exist in New York."*[14]

Recognizing that many of the state's treatment plants would not be able to treat fracking wastes, in 2008, the DEC sent a memo to all permitted plants advising them to follow pretreatment regulations and requirements before accepting any drilling fluids. The agency went on to explain the process by which sewage plants may or may not accept waste and the types of information that drillers would need to submit to the plant in order for the consideration to be made.

Based on these problems, many plants that were accepting or considering accepting fracking wastes have stopped. According to DEC staff, the Auburn Wastewater Treatment Plant is the only treatment plant planning to accept fracking waste in New York State, a dubious distinction that is causing heated public debate.

Road Spreading

In New York, it is legal to use drilling wastewater from the state's existing wells on roads as a dust control or de-icing agent. And prior to 2009, any hauler licensed under 6 NYCRR 364 could spread wastewaters on roads without any additional permission from the DEC. Based upon conversations with DEC staff, it is suspected that road spreading is how the majority of the state's current fracking waste is being disposed.

Fracking wastewater spread on roads runs off into adjacent ditches, which in turn lead to streams or allow the fluids to be absorbed, potentially entering underground aquifers.

Although the DEC has put forth a proposal to ban road spreading for fracking wastes produced by Marcellus Shale wells, the wastes produced by smaller fracking operations is similar. New York State should prohibit road spreading of all fracking wastes.

Brine road spreading Photo: Newton Crouch

Reuse & Recycling

Industry is quick to say it is working to recycle and reuse fracking wastes. In Pennsylvania, the gas industry falsely claims to reuse as much as 90 percent of its wastewater. According to *The New York Times* (March 2011), recycling rates have ranged from 20 percent to 65 percent of the total produced wastewater.[15]

Recycling and/or reusing wastewater would use less fresh water and reduce the quantity of wastewater ultimately produced. But there will always be recycling byproducts (e.g., residuals and sludges) that must be treated, and those byproducts are comprised of toxic wastes much more concentrated than those found in the wastewater itself.

Underground Injection

In much of the country where fracking has been used to extract natural gas, deep disposal wells are considered to be the answer to the wastewater problem. However, based on a recent string of earthquakes in Ohio[16] and Arkansas,[17] this option is no panacea.

New York has six underground injection wells, only one of which is used for oil and gas waste disposal. Owned by Lenape Resources, the company uses it exclusively for wastewater from its own gas fields.[18]

RECOMMENDATIONS

New York State needs a safer and more responsible way to characterize, track, and dispose of drilling waste if high-volume fracking operations are permitted, as well as for smaller operations that also employ fracking. Based on our analysis, the DEC doesn't know how much waste is being produced by the state's 6,628 active gas wells,[19] what the waste is comprised of, where it is going, how it is being treated, or how it is ultimately being disposed. These failures are putting public health and New York's environment at risk.

> *New York State needs a safer and more responsible way to characterize, track, and dispose of drilling waste if high-volume fracking operations are permitted, as well as for smaller operations that also employ fracking.*

The best we can do is guess. Drilling waste may be sent to sewage treatment plants that are ill-equipped to handle them, spread on roads where toxics can find their way into underground water supplies, trucked out of state to become someone else's problem, recycled until all that's left is a super toxic sludge, or illegally stored or dumped.

None of these options are acceptable for current drilling operations. And none of these options would be adequate if

Governor Cuomo allows high-volume fracking, which produces significantly more fracking wastewater.

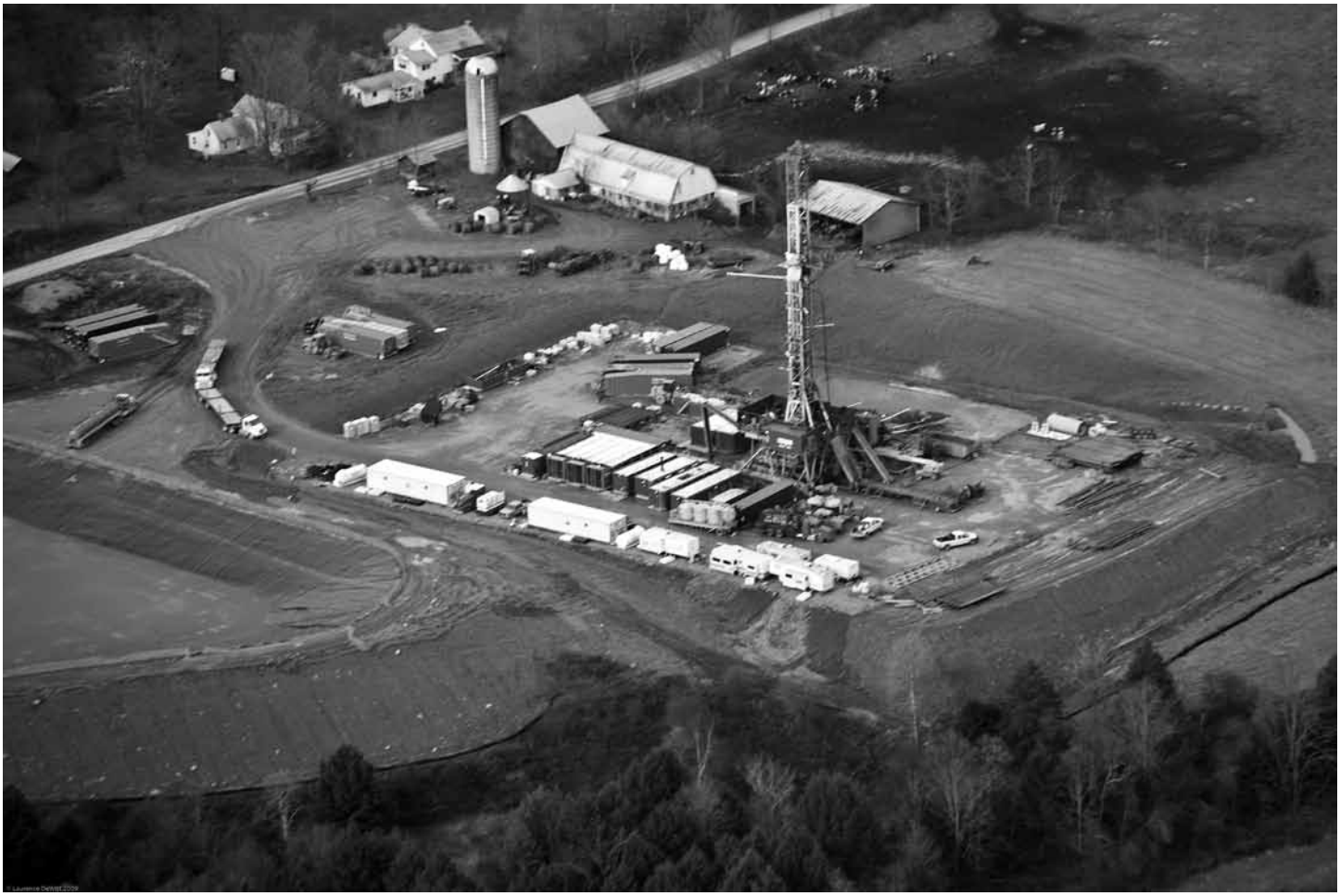
Based on this review, New York State should take a hard look at all of its oil and gas drilling regulations. Governor Cuomo should adopt the following recommendations in order to take responsible steps to safeguard the state's waters and communities:

1. Require that all new measures to protect New York's environment from the dangers of high-volume fracking apply to all fracking operations, regardless of size. All fracked wells have similar environmental impacts, including impacts from the use of toxic and carcinogenic fracking fluids and waste generation, transport, and disposal.

2. Require drillers to test their waste for toxicity, just like every other generator of hazardous wastes. In many cases, fracking wastes would be classified and treated as hazardous waste. But due to a special carve-out for the gas industry and because they are produced on a well pad, such wastes are exempt from the storage, handling, and treatment requirement for other hazardous substances.

3. Prohibit the disposal of all drilling wastes at municipal sewage treatment facilities. The risks are simply too great to dispose of this wastewater in plants that are not at all equipped to treat them.

4. Prohibit the disposal of all drilling waste by spreading on roads or using as a de-icing agent.



Drilling rig in Pennsylvania, 2009 Photo: Laurence B. DeWitt, www.photosbydewitt.com

APPENDIX A: REPORT METHODOLOGY

In order to discover where wastes are going from the state's existing 6,628 wells, Environmental Advocates of New York used the Freedom of Information Law (FOIL) to request relevant documents relating to 100 active wells.

The particular wells were chosen at random, but an effort was made to ensure that documents were requested on applications submitted by a variety of drillers throughout the state's gas-producing counties (Cattaraugus, Chautauqua, Erie, Genesee, Madison, Ontario, Seneca, Steuben, and Wyoming).

We specifically requested all documents:

- relating to waste management, storage, treatment, transport, and disposal;
- detailing how wastes generated at any point during the drilling and gas extraction process are handled and treated prior to disposal; and
- detailing where the wastes are ultimately disposed.

In response to the request, Environmental Advocates received portions of permit applications (namely an application's Environmental Assessment Form), conditions placed on wells permitted in freshwater aquifers, and permits.

Please visit www.eany.org to view a table listing information we received from the DEC in response to our FOIL request.

APPENDIX B: WELL PERMIT RECORDS REQUESTED

Town	County	Company Name	Spud/Start Drilling Date	API Well Number
Alden	Erie	Alden Aurora Gas Co., Inc.	3/31/2009	31029257330000
Busti	Chautauqua	EnerVest Operating, LLC	5/21/2007	31013248530000
Campbell	Steuben	Talisman Energy USA Inc.	7/21/2006	31101238790000
Campbell	Steuben	Talisman Energy USA Inc.	9/25/2007	31101260110000
Catlin	Chemung	Talisman Energy USA Inc.	1/11/2006	31015238200000
Charlotte	Chautauqua	McQuiggan & Nalepa	3/24/2006	31013242970000
Chautauqua	Chautauqua	Empire Energy E&P LLC	8/18/2006	31013245100000
Cherry Creek	Chautauqua	Pine Valley Central School District	2/5/2009	31013252350000
Collins	Erie	U S Energy Development Corp.	1/10/2008	31029250720000
Collins	Erie	U S Energy Development Corp.	1/14/2008	31029251100000
Collins	Erie	U S Energy Development Corp.	1/15/2009	31029256020000
Collins	Erie	U S Energy Development Corp.	1/17/2008	31029251120000
Collins	Erie	Pan Energy Company, Inc.	11/3/2008	31029255500000
Collins	Erie	U S Energy Development Corp.	2/20/2008	31029251160000
Concord	Erie	U S Energy Development Corp.	12/12/2006	31029246740000
Corning	Steuben	Talisman Energy USA Inc.	10/5/2006	31101239020000
Covington	Wyoming	Lenape Resources, Inc.	3/16/2006	31121244380000
Covington	Wyoming	Lenape Resources, Inc.	3/20/2006	31121244370000
Covington	Wyoming	Lenape Resources, Inc.	3/21/2006	31121244390000
Covington	Wyoming	Lenape Resources, Inc.	3/21/2006	31121244400000
Covington	Wyoming	Lenape Resources, Inc.	3/21/2006	31121244410000
Covington	Wyoming	Lenape Resources, Inc.	3/22/2006	31121244420000
Covington	Wyoming	Lenape Resources, Inc.	3/24/2006	31121244360000
Darien	Genesee	New York Gas & Oil Co, Inc.	1/11/2007	31037239330000
Darien	Genesee	New York Gas & Oil Co, Inc.	10/31/2007	31037239940000
Darien	Genesee	New York Gas & Oil Co, Inc.	10/31/2007	31037239940000
Darien	Genesee	New York Gas & Oil Co, Inc.	10/9/2007	31037239930000
Darien	Genesee	New York Gas & Oil Co, Inc.	11/28/2006	31037239240000
Darien	Genesee	New York Gas & Oil Co, Inc.	11/9/2006	31037239140000
Darien	Genesee	New York Gas & Oil Co, Inc.	12/4/2006	31037239230000
Darien	Genesee	New York Gas & Oil Co, Inc.	2/22/2010	31037262250000
Darien	Genesee	New York Gas & Oil Co, Inc.	3/21/2007	31037239620000
Darien	Genesee	United States Gypsum Co.	4/27/2006	31037238180000
Dayton	Cattaraugus	Chautauqua Energy, Inc.	2/1/2010	31009275490000
East Bloomfield	Ontario	Seneca Resources Corp.	8/13/2008	31069261300000
East Otto	Cattaraugus	U S Energy Development Corp.	1/28/2008	31009248590001
Ellery	Chautauqua	Hayden Harper Energy KA LLC	4/29/2008	31013252930000
Fayette	Seneca	Chesapeake Appalachia, L.L.C.	10/13/2007	31099239740000
Fayette	Seneca	Chesapeake Appalachia, L.L.C.	10/18/2007	31099239750000
Fayette	Seneca	Chesapeake Appalachia, L.L.C.	10/22/2007	31099239390000
Fayette	Seneca	Chesapeake Appalachia, L.L.C.	10/24/2007	31099239790000
Fayette	Seneca	Chesapeake Appalachia, L.L.C.	10/4/2007	31099239780000
Fayette	Seneca	Chesapeake Appalachia, L.L.C.	10/8/2007	31099239730000
Fayette	Seneca	Chesapeake Appalachia, L.L.C.	2/7/2007	31099238780000
Fayette	Seneca	Chesapeake Appalachia, L.L.C.	3/29/2007	31099239370000
Fayette	Seneca	Chesapeake Appalachia, L.L.C.	4/12/2008	31099239530000
Fayette	Seneca	Chesapeake Appalachia, L.L.C.	4/15/2008	31099260840000
Fayette	Seneca	Chesapeake Appalachia, L.L.C.	4/24/2008	31099261190000
Fayette	Seneca	Chesapeake Appalachia, L.L.C.	4/29/2008	31099261070000
Fayette	Seneca	Chesapeake Appalachia, L.L.C.	4/6/2008	31099239420000
Gerry	Chautauqua	Chautauqua Energy, Inc.	6/16/2008	31013254690000
Hanover	Chautauqua	U S Energy Development Corp.	1/11/2006	31013243350000
Hanover	Chautauqua	U S Energy Development Corp.	1/17/2008	31013247320001
Hanover	Chautauqua	U S Energy Development Corp.	1/19/2007	31013246790000
Hanover	Chautauqua	U S Energy Development Corp.	1/24/2006	31013243460000
Hanover	Chautauqua	U S Energy Development Corp.	1/3/2006	31013243370000
Hanover	Chautauqua	U S Energy Development Corp.	1/30/2006	31013243490000
Hanover	Chautauqua	U S Energy Development Corp.	2/23/2005	31013240280000
Harmony	Chautauqua	Empire Energy E&P LLC	3/3/2005	31013235630001
Horseheads	Chemung	Anschutz Exploration Corporation	9/23/2008	31015261960000
Kiantone	Chautauqua	U S Energy Development Corp.	1/1/2008	31013248990000
Le Roy	Genesee	Leroy Central School District	7/30/2008	31037260710000
Le Roy	Genesee	Leroy Central School District	7/31/2008	31037260720000
Lebanon	Madison	Norse Energy Corp USA	12/9/2009	31053262800000
Lebanon	Madison	Norse Energy Corp USA	3/24/2007	31053239000000
Lebanon	Madison	Norse Energy Corp USA	6/16/2007	31053239650000
Lebanon	Madison	Norse Energy Corp USA	8/16/2006	31053238650000
Lebanon	Madison	Norse Energy Corp USA	8/19/2006	31053238640000
Lebanon	Madison	Norse Energy Corp USA	9/18/2006	31053238910000
Lebanon	Madison	Norse Energy Corp USA	9/22/2006	31053238580000
Leon	Cattaraugus	U S Energy Development Corp.	1/15/2009	31009250900001
Leon	Cattaraugus	U S Energy Development Corp.	6/23/2010	31009250760002
Leon	Cattaraugus	U S Energy Development Corp.	7/13/2010	31009252370001
Mina	Chautauqua	Eclipse Energy Company, LLC	9/20/2007	31013249850000
Newstead	Erie	Subsea Oil & Gas, Inc.	7/27/2010	31029276470000
North Collins	Erie	U S Energy Development Corp.	1/14/2011	31029277390000
North Collins	Erie	U S Energy Development Corp.	1/21/2010	31029256840001
North Collins	Erie	U S Energy Development Corp.	1/22/2008	31029250600000
North Collins	Erie	U S Energy Development Corp.	1/22/2008	31029251290000
North Collins	Erie	U S Energy Development Corp.	1/28/2011	31029276920000
North Collins	Erie	U S Energy Development Corp.	2/22/2008	31029252500000
North Harmony	Chautauqua	Resource Energy, LLC	1/18/2007	31013247630000
Perrysburg	Cattaraugus	U S Energy Development Corp.	1/11/2006	31009243440000
Persia	Cattaraugus	Texas Keystone, Inc.	10/3/2007	31009245810000
Poland	Chautauqua	EnerVest Operating, LLC	5/3/2006	31013244920000
Poland	Chautauqua	Universal Resources Holdings, Inc.	8/7/2007	31013249400000
Pomfret	Chautauqua	Ellington Energy, Inc.	8/1/2007	31013250000000
Portland	Chautauqua	Vertical Energy, Inc.	4/25/2008	31013247960001
Ripley	Chautauqua	Chautauqua Energy, Inc.	3/10/2010	31013275540000
Seneca Falls	Seneca	Chesapeake Appalachia, L.L.C.	3/13/2007	31099239350000
Seneca Falls	Seneca	Chesapeake Appalachia, L.L.C.	3/8/2007	31099239360000
Sherman	Chautauqua	Lion Energy Company LLC	4/10/2006	31013243120000
Sherman	Chautauqua	Lion Energy Company LLC	4/25/2006	31013243110000
Smyrna	Chenango	Norse Energy Corp USA	4/25/2007	31017239660001
Springport	Cayuga	Chesapeake Appalachia, L.L.C.	10/6/2006	31011238740000
Varick	Seneca	Chesapeake Appalachia, L.L.C.	10/28/2007	31099260420000
Varick	Seneca	Chesapeake Appalachia, L.L.C.	10/29/2007	31099260410000
Varick	Seneca	Chesapeake Appalachia, L.L.C.	2/16/2007	31099239160000
Varick	Seneca	Chesapeake Appalachia, L.L.C.	4/18/2008	31099239560000
Villenova	Chautauqua	U S Energy Development Corp.	7/21/2010	31013257720001
Wales	Erie	U S Energy Development Corp.	1/25/2010	31029256600001

NOTES

[1] NYS Department of Environmental Conservation, Division of Mineral Resources. *New York State Oil Gas and Mineral Resources, 2009* (2009), p. 9.

[2] NYS Department of Environmental Conservation. *Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program* (1992). p. 10-6, 10-7. According to the document, less than one and up to five barrels of brine may be produced daily by a gas well. One barrel equals 42 gallons.

[3] Ibid, 15-6.

[4] NYS Department of Environmental Conservation. *Revised Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program* (2011), p. 5-99–5-100.

[5] NYS Department of Environmental Conservation. *Revised Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program* (2011), p. 5-41.

[6] A.W. Gaudlip, L.O. Paugh, and T.D. Hayes. "Marcellus Shale Water Management Challenges in Pennsylvania" (paper presented at the 2008 SPE Shale Gas Production conference, Fort Worth, TX, November 2008). p. 5.

[7] Don Hopey and Sean D. Hamill. "Pa.: Marcellus wastewater shouldn't go to treatment plants," *Pittsburgh Post-Gazette*, April 19, 2011. www.postgazette.com/pg/11109/1140412-100-0.stm

[8] NYS Department of Environmental Conservation. *Revised Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program* (2011), p. 5-118.

[9] Ibid.

[10] NYCRR part 371.1 (e) (2) (v) states: The following solid wastes are not hazardous wastes ... (v) drilling fluids, produced waters, and other wastes associated with the exploration, development, or production of crude oil, natural gas or geothermal energy.

[11] ALL Consulting, p. 20 and p. 34.

[12] NYS Department of Environmental Conservation. R*evised Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program* (2011), p. 5-106.

[13] NYS Department of Environmental Conservation. *Revised Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program* (2011), p. 6-56–6-61.

[14] Brian G. Rahm, Ph.D. Hearing on Waste Water and Cuttings as they pertain to hydraulic fracturing Senate Standing Committee on Environmental Conservation, December 12, 2011, Canandaigua, NY.

[15] Ian Urbana. "Wastewater Recycling No Cure-All in Gas Process," *The New York Times*, March 1, 2011. www.nytimes.com/2011/02/27/us/27gas.html?ref=drillingdown

[16] Associated Press. "Ohio: Gas-drilling injection well led to quakes," March 9, 2012. www.foxnews.com/us/2012/03/09/apnewsbreak-gas-drilling-waste-behind-ohio-quakes/

[17] Associated Press. "Ark. commission votes to shut down wells," July 27, 2011. www.businessweek.com/ap/financialnews/D9OO85KO1.htm

[18] Joaquin Sapien and Sabrina Shankman. "Drilling Wastewater Disposal Options in N.Y. Report Have Problems of Their Own," *ProPublica*, December 29, 2009. www.propublica.org/article/drill-wastewater-disposal-options-in-ny-report-have-problems-1229

[19] NYS Department of Environmental Conservation, Division of Mineral Resources. *New York State Oil Gas and Mineral Resources, 2009* (2009), p. 9.

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