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In Fracking's Wake: New Rules are Needed to Protect Our Health and Environment from Contaminated Wastewater

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This report combines an evaluation of federal and state laws regulating fracking wastewater with a thorough review, compiled for NRDC by an independent scientist, of the health and environmental risks posed by this high-volume waste stream and the currently available treatment and disposal methods. It finds that the currently available options are inadequate to protect human health and the environment, but that stronger safeguards at the state and federal levels could better protect against the risks associated with this waste. The most significant of the policy changes needed now are (a) closing the loophole in federal law that exempts hazardous oil and gas waste from treatment, storage, and disposal requirements applicable to other hazardous waste, and (b) improving regulatory standards for wastewater treatment facilities and the level of treatment required before discharge to water bodies.

In examining a number of different fracking wastewater disposal methods that are being used in the Marcellus Shale region, the report finds that although all are problematic, with better regulation some could be preferable while others should not be allowed at all. NRDC opposes expanded fracking without effective safeguards. States such as New York that are considering fracking should not move forward until the available wastewater disposal options are fully evaluated and safeguards are in place to address the risks and impacts identified in this report. Where fracking is already taking place, the federal government and states must move forward swiftly to adopt the policy recommendations in this report to better protect people and the environment.

About NRDC

NRDC (Natural Resources Defense Council) is a national nonprofit environmental organization with more than 1.3 million members and online activists. Since 1970, our lawyers, scientists, and other environmental specialists have worked to protect the world's natural resources, public health, and the environment. NRDC has offices in New York City, Washington, D.C., Los Angeles, San Francisco, Chicago, Montana, and Beijing. Visit us at www.nrdc.org.

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This report and its recommendations are solely attributable to NRDC and do not necessarily represent the views of these individuals.

Author's Note

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The contents of this issue brief are based on a lengthier peer reviewed report that delves into this topic in greater detail. For more information, please see: www.nrdc.org/energy/files/Fracking-Wastewater-FullReport.pdf

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This paper analyzes the problem of wastewater generated from the hydraulic fracturing process of producing natural gas, particularly with regard to production in the Marcellus Shale.* It shows that, while hydraulic fracturing (often called "hydrofracking" or "fracking") generates massive amounts of polluted wastewater that threaten the health of our drinking water supplies, rivers, streams, and groundwater, federal and state regulations have not kept up with the dramatic growth in the practice and must be significantly strengthened to reduce the risks of fracking throughout the Marcellus region and elsewhere.**

Hydrofracking and the production of natural gas from fracked wells yield by-products that must be managed carefully to avoid significant harms to human health and the environment. These wastewater by-products are known as "flowback" (fracturing fluid injected into a gas well that returns to the surface when drilling pressure is released) and "produced water" (all wastewater emerging from the well after production begins, much of which is salty water contained within the shale formation).

Both types of wastewater contain potentially harmful pollutants, including salts, organic hydrocarbons (sometimes referred to simply as oil and grease), inorganic and organic additives, and naturally occurring radioactive material (NORM). These pollutants can be dangerous if they are released into the environment or if people are exposed to them. They can be toxic to humans and aquatic life, radioactive, or corrosive. They can damage ecosystem health by depleting oxygen or causing algal blooms, or they can interact with disinfectants at drinking water plants to form cancer-causing chemicals.

* This paper focuses primarily on hydraulic fracturing in the Marcellus Shale, although the issues raised herein are relevant anywhere fracking occurs. Thanks to the knowledge gained from years of experience with fracking in the Marcellus, highlighting that region can provide insight for other regions undergoing new or expanded fracking.

** Due to the breadth and depth of this topic, there are certain issues relating to the management of shale gas wastewater that we do not attempt to address in this paper, although they can present important environmental concerns in their own right. These include stormwater issues, accidental spills, waste generated before fracking fluid is injected, and impacts of wastewater management that are not water-related. Also not addressed in this paper are the impacts of water withdrawals for use in the hydraulic fracturing process or impacts from well drilling and development (including contamination of groundwater during hydraulic fracturing).

Table 1. Chemical Constituents in Produced Water from Marcellus Shale Development[1,*]			
Chemical constituent or surrogate parameter	**Unit of measure**	**Range reported in produced water from wells drilled in Marcellus Shale at 5 days post hydraulic fracturing**	**Range reported in produced water from wells drilled in Marcellus Shale at 14 days post hydraulic fracturing**
Total Suspended Solids (TSS)	mg/L	10.8–3,220	17–1,150
Turbidity	NTU	2.3–1,540	10.5–1,090
Total Dissolved Solids (TDS)	mg/L	38,500–238,000	3,010–261,000
Specific Conductance	umhos/cm	79,500–470,000	6,800–710,000
Total Organic Carbon (TOC)	mg/L	3.7–388	1.2–509
Dissolved Organic Carbon (DOC)	mg/L	30.7–501	5–695
Chemical Oxygen Demand (COD)	mg/L	195–17,700	228–21,900
Biochemical Oxygen Demand (BOD)	mg/L	37.1–1,950	2.8–2,070
BOD/COD Ratio (% biodegradable)			0.1 (10%)
Alkalinity	mg/L	48.8–327	26.1–121
Acidity	mg/L	<5–447	<5–473
Hardness (as $CaCO_3$)	mg/L	5,100–55,000	630–95,000
Total Kjeldahl Nitrogen (TKN)	mg/L as N	38–204	5.6–261
Ammonia Nitrogen	mg/L as N	29.4–199	3.7–359
Nitrate–N	mg/L as N	<0.1–1.2	<0.1–0.92
Chloride	mg/L	26,400–148,000	1,670–181,000
Bromide	mg/L	185–1,190	15.8–1,600
Sodium	mg/L	10,700–65,100	26,900–95,500
Sulfate	mg/L	2.4–106	<10–89.3
Oil and Grease	mg/L	4.6–655	<4.6–103
BTEX (benzene, toluene, ethylbenzene, xylene)	µg/L		Non-detect–5,460
VOC (volatile organic compounds)	µg/L		Non-detect–7,260
Naturally occurring radioactive materials (NORM)	pCi/L	Non-detect–18,000 pCi/L; median 2,460 pCi/L	
Barium	mg/L	21.4–13,900	43.9–13,600
Strontium	mg/L	345–4,830	163–3,580 J
Lead	mg/L	Non-detect–0.606	Non-detect–0.349
Iron	mg/L	21.4–180	13.8–242
Manganese	mg/L	0.881–7.04	1.76–18.6

1 T. Hayes, Gas Technology Institute, *Sampling and Analysis of Water Streams Associated with the Development of Marcellus Shale Gas*, report prepared for Marcellus Shale Coalition, December 2009, http://www.bucknell.edu/script/environmentalcenter/marcellus/default.aspx?articleid=14; E.L. Rowan et al., *Radium Content of Oil- and Gas-Field Produced Waters in the Northern Appalachian Basin (USA): Summary and Discussion of Data*, 2011, 31, http://pubs.usgs.gov/sir/2011/5135/pdf/sir2011-5135.pdf.

* These data are from a single source (Hayes, "Sampling and Analysis of Water Streams"), with the exception of NORM (from Rowan et al., "Radium Content of Oil- and Gas-Field Produced Waters"). NORM data did not specify how long after well completion the samples were taken, and thus cannot be associated with either 5 or 14 days post hydraulic fracturing. BTEX and VOC data provided here have significant uncertainty. Data marked J are estimated due to analytical limitations associated with very high concentrations. Extensive data on produced water quality throughout the United States are available (see energy.cr.usgs.gov/prov/prodwat/intro.htm). Additional data specific to Marcellus are available from a variety of sources (produced water treatment plants, PADEP, drilling companies), although they have not been collated into a single database, making summative analysis difficult.

Because of these risks, shale gas wastewater must be carefully managed. The most common management options currently in use are recycling for additional hydraulic fracturing, treatment and discharge to surface waters, underground injection, storage in impoundments and tanks, and land application (road spreading). All of these options present some risk of harm to health or the environment, so they are regulated by the federal government and the states. But many of the current regulatory programs are not adequate to keep people and ecosystems safe. Consequently, this paper concludes with policy recommendations regarding how the regulation of shale gas wastewater management should be strengthened and improved.

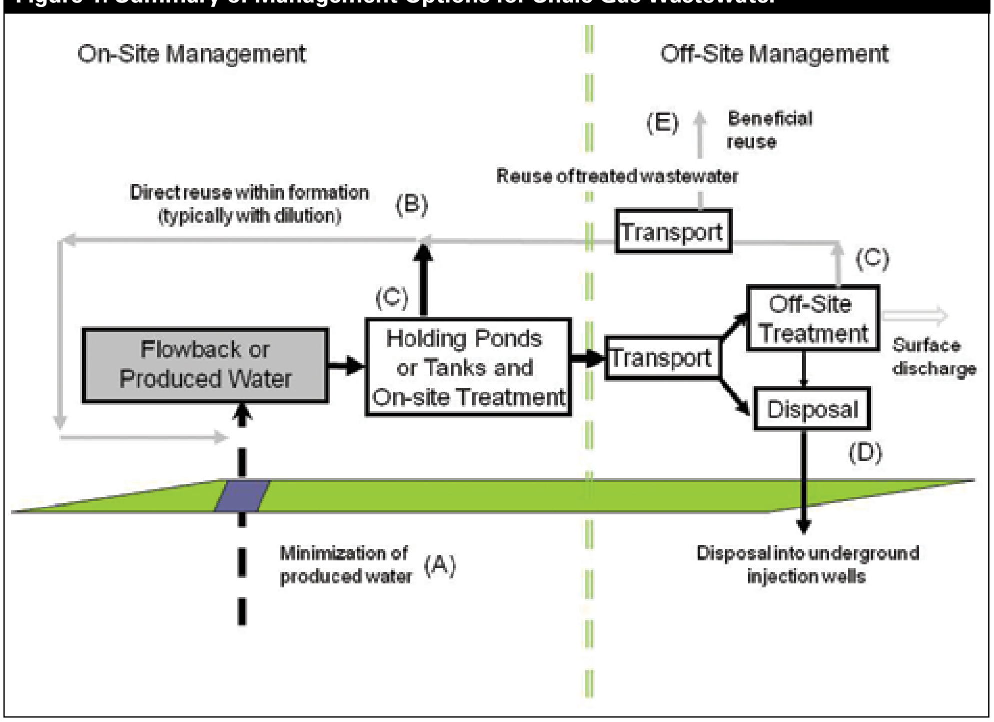
MANAGEMENT OPTIONS FOR SHALE GAS WASTEWATER

There are five basic options to manage wastewater generated during the production of natural gas from shale formations: minimization of produced water generation, recycling and reuse within gas drilling operations, treatment, disposal, and beneficial reuse outside of operations. On-site options associated with minimization, recycling, and reuse are used mostly for water during the flowback period; off-site treatment and disposal methods dominate the management of produced water.

Minimization and Recycling/Reuse. Minimization of wastewater generation and recycling/reuse within operations take place at the well site during drilling. While these have not been popular management choices in oil and gas drilling previously, they are increasingly being used in the Marcellus Shale because traditional off-site disposal methods are not often available in close proximity to wells. On-site recycling can have significant cost and environmental benefits as operators reduce their freshwater consumption and decrease the amount of wastewater destined for disposal. However, it can generate concentrated residual by-products (which must be properly managed) and can be energy-intensive.

Disposal. Direct discharge of wastewater from shale gas wells to surface waters is prohibited by federal law. Consequently, when operators want to dispose of wastewater with little or no treatment, they do so predominantly through underground injection. Disposal through underground injection requires less treatment than other management methods, and when done with appropriate safeguards, it creates the least risk of wastewater contaminants' being released into the environment. However, it does create a risk of earthquakes and can require transportation of wastewater over long distances if disposal wells are not located near the production well. Almost all onshore produced water in the U.S. (a category that includes natural gas produced water) is injected, either for disposal or to maintain formation

Figure 1. Summary of Management Options for Shale Gas Wastewater



pressure in oil fields. Marcellus wastewater is often transported to injection wells in Pennsylvania, Ohio, and West Virginia.

Treatment. Treatment is the most complex management option. It can occur on-site or off-site and in conjunction with recycling/reuse, discharge, and disposal. While treatment can be costly and energy-intensive, all methods of wastewater management generally involve some form of treatment—e.g., to prepare wastewater for subsequent reuse in gas development or for injection into disposal wells, or to generate clean water for discharge or partially treated water and/or residuals for beneficial reuse.

When wastewater is bound for subsequent reuse within hydraulic fracturing operations or for injection in disposal wells, treatment focuses on removing organic contaminants and inorganic constituents that can cause the fouling of wells. Treatment for other objectives—to produce a water clean enough for reuse or discharge, or to produce a brine or solid residual for subsequent reuse—may include additional, targeted removal of other constituents.

Shale gas operators in some regions, including the Marcellus, have sent wastewater to publicly owned treatment works (POTWs) for treatment, but this practice can have serious environmental consequences. With regard to salts, among the most prevalent contaminants in Marcellus wastewater, POTWs do not provide any meaningful treatment at all because they are not designed to remove dissolved solids; most salts that enter POTWs will be discharged directly to receiving water bodies. Additionally, high concentrations of salt, organics, and heavy metals in wastewater can disrupt the treatment process in POTWs. Consequently, sending wastewater to POTWs without pretreatment to remove salts is generally no longer permitted in Pennsylvania. (Some POTWs were exempted from state regulations requiring pretreatment, but they have been asked voluntarily to stop accepting shale gas wastewater.)

An alternative to POTW treatment for removal of suspended solids and organic constituents is treatment at dedicated brine or industrial wastewater facilities, also called centralized waste treatment (CWT) facilities. These plants use many of the same treatment processes that are found in POTWs but may also add coagulation and precipitation techniques to remove dissolved solids. However, while CWTs may be designed to remove more pollutants from wastewater than POTWs do, their discharges may still contain high levels of pollutants such as bromide. Brine treatment plants have been operating in the Marcellus production basin for many decades. After treatment at a CWT, water can be discharged to a surface water body or discharged to sewers for subsequent discharge from a POTW.

Beneficial Reuse. The beneficial reuse of oil and gas brines has a long history in many states. In many areas, produced water is used for dust control on unpaved roads and for deicing or ice control on roads in northern climates during the winter. Such application of Marcellus brines to roadways is permitted in Pennsylvania, provided the brines meet certain water quality requirements. Selling wastewater to local governments for this use allows gas operators to recover some of their treatment and management costs, but applying wastewater onto land surfaces increases the risk that pollutants will be washed into nearby water bodies or leach into groundwater.

Management Options for Residuals. In addition to the treated wastewater, all treatment methods produce residuals—waste materials, mostly in solid, sludge, or liquid form, that remain after treatment. In the Marcellus region and elsewhere, solids and sludges are managed through conventional processes: land application or landfill, depending on their characteristics. Highly concentrated liquid brine wastes (i.e., highly salty water) have the same disposal options as the original produced waters, at lower transportation costs. The most common disposal option for concentrated brines from desalination is deep well injection. If desalination brines are sent to treatment facilities that are not subject to discharge limits on dissolved solids (as is often the case with POTWs), the benefits of concentrating these wastewaters are completely lost.

Use of These Practices in Pennsylvania in 2011. Based on data from the Pennsylvania Department of Environmental Protection, in 2011, about half of all wastewater from shale gas production in Pennsylvania was treated at CWTs that are subject to the state's recently updated water pollution discharge limits, described below. (It is not possible to determine from the data what volumes of wastewater treated at CWTs were subsequently discharged to surface waters, reused, or disposed of in another way.) About one-third was recycled for use in additional hydraulic fracturing. Less than one-tenth was injected into disposal wells, and a similar amount was treated at CWTs not subject to updated treatment standards. Less than 1 percent was treated at POTWs. The remainder (less than 1 percent) was reported as in storage pending treatment or disposal.

From the first half to the second half of 2011, total reported wastewater volumes more than doubled. Treatment at CWTs increased nearly four-fold, even as wastewater volumes directed to "exempt" CWTs decreased by 98 percent. Deep-well injection more than tripled, and re-use in fracking operations increased by about 10 percent. Treatment at POTWs was virtually eliminated.

Figure 2. Technologies for Removing Oil, Grease, and Organics from Produced Water

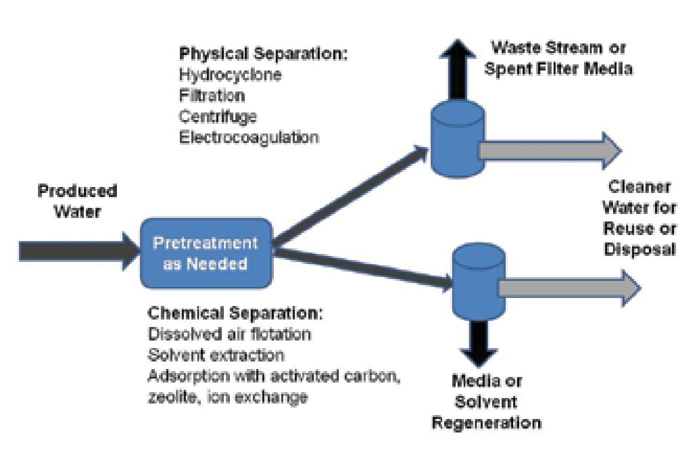
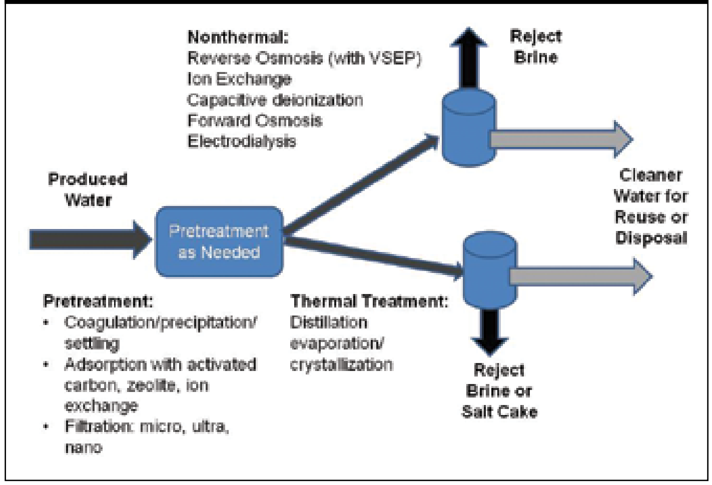


Figure 3. Technologies for Removing Dissolved Ionic Constituents from Produced Water



TECHNICAL ANALYSIS OF TREATMENT METHODS

Many technologies are available for treating shale gas wastewater. Regardless of the ultimate fate of the wastewater, some degree of treatment is typically necessary. The choice of a specific treatment method will depend on the nature and concentration of the contaminants in the wastewater as well as the intended disposition of the treated water, which determines the necessary levels of pollutant reduction.

Discharge to surface waters requires extensive treatment to protect drinking water supplies and aquatic ecosystems. Reuse may require partial treatment to avoid reintroducing into the next well contaminants that will affect production. Wastewater used in road spreading may also require treatment to reduce pollutant concentrations in runoff. Similarly, when wastewater is injected into disposal wells, partial treatment is often done to minimize the risk of clogging the well.

For any given drilling operation, once the wastewater is characterized and the necessary water quality is known, a treatment system made up of different components can be selected. Treatment begins with removal of suspended solids, inorganic or organic, and then removal of dissolved organics and potentially scale-forming constituents. When all that remains is simple dissolved salts, desalination can be done, as would often be necessary for discharge to surface waters. Additionally, high levels of NORM will require special handling.

Other factors can also influence the selection of appropriate treatment methods, such as the energy intensity of a treatment method and the nature of the residuals generated by treatment. For all types of treatment, the separation of the contaminant from the water will generally require significant chemical and energy inputs, depending upon the process, the quality of the influent wastewater, and the desired quality of the effluent finished water. Likewise, all treatment methods generate a residual waste that contains the contaminants that have been removed or the by-products of their transformation. This residual can be a liquid stream, a solid or sludge product, or a gaseous stream, and it must be managed appropriately to avoid environmental harms. For example, brines and sludges created through treatment processes can be disposed of as solid waste or sent to disposal wells.

Applicable treatment technologies involve chemical, physical, and/or biological processes. These include settling, filtration, coagulation, centrifugation, sorption, precipitation, and desalination. Desalination can be achieved through thermal methods (like vapor compression, distillation, multi-stage flash, dew vaporization, freeze-thaw, evaporation, and crystallization) or non-thermal methods (like reverse osmosis, nanofiltration, electrodialysis, electrodeionization, capacitative deionization, membrane distillation, and forward osmosis). In Pennsylvania, treatment plants use a wide range of technologies like these; however, because desalination is the most energy intensive, many facilities treat only up to the point at which desalination would occur and then repurpose the water for additional activities in oil and gas development.

POTENTIAL WATER IMPACTS OF SHALE GAS WASTEWATER MANAGEMENT

Wastewater associated with hydraulic fracturing itself and, later, with the production of gas from a fractured well must be managed to avoid environmental harms. However, many of the available management techniques may directly cause environmental harm due to the release of pollutants to surface waters, soil, and groundwater.

On-Site Impoundments and Tanks. As with any liquid material in storage, accidental spills and mismanagement can cause releases to the environment that could contaminate nearby waters and soils. Open impoundments, also called pits, are typically subject to requirements designed to minimize the risk of contamination, though the adequacy of those requirements varies from place to place. Closed tanks are also sometimes used for collection of produced water during the flowback period, sometimes with secondary containment, a best management practice where the tank sits within a traylike structure with raised sides, such that materials released during a tank rupture would be contained and not leach into soil or travel to nearby waterways.

Impacts Away from the Well Site. The most significant potential for water impacts from shale gas wastewater is associated with the long-term production of water from the well and occurs away from the well site. Produced water is generally shipped off-site for management and disposal, at which point pollutants in wastewater can be intentionally released directly to the environment, either with or without appropriate treatment and safeguards to limit pollution discharges. Additionally, at any of the locations where produced water is handled, accidental releases can occur, and best practices and good management are necessary to avoid accidents, as are contingency plans to reduce the impact of accidental releases.

Deep Well Injection. Underground injection of wastewater is designed to isolate materials that could cause harm if released to the biosphere. A U.S. Environmental Protection Agency (EPA) risk analysis determined that injection via strictly regulated Class I hazardous waste wells is a safe and effective technology that presents a low risk to human health and the environment. Additional studies have confirmed this assessment. However, oil and gas wastes are currently injected into Class II disposal wells, which are subject to fewer safety requirements and therefore pose a greater risk of contaminating groundwater and triggering earthquakes. Partial treatment of produced water, either prior to injection or at the injection well facility, is often used to reduce the likelihood of well clogging.

Surface Water Discharge. Inadequate treatment at a CWT or POTW followed by discharge of treated water can pollute surface waters—including drinking water sources—downstream of the discharge. If quantities or concentrations of contaminants in the discharge are too high, or if the receiving water lacks adequate assimilative capacity, the pollution can seriously harm ecosystems and human health. Some contaminants (e.g., benzene, toluene, ethylbenzene, and xylenes) are directly toxic to ecosystems or people; others interact in the environment to produce unwanted effects (e.g., nutrients like ammonia that can encourage harmful algal blooms). Some are a concern because they can affect the beneficial use of the water downstream (e.g., sulfate, which can make drinking water taste bad), and still others can disrupt ecosystems (e.g., chloride, which alters fish reproduction).

Land Application. Application of produced water to roads for dust control has several potential impacts. Rainfall and snowmelt wash salts and other chemicals off roadways, which can result in stream or groundwater contamination. The potential for such harm increases when application rates are high or take place in close proximity to rainfall events. Moreover, when produced waters are used for road spreading, they may replace equally effective dust suppressant and deicing agents while resulting in higher levels of chloride pollution to surface water and groundwater (due to higher concentrations or more frequent application).

Residuals Management. Regardless of the treatment option selected, residuals—the concentrated brines and solids containing the chemicals removed from the produced water—will be created as a by-product. Since chemicals in these residual wastes are present at higher concentrations than in the original produced waters, careful management is essential to avoid undermining the value of the treatment process through release of residuals to the environment. For example, in light of the high pollutant concentrations, surface water discharge of residual brines or land or road application of brines or solid salts produced through treatment can result in watershed impacts equal to, or greater than, the potential impact of the original produced water.

REGULATORY FRAMEWORK FOR SHALE GAS WASTEWATER

A number of federal and state statutes and regulations govern the treatment, disposal, and reuse of shale gas wastewater. These regulations are intended to minimize or eliminate the risk of harm from exposure to wastewater pollutants, but many regulatory programs are not adequately protective, and several even have complete exemptions for shale gas wastewater (or exemptions for oil and gas wastewater of all kinds, including Marcellus Shale wastewater).

Treatment and Discharge to Water Bodies. The Federal Water Pollution Control Act, more commonly called the Clean Water Act, regulates the treatment and discharge of shale gas wastewater into surface water bodies. Under the Act, facilities must obtain permits if they intend to discharge shale gas wastewater, or any by-product resulting from treatment of that wastewater, into a surface water body. These permits contain limitations on pollutants that may be discharged in the wastewater.

Federal regulations completely prohibit the direct discharge of wastewater pollutants from point sources associated with natural gas production. Instead of discharging wastewater directly to surface waters, then, many hydraulic fracturing operators send wastewater to treatment facilities that are authorized to discharge under Clean Water Act permits issued (typically) by the states under authority delegated by the EPA. These facilities include POTWs and CWTs. EPA regulations set pretreatment requirements for the introduction of industrial wastewater to POTWs (known in EPA regulations as "indirect discharge") and for the discharge of industrial wastewater from CWTs. However, the Clean Water Act regulatory program is not comprehensive; for example, there are no pretreatment requirements specifically for shale gas wastewater, and discharge standards for CWTs are out of date.

States may also establish requirements for these discharges that are stricter than the federal standards. For example, the Pennsylvania Department of Environmental Protection (PADEP) has issued regulations implementing the Clean Water Act and the state's Clean Streams Law with industrial waste discharge standards. In 2010 PADEP finalized revisions to state regulations addressing the discharge to surface waters of wastewater from natural gas operations. The regulations prohibit the discharge of "new and expanding" discharges of shale gas wastewater unless the discharge is authorized by a state-issued permit. Such discharges may be authorized only from CWTs; POTWs may be authorized to discharge new or increased amounts of shale gas wastewater only if the wastewater has been treated at a CWT first.

Underground Injection. The federal Safe Drinking Water Act (SDWA) regulates the underground injection of wastewater. SDWA establishes the Underground Injection Control (UIC) program. This program is designed to prevent the injection of liquid wastes into underground sources of drinking water by setting standards for safe wastewater injection practices and banning certain types of injection altogether. All underground injections are prohibited unless authorized under this program.

Under the UIC program, the EPA groups underground injection wells into five classes, with each class subject to distinct requirements and standards. Because of a regulatory determination by the EPA not to classify shale gas wastewater as "hazardous" (discussed below), it is not required to be injected into Class I wells for hazardous waste. Rather, shale gas wastewater may be injected into Class II wells for fluids associated with oil and gas production. Class II wells are subject to less stringent requirements than Class I hazardous waste wells.

In the Marcellus region, Maryland, Ohio, and West Virginia have assumed primacy and implement the UIC program. New York, Virginia, and Pennsylvania have not assumed primacy, so the EPA directly implements the UIC program in those states.

Reuse for Additional Hydraulic Fracturing. In contrast to the injection of shale gas wastewater as a disposal practice, the injection of fluids (which may include recycled wastewater) for the hydraulic fracturing process itself is exempted from regulation under the federal Safe Drinking Water Act. As a result, if shale gas wastewater is managed or treated for the sole purpose of reuse for further hydraulic fracturing, it is not subject to federal regulation.

However, states can have their own regulations that apply to the reuse of shale gas wastewater. In Pennsylvania, facilities that process wastewater for beneficial reuse may be authorized under PADEP-issued general permits, which establish generally applicable standards. Operations authorized under these general permits do not require individualized permits for wastewater processing.

Impoundments. Because of an exemption from federal law (discussed below), the storage and disposal of shale gas wastewater in impoundments is regulated solely by the states. In Pennsylvania, facilities that store and dispose of shale gas wastewater in impoundments must obtain permits under PADEP solid waste regulations, which contain construction and design specifications and operating requirements for those impoundments. Pennsylvania has also enacted a law that limits the ability of municipalities to regulate the siting of impoundments; several municipalities are challenging this law in court.

Land Application. Because of an exemption from federal law (discussed below), the land application of shale gas wastewater is regulated primarily at the state level. While Pennsylvania's oil and gas well regulations generally prohibit operators of oil and gas wells from discharging brine and other produced fluids onto the ground, the state's solid waste management regulations state that PADEP may issue permits authorizing land application of waste. Using this authority, PADEP has issued a general permit authorizing the application of natural gas well brines specifically for roadway prewetting, anti-icing, and deicing purposes as long as the brines meet certain pollutant concentration limits. In some other states, however, the road spreading of shale gas wastewater is prohibited.

Handling, Storage, and Transport Prior to Disposal. State regulations govern the handling, storage, and transport of shale gas wastewater prior to its ultimate disposal. Oil and gas wastes are currently exempt from the federal Resource Conservation and Recovery Act (RCRA), which generally regulates the handling and disposal of waste. A 1980 amendment to the statute exempted oil and gas wastes from coverage under RCRA for two years. In the meantime, it directed the EPA to determine whether regulation of those wastes under RCRA was warranted. In 1988, the EPA made a determination that such regulation was not warranted. Consequently, oil and gas wastes remain exempt from the hazardous waste provisions of RCRA. This means that natural gas operators transporting shale gas wastewater, along with the POTWs, CWTs, and any other facilities receiving it, are not transporting or receiving "hazardous" wastes and thus do not need to meet the cradle-to-grave safeguards established by RCRA regulations.

In the absence of federal regulations, states regulate the handling, storage, and transport of shale gas wastewater. In Pennsylvania, wastewater from industrial operations is classified as nonhazardous, and it must be managed and disposed of in accordance with the state's Solid Waste Management Act.

Residual Waste. Residual wastes are subject to various regulations depending on their composition (liquid or solid) and method of disposal (surface water discharge, injection, land application, etc.). Many of the regulatory issues described above arise with residuals as well.

POLICY RECOMMENDATIONS

The current regulation of shale gas wastewater management, treatment, and disposal is inadequate because it fails to safeguard against foreseeable risks of harm to human health and the environment. Government oversight of wastewater treatment and disposal must be improved at both the federal and the state level.

Treatment and Discharge to Water Bodies. Currently, discharge of pollutants in shale gas wastewater is allowed in amounts and concentrations inadequate to protect water quality. The EPA and the states must develop limits both on the discharge of shale gas wastewater from POTWs and CWTs and on the amount of pollution allowable in surface water bodies.

- The EPA and the states should ban or more strictly regulate the discharge of shale gas wastewater to POTWs.
- The EPA and the states should update pollution control standards for CWTs that accept shale gas wastewater.
- The EPA and the states should develop water quality criteria for all chemicals in shale gas wastewater. Water quality criteria are numeric limitations on pollutants in a particular water body that are adequate to support the water body's designated uses.
- The EPA and the states should identify water bodies impaired by pollutants in shale gas wastewater, or with the reasonable potential to become impaired, and should require reductions in pollution loads to those waters.
- The EPA and the states should protect water bodies not yet impaired by shale gas wastewater.

Handling, Storage, and Transport Prior to Disposal. Improper handling, storage, or transport of shale gas wastewater can lead to spills and other releases of pollutants that contaminate land and water with toxic or radioactive material.

- Congress or the EPA should eliminate the RCRA hazardous waste exemption for shale gas wastewater and subject such wastewater to regulation as "hazardous waste" in cases where it does, in fact, display physical and chemical characteristics that qualify as hazardous.
- Regardless of whether the federal RCRA exemption is eliminated, states can and should classify shale gas wastewater as hazardous when it meets relevant technical criteria and should regulate it accordingly.
- States should require regular testing of shale gas wastewater to assess whether wastewater from any given source, at any given time, possesses hazardous characteristics.

Underground Injection. Injection into wells creates a risk that injection fluids will migrate into sources of drinking water, as well as a risk of triggering earthquakes. These unnecessary risks should be minimized.

- Wastewater with hazardous characteristics should be injected into Class I hazardous waste wells, which are subject to regulations more stringent than those governing Class II wells. This can be achieved if Congress or the EPA eliminates the RCRA hazardous waste exemption for oil and gas wastes, or if the EPA amends UIC program regulations.
- In the interim, states should use their authority to more strictly regulate Class II wells for oil and gas wastewater.

Reuse for Additional Hydraulic Fracturing. The hydraulic fracturing process itself should be federally regulated. However, when fracking occurs, reuse of wastewater for additional hydraulic fracturing can offer many benefits (although these benefits can in some cases be offset by energy use and the generation of concentrated residuals). Where appropriate, states should encourage or even require the reuse and recycling of shale gas wastewater.

- Congress should eliminate the Safe Drinking Water Act exemption for hydraulic fracturing to ensure that injection of fracturing fluid will not endanger drinking water sources.
- When the benefits of recycling outweigh disadvantages, states should encourage or require reuse of shale gas wastewater in the hydraulic fracturing process.

Impoundments and Tanks. States should prohibit or strictly regulate impoundments to minimize the risk of spills or leakage.

- States should not allow the storage or disposal of shale gas wastewater in open impoundments. Flowback and produced water should be collected at the well and either recycled or directly routed to disposal. In the event that storage of wastewater is necessary, it should be done in closed tanks.
- If states do not prohibit impoundments, they should regulate them more strictly with regard to location, construction, operation, and remediation.
- States should also regulate closed storage tanks more strictly; this regulation should require, among other things, secondary containment.

Land Application. Because application of shale gas wastewater to land and roadways can lead to environmental contamination through runoff of toxic pollutants into surface waters, it should be prohibited, or at minimum strictly regulated.

- States should prohibit the land application or road spreading of shale gas wastewater. Other available substances are equally effective but have less environmental impact, and these should be used on roads for dust suppression and de-icing.
- If land application and road spreading are not prohibited, they should only be authorized subject to strict limits on pollutant concentrations and required preventive measures to limit runoff.
- The EPA and states should enforce existing Clean Water Act requirements for controlling polluted runoff from municipal storm sewer systems to ensure that any road spreading does not violate those requirements. The EPA should also complete its ongoing development of new rules to strengthen the CWA stormwater regulatory program.

Residual Waste. Just as shale gas wastewater should not be categorically exempt from RCRA hazardous waste regulations, residual waste derived from the treatment of that wastewater should not be exempt from regulation if it displays the characteristics of a hazardous waste.

- Shale gas wastewater treatment residuals should be subject to RCRA's hazardous waste regulations. Congress or the EPA should require that residual waste with hazardous characteristics be regulated as hazardous by eliminating the RCRA hazardous waste exemption for oil and gas wastes.

Public Disclosure. Regardless of which treatment or disposal method an operator uses to manage its shale gas wastewater, it should be required to publicly disclose the final destination of the waste.

Model Regulations. The federal Bureau of Land Management (BLM) regulations now under development for hydraulic fracturing activities on federal lands should be as protective of health and environment as possible and should include at minimum (to the extent BLM has regulatory jurisdiction) all recommendations set forth in this paper. Since BLM has expansive authority over development of federal oil and gas resources and other activities on federal lands, strong BLM rules could serve as model regulations on which states could base their own.

NRDC supports establishing a fully effective system of safeguards to ensure that natural gas is produced, processed, stored, and distributed in a way that helps protect our water, air, land, climate, human health, and sensitive ecosystems. NRDC opposes expanded fracking until effective safeguards are in place. For more information on NRDC's position on natural gas and fracking, go to http://www.nrdc.org/energy/gasdrilling/.