WHAT LIES BENEATH: IS AMERICA'S MOST COMMON METHOD FOR DISPOSING OF OILFIELD WASTEWATER LEGAL?

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INTRODUCTION[1]

It is well understood that the oil and gas industry enjoys a host of exemptions from the United States' environmental laws.[2] Indeed, nearly every one of our bedrock environmental statutes or their implementing regulations have nestled inside them some exemption for the oil and gas industry. These exemptions are so well-known that they are in some cases known by name: the Safe Drinking Water Act's (SDWA's) Halliburton Loophole and the Resource Conservation and Recovery Act's (RCRA's) Bentsen Amendment.[3]

This article is about an even more insidious exemption. This exemption is nameless and appears nowhere in statute, regulation, or even formal agency guidance. Rather, it is an unwritten practice of the United States Environmental Protection Agency (EPA). The article calls this exemption the "Class II Loophole." Put simply, the Class II Loophole is the practice of turning a blind eye to the fact that the liquid brew that emerges as a waste product from fracking (often called simply "produced water," "brine," or "salt water") plainly meets the SDWA's definition of "radioactive waste" and must be regulated accordingly.

This article tells the history of the Class II Loophole, describe its effects, and makes the case for closing it. It argues that closing the Class II Loophole requires no new regulation, no act of Congress, merely the enforcement of existing SDWA regulations. Section I provides a primer on radioactivity. Section II explains the SDWA's Underground Injection Control Program (UIC), including its role in regulating radioactive wastes. Section III details the radioactive constituents of oil and gas wastes. Section IV describes the rise of Class II disposal wells as a predominant method of oil and gas waste disposal. Section V presents current environmental and public health harms associated with Class II injection well disposal. Section VI documents EPA's understanding of how the SDWA applies to radioactive wastes and oil field wastes, and the oil and gas industry's own understanding of how the SDWA applies to its wastes. Section VII then makes the case for the immediate regulation of produced water as "radioactive waste" under the SDWA.

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1. All legal opinions expressed herein are solely the view of the authors and are not expressed on behalf of, nor can they be attributed to, any organization.

2. Adam Kron, *EPA's Role in Implementing and Maintaining the Oil and Gas Industry's Environmental Exemptions: A Study in Three Statutes*, 16 VT. J. ENV'T L. 586, 587 (2015).

3. *Id.* at 588.

This article makes the case for applying regulations already on the books in order to protect our drinking water and people's health, and tells an important story. It is a story about the underground Earth, what lies deep beneath our feet yet is connected to our world and its water in myriad ways; a story about how it came to be that the United States annually injects approximately a trillion gallons of oilfield wastewater via a disposal technique that, as this article demonstrates, lacks scientific merit;[4] a story about little-known legal risks and liabilities to a waste disposal practice that has become stunningly commonplace, yet most Americans have no idea it even exists. Most importantly, this is a story about a diverse group of people in rural and rust-belt America standing up to protect their communities. Many of them have been oppressed and contaminated across generations by aggressive extractive industries and repeatedly let down by paltry regulations. Some are workers in the oil and gas industry, tending the wells or driving trucks of waste. Quite a few of these people tend not to call themselves environmentalists, even though they may live a life more deeply immersed in their local environment than most environmentalists. Among many others, this is a story about Felicia Mettler, a former Ohio elementary school archery instructor who co-founded an advocacy group called "Torch CAN DO" to hold accountable an injection well in her rural southeast Ohio community. Her daughters, Autumn and Alexus, who she pulled into the fight, participated in a series of artful protests at the site. They dressed as monsters for a Halloween "Frackenstine Rally" and, inspired by Alice in Wonderland, dressed as fairies and hosted a toxic tea party.[5]

One morning in Ms. Owen's class, in Coolville, Ohio, a nervous eight-year-old Alexus Mettler stood up before her fellow third-graders, strode to the front of the classroom, and made a speech about injection wells, where fracking wastewater is injected deep underground. "I said basically it was radioactive and nobody knew about it and I told people my mom was trying to stop it and nobody was believing her," says Lexie, as she likes to be called.[6] "I remember the class kind of quiet, then I heard a couple people laughing."[7]

But there is really no reason to laugh. The string Lexie was pulling on is a string that could unravel the entire oil and gas industry, and to understand how and why, we must go back to the beginning, or at least the beginning of the modern story of radioactivity.

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4. ALL CONSULTING, U.S. PRODUCED WATER VOLUMES AND MANAGEMENT PRACTICES IN 2021 8 (2022).

5. JUSTIN NOBEL, PETROLEUM-238: BIG OIL'S DANGEROUS SECRET AND THE GRASSROOTS FIGHT TO STOP IT 215 (Karen LeBlanc ed., 2024).

6. Interview by Justin Nobel with Felica Mettler and Alexis Mettler (Oct. 2024) (on file with author).

7. Correspondence with Felica Mettler and Alexis Mettler (Oct. 2024) (on file with author).

I. RADIOACTIVITY—THE SCIENCE AND HISTORY

Marie and Pierre Curie discovered radium, but it was Dr. Harrison Martland, a Newark, New Jersey medical examiner, who made the radioactive element famous.[8] During the mid-1920s, Martland began to notice unusual bone and blood cancers in a curious set of female patients, along with a lethal condition that came to be called radium jaw, in which the bones of the mouth rot and crumble to pieces.[9] Martland, who helped found the field of occupational health medicine, was able to crack the code on an extraordinary industrial secret, and it involved timepieces.[10] When radium was put in paint, the radiation released as it decayed excited zinc sulfide molecules.[11] The women who piqued Martland's concern worked in factories, applying this paint to the dials of clocks and watches, which caused them to glow in the dark.[12] Martland theorized that in regularly running their brushes between their lips to keep the tips firm, these women had accidentally ingested significant amounts of radium, and a portion had gone to their bones.[13] Radium is in the same column of the Periodic Table as calcium, and chemically-speaking, the elements resemble and act like one another.[14] Martland believed it was radium that caused the cancers and jaw-rot that killed these women—the infamous radium girls.[15]

Many notable scientists of the day denied radium posed radiological risks.[16] Among them was James Ewing, a pioneering American cancer researcher who had appeared on the cover of Time Magazine in 1931 as "Cancer Man Ewing."[17] Ewing helped found both the American Society for the Control of Cancer, which became the American Cancer Society, and a

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8. *Marie Curie: Her Story in Brief*, THE AM. INST. OF PHYSICS (2000), https://history.aip.org/exhibits/curie/brief/index.html.; *Harrison S. Martland's Research Proved that Ra-226 Caused Death of the Radium Dial Painters*, RUTGERS N.J. MED. SCH., https://njms.rutgers.edu/departments/division_radiation/history_pub.php (last visited Apr. 19, 2025).

9 . Harrison Martland, *The Occurrence of Malignancy in Radioactive Persons: A General Review of Data Gathered in the Study of the Radium Dial Painters, With Special Reference to the Occurrence of Osteogenic Sarcoma and the Inter-Relationship of Certain Blood Diseases*, 15 AM. J. CANCER 2435, 2440–41 (1931).

10. RUTGERS N.J. MED. SCH., *supra* note 8.

11. NOBEL, *supra* note 5.

12. *See generally* KATE MOORE, THE RADIUM GIRLS: THE DARK STORY OF AMERICA'S SHINING WOMEN (Sourcebooks 2017) (telling the story of the women who worked in factories that used radium).

13. Martland, *supra* note 9, at 2436.

14. Mary Beth Genter, *Magnesium, Calcium, Strontium, Barium, and Radium*, *in* 1 PATTY'S TOXICOLOGY 145, 148, 159 (Eula Bingham & Barbara Cohrssen eds., 6th ed. 2012).

15. Martland, *supra* note 9, at 2436.

16. Matthew Tontonoz, *What Ever Happened to Coley's Toxins?*, CANCER RSCH. INST. (Apr. 2, 2015), https://www.cancerresearch.org/blog/april-2015/what-ever-happened-to-coleys-toxins; *see* Arty R. Zantinga & Max J. Coppes, *James Ewing (1866–1943): "The Chief"*, 21 MED. & PEDIATRIC ONCOLOGY 505, 508 (1993) (noting Ewing's belief that radiation is a cure for cancer, not a cause).

17. *Professor James Ewing: Jan. 12, 1931*, TIME MAG., https://content.time.com/time/covers/0,16641,19310112,00.html (last visited Apr. 19, 2025).

clinical cancer research unit at Memorial Hospital in New York, now Memorial Sloan Kettering Cancer Center.[18] Ewing served as an expert witness for the U.S. Radium Corporation, from which the women were trying to secure damages for their tragic condition.[19] He doubted radium had seriously harmed them, and in court quibbled at the medical expenses they were racking up, which U.S. Radium had to pay for.[20] Nevertheless, Martland supported his theory with dazzling science. He performed autopsies on half a dozen radium girls and discovered their bones were filled with radium.[21] "For instance in the year 3491 A.D.," Martland wrote in his seminal 1931 paper in *The American Journal of Cancer*, "the skeleton will still be giving off 185,000 alpha particles per second."[22] Using a device called an electroscope, which indicates electrical charge, he also measured the women's exhaled breath, demonstrating that it was radioactive.[23] As the women's radium-filled bones were continuously producing the radioactive gas radon, the direct daughter product of radium, some would inevitably escape the body through the mouth, essentially transforming the women into human radioactive chimneys.[24]

From his research with the radium girls, Martland came away with several important revelations: radiation can cause cancer, we live on a radioactive planet so some cancer may be expected, and increasing our exposure to radioactivity by even minute amounts may increase the amount of cancer.[25] "The radium cases should be looked upon as an unfortunate but valuable experiment," he warned in his 1931 paper, "in which, through ignorance and lack of proper governmental supervision, human beings have been allowed to swallow, over long periods of time, radio-active substances."[26]

In a way, Martland's alarm bell has been heard. The medical community knows about radium, and EPA has strict standards, regarding, for example, the permissible level of radium in drinking water, 5 picocuries per liter (pCi/L).[27] The Nuclear Regulatory Commission created a multitude of tables

18. *History of Medicine: Time Magazine's "Cancer Man,"* COLUM. SURGERY, https://columbiasurgery.org/news/2015/07/23/history-medicine-time-magazines-cancer-man (last visited Apr. 19, 2025); *Professor James Ewing: Jan. 12, 1931*, TIME MAG., https://content.time.com/time/covers/0,16641,19310112,00.html (last visited Apr. 19, 2025).

19. MOORE, *supra* note 12 at 157, 241.

20. *Id.*

21. Martland, *supra* note 9, at 2435-516.

22. *Id*. at 2510.

23. *Id*. at 2438, 2453, 2470.

24. *Id*. at 2453, 2470.

25. *Id*. at 2513–14.

26. *Id*. at 2436.

27. 40 C.F.R. § 141.66(b) (2024). The curie is a unit used to measure the rate of radioactive decay and named for Pierre and Marie Curie, who received the Nobel Prize for their groundbreaking work on

covering hundreds of different radioactive elements and their various isotopes setting limits protecting human health.[28] Numerous federal and state agencies incorporate these limits into their own regulations for radioactivity, including EPA's regulations implementing the SDWA.[29]

People connected to the oil and gas industry will often point out that even bananas are naturally radioactive, but the statement is designed to mislead, and helps cloak the dangers posed by oilfield radioactivity.[30] "A banana's radioactivity comes from a radioactive isotope of potassium which has a half-life of over a billion years and in decay gives off a beta particle to become nonradioactive elements."[31] The radioactive isotopes brought to the surface in oil and gas production decay to other radioactive isotopes, and these too will decay. With each decay, radiation is blasted off.[32]

> Sludge sitting in the bottom of a brine truck or tank, or scale stuck to the inside of an oilfield pipe gives off radiation in the form of gamma rays, beta particles, and alpha particles. Gamma rays can travel several hundred feet through the air, go right through a human body, and even go through concrete and steel. Beta are minuscule particles and can go several feet through the air and penetrate human flesh. But of greatest concern are alpha particles, which are many thousands of times heavier than a beta particle and travel at a speed of 12,430 miles per second. The outer layers of human skin or a piece of paper are dead and act as shielding, absorbing an alpha particle's incredible energy. But the soft lining of an organ, the marrow of a bone, or the delicate tissue of the lung is very much alive. An alpha particle fired off here will smash about the cellular space, colliding with tens of thousands of different things. Any hit to the nucleus can break strands of DNA, usually killing the cell, or worse, leaving it genetically mutated, damage that can lead to cancer.[33]

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radioactivity. Daniel J. Bell, *Curie (unit)*, RADIOPAEDIA, https://radiopaedia.org/articles/curie-unit (May 5, 2021). A picocurie is one trillionth of a curie. *Picocurie*, MERRIAM-WEBSTER, https://www.merriam-webster.com/medical/picocurie (last visited May 7, 2025).

28. 10 C.F.R. § 20 (2024).

29. *See, e.g.*, 40 C.F.R. § 146.3 (defining "radioactive waste" as "any waste which contains radioactive material in concentrations which exceed those listen in 10 CFR part 20, appendix B, table II column 2"). Radium-226 and radium-228, individually and combined, appear in the table with a limit of 60 picocuries per liter. 10 C.F.R. pt. 20, app. B tbl. 2, col. 2.

30. NOBEL, *supra* note 5, at 57.

31. *Id.*

32. Telephone Interview with Dr. Marco Kaltofen, Nuclear Forensic Scientist (May 2, 2020) (on file with author).

33. NOBEL, *supra* note 5, at 57–58.

Oilfield waste happens to contain a number of radioactive isotopes that emit alpha particles as they decay, including radium-226, radon-222, and five different isotopes of polonium.[34] Working in a contaminated workspace littered with piles of sludge or open pits of brine provides several pathways for workers to inhale or inadvertently ingest these elements. Even wearing some protective gear, workers cleaning out a tank can get their underclothes, faces, boots, and bodies splattered in sludge, including their hands. Because workers are uninformed, easily preventable actions can still lead to exposures, such as drinking a soda, smoking a cigarette, or not washing their hands before eating lunch.[35]

Whether or not elevated levels of radium in drinking water can over time cause human health harms and cancers is a complicated question. In 2019, investigative reporters at the Pittsburgh Post-Gazette revealed that in the community of Cecil, five cases of Ewing sarcoma had been diagnosed since 2008. Cecil is in Washington County, in the heart of southwestern Pennsylvania's Marcellus shale boom.[36] Across this four-county region, from 2008 through 2018, 27 cases of Ewing sarcoma were reported.[37]

Six cases of Ewing's were diagnosed within the Canon-McMillan School District alone, and several kids had attended the local high school together, known as Canon-Mac, in Canonsburg, Pennsylvania.[38] Luke Blanock was diagnosed with Ewing's in 2013, married his high school sweetheart in February 2016, and passed away that August.[39] In 2018, Canon-Mac graduate Mitchell Barton, who played baseball with Luke Blanock, was also diagnosed with Ewing's.[40] The Post-Gazette article described ten other cases of unusual cancer that were afflicting or killing the children and students of Cecil and Canon-Mac.[41] The cases included: one astrocytoma (brain and spinal cord); two osteosarcomas (bone); one liposarcoma (joint); one rhabdomyosarcoma (muscle); one Wilms tumor (kidney); one liver cancer; and two cases of leukemia (blood).[42]

David Spigelmyer, the 2019 president of the Marcellus Shale Coalition trade group that represents fracking interests in Pennsylvania, told the Post-

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34. Telephone Interview with Dr. Marco Kaltofen, Nuclear Forensic Scientist (May 2, 2020) (on file with author).
35. *Id.*
36. NOBEL, *supra* note 5, at 292.
37. David Templeton & Don Hopey, *CDC, State Officials Investigating Multiple Cases of Rare Cancer in Southwestern Pa.*, PITTSBURGH POST-GAZETTE (Mar. 28, 2019, 7:54 AM), https://www.post-gazette.com/news/health/2019/03/28/Ewing-sarcoma-Washington-Westmoreland-cancer-Canon-McMillan-school-cecil-pennsylvania/stories/201903280010.
38. *Id.*
39. *Id.*
40. *Id.*
41. *Id.*
42. *Id.*

Gazette that attempts to link the incidence of Ewing sarcoma to the industry were without scientific or medical support.[43] His group cited a review of medical data by the American Cancer Society that found "no known lifestyle-related or environmental causes of Ewing tumors."[44]

Indeed, the medical profession supports this conclusion. "Doctors have not identified any risk factors that make one child more susceptible than another," says the American Academy of Orthopaedic Surgeons.[45] "Parents should know that there is nothing they could have done differently to prevent their child's tumor," says the Academy, and the disease "does not develop as a result of any dietary, social, or behavioral habits."[46] There are about 75 million children and adolescents in the United States and, according to Johns Hopkins University School of Medicine, about 225 of them are diagnosed with Ewing sarcoma each year. "The exact cause of Ewing sarcoma," says Johns Hopkins, "is not fully understood."[47]

Still, there is important research largely ignored among researchers, attorneys, regulators, and the oil and gas industry. During the 1990s, the Canadian epidemiologist Dr. Murray Finkelstein authored a pair of studies on naturally occurring radium contamination in drinking water and the presence of Ewing sarcoma and osteosarcoma among Ontario youths.[48] He wanted to know if there was an association between the amount of radium in home drinking water and the risk of death from these bone cancers.[49]

While studying Ewing sarcoma, Dr. Finkelstein was working as an epidemiologist for the province of Ontario and had access to reliable data. He obtained a computer tape containing the death certificates for Ontario residents between 1950 and 1983 and identified people 25 years or younger who had died of bone cancer during this time.[50] Dr. Finkelstein then linked these people to their birth certificates and found the patients' addresses at

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43. Templeton & Hopey, *supra* note 37.

44. *Id.*; David Templeton & Don Hopey, *Human Toll: Are the 27 Cases of Ewing Sarcoma Near Pittsburgh a Cluster?*, PITTSBURGH POST-GAZETTE (May 14, 2019), https://newsinteractive.post-gazette.com/ewing-sarcoma-cancer-cluster-pittsburgh-washington-westmoreland/.

45. *Diseases & Conditions: Ewing's Sarcoma*, AM. ACAD. OF ORTHOPAEDIC SURGEONS, https://orthoinfo.aaos.org/en/diseases--conditions/ewings-sarcoma (April 2019).

46. *Id.*

47. *Ewing Sarcoma in Adults*, JOHNS HOPKINS MED., https://www.hopkinsmedicine.org/health/conditions-and-diseases/sarcoma/ewing-sarcoma-in-adults (last visited Apr. 5, 2025).

48. Murray Finkelstein, *Radium in Drinking Water and the Risk of Death from Bone Cancer among Ontario Youths*, 151 CAN. MED. ASSOC. J. 565 (1994); Murray Finkelstein & Nancy Kreiger, *Radium in Drinking Water and Risk of Bone Cancer in Ontario Youths: A Second Study and Combined Analysis*, 53 OCCUPATIONAL ENV'T MED. 305 (1996).

49. Murray Finkelstein, *Radium in Drinking Water and the Risk of Death from Bone Cancer Among Ontario Youths*, 151 CAN. MED. ASSOC. J. 565, 565 (1994).

50. *Id.* at 566.

their times of death, and their mothers' addresses at their times of birth.[51] This meant water samples could be collected from the same drinking water source presumably used by the patient throughout their youth, and that water could then be sampled for radium.[52]

Finkelstein's paper reported the stunning result that even minute increases of radium in drinking water can lead to an increase in death from bone cancers, including Ewing sarcoma.[53] There is a "statistically significant" relationship between levels of radium in drinking water and Ewing sarcoma, he wrote.[54] Finkelstein co-authored a follow-up paper in 1996 which found an association between risk of osteosarcoma, the more common form of bone cancer, and birthplace exposure to radium in drinking water.[55] This paper did not find the same association for Ewing's, but it did not negate his prior results.[56]

II. THE SAFE DRINKING WATER ACT AND RADIOACTIVITY

Congress enacted the SDWA in 1974.[57] It included two main parts. The first focused on regulating public drinking water systems, including setting national drinking water standards and requirements for public drinking water suppliers.[58] The second—the UIC program—was designed to protect actual and potential sources of drinking water by protecting groundwater resources from contamination caused by underground injection of fluids or waste.[59]

In 1980, pursuant to the SDWA, EPA adopted regulations delineating five major Classes of injection wells and the types of waste they can receive.[60] EPA based these delineations on the wells' potential to endanger drinking water sources depending on their depth, injectate, and geologic setting.[61] Class I wells are for the injection of hazardous, non-hazardous, and radioactive wastes into deep rock formations.[62] Class II wells are for the

51. Murray Finkelstein, *Radium in Drinking Water and the Risk of Death from Bone Cancer Among Ontario Youths*, 151 CAN. MED. ASSOC. J. 565, 566-67 (1994).

52. *Id*. at 567.

53. *Id.* at 565.

54. *Id*. at 565.

55. Murray Finkelstein & Nancy Kreiger, *Radium in drinking water and risk of bone cancer in Ontario youths: a second study and combined analysis*, 53 OCCUPATIONAL & ENV'T MED. 305, 307 (1996).

56. *Id*. at 307.

57. 42 U.S.C. § 300g *et seq.*; Sierra Club v. Chesapeake Operating, LLC, 248 F. Supp. 3d 1194, 1199–200 (W.D. Okla. 2017).

58. 42 U.S.C. § 300g *et seq.*; *Sierra Club*, 248 F. Supp. 3d at 1199–200.

59. 42 U.S.C. § 300g, *et seq.*; Miami-Dade Cnty. v. EPA, 529 F.3d 1049, 1052 (11th Cir. 2008).

60. 40 C.F.R. § 146.5 (2024). In 2010, EPA also added a sixth category, Class VI, for the injection of carbon dioxide into deep subsurface rock formation for long-term storage. *Id*. § 144.6(f).

61. ENV'T PROT. AGENCY, INTRODUCTION TO THE UNDERGROUND INJECTION CONTROL PROGRAM, 8, 12 (2003).

62. 40 CFR § 144.6(a).

injection of fluids associated with oil and gas production.[63] Class III wells are used to inject fluids for mineral extraction.[64] Class IV wells are shallow wells used for injection of hazardous and radioactive wastes.[65] Class V wells are for non-hazardous fluids.[66]

Radioactive waste is only permitted in Class I wells.[67] Aside from Class IV wells, a more recent class of wells designed for long-term storage of carbon dioxide, Class I wells are the most technically sophisticated well class, requiring the greatest regulatory attention.[68] The purpose of Class I wells is to inject waste deep into isolated rock formations separated from the lowest underground source of drinking water by layers of impermeable clay and rock.[69] All Class I wells have continuous monitoring for internal mechanical integrity and must submit quarterly reports to EPA or the delegated state director for those states with enforcement primacy.[70] Class I wells also require an ambient monitoring plan to help detect any migration before it reaches underground sources of drinking water wells.[71] EPA's website claims that the agency is not aware of any current radioactive waste injections into Class I wells.[72]

Class IV wells are a category designed strictly for use in enforcement.[73] Construction or injection into Class IV wells has been banned since 1984.[74] These wells present the greatest risks to drinking water sources.[75]

Class V wells serve as a catch-all category for all wells that are not one of the other classes of wells.[76] At the time of EPA's original UIC regulations, some Class V wells were used for the disposal of radioactive waste.[77] In 1999, addressing the need for more rigorous standards, EPA promulgated a

63. 40 CFR § 144.6(b).

64. *Id*. § 144.6(c).

65. *Id*. § 144.6(d).

66. *Id*. § 144.6(e).

67. *See* 40 C.F.R. § 146.5(a)(3) (2024) (defining Class I wells as, among other things, "[r]adioactive waste disposal wells. . . ."); *see also* 40 C.F.R. § 146.5(d) (2024) (defining Class IV wells as, among other things, wells used to dispose of radioactive waste); 40 C.F.R. §§ 144.13(a)(1)–(2) (prohibiting constructing or operating any Class IV well).

68. ENV'T PROT. AGENCY., *supra* note 61, at 41; *see* 40 C.F.R. § 146.81(a)–(d) (2024) (detailing the standards and criteria applicable to Class VI wells).

69. 40 C.F.R. § 146.5(a).

70. *Id.* § 146.13(b)–(c) (2024).

71. *Id.* § 146.13(d).

72. *Class I Industrial and Municipal Waste Disposal Wells*, ENV'T PROT. AGENCY, https://www.epa.gov/uic/class-i-industrial-and-municipal-waste-disposal-wells (last updated Mar. 12, 2025).

73. 40 CFR § 146.5(d); 40 C.F.R. § 144.13; ENV'T PROT. AGENCY, *supra* note 61, at 51.

74. 40 C.F.R. § 144.13.

75. ENV'T PROT. AGENCY, *supra* note 61, at 51.

76. 40 C.F.R. § 146.5(e).

77. *Id.* § 146.5(e)(11).

rule clarifying that radioactive waste could not be injected into Class V wells, and only Class I wells could receive this waste.[78]

Class II wells are for fluids "[w]hich are brought to the surface in connection with conventional oil or natural gas production."[79] Class II wells are sub-categorized as: II-D wells for the commercial disposal of brine into injection zones other than the production formation; II-R wells where brine is re-injected into the production formation for "enhanced recovery" of oil and gas; and II-H wells where hydrocarbons are injected for storage and reuse.[80] Class II wells do not require continuous monitoring or ambient monitoring and only require annual reporting.[81] Unlike Class I wells, Class II wells do not feature complete cementing of the protective long-string casing, and surface casing may not extend to below the lowest underground source of drinking water.[82] Thus, Class II construction standards are less protective of nearby drinking water sources than those for Class I wells.

III. RADIOACTIVITY IN OIL AND GAS WASTE

Brine, also called "produced water" because it is the fluid that surfaces with the production of oil and gas, is where many of the oil and gas industry's radioactive troubles begin.[83] Brine can be loaded with toxic levels of salt, elevated levels of heavy metals like lead and arsenic—and the radioactive metal radium. Radium is moderately soluble and thus flows to the surface with brine.[84] America's oil and gas industry generates more than three billion gallons of brine a day, or a trillion gallons a year.[85] If this brine was put into oil barrels, and these barrels were stacked atop one another, the barrels would

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78. *See* EPA, State Implementation Guide, Revisions to the Underground Injection Control Regulations for Class V Wells (2000), available at https://www.epa.gov/sites/default/files/2015-08/documents/class5_state_imp_guid.pdf (last visited Feb. 6, 2005) (explaining that EPA found the full set of Class I regulations for permitting, construction, operation, monitoring, reporting, mechanical integrity testing, area of review, and plugging and abandonment to be applicable to wells injecting radioactive waste, and accordingly EPA had reclassified radioactive waste disposal wells injecting below underground sources of drinking water as Class I wells.).

79. 40 C.F.R. § 146.5(b)(1).

80. ENV'T PROT. AGENCY, *supra* note 61, at 45.

81. *Id.* at 46.

82. *Id.* at 47; *see also* 40 C.F.R. §§ 146.21–.24 (setting forth criteria and standards for Class II wells).

83. Peter Gray, *NORM Contamination in the Petroleum Industry*, 45 J. PETROLEUM TECH. 12, 12 (1993). Brine is known by many names and is sometimes even deceptively referred to as "saltwater," or simply "water." None of these colloquialisms change the chemical makeup of the toxic liquid described throughout this article.

84. *TENORM: Oil and Gas Production Wastes*, ENV'T PROT. AGENCY, https://www.epa.gov/radiation/tenorm-oil-and-gas-production-wastes (last updated Feb. 13, 2025).

85. ALL CONSULTING, *supra* note 4.

reach the moon and back almost 28 times,[86] a monumental waste stream that must be disposed of. The industry wants to keep and use the oil, gas, and natural gas liquids—fuels like butane, propane, and ethane—a plastics feedstock. The industry does not want this liquid waste (i.e. brine, a.k.a. produced water), and operators have never had a good solution for what to do with it all.[87]

The radioactive element radium is one of the most concerning contaminants in brine. UIC regulations in the SDWA define a liquid as "radioactive waste" at radium levels of 60 pCi/L.[88] In the oilfield setting, radium values are commonly presented as the addition of two of the radioactive element's isotopes, radium-226 and radium-228.[89] Pennsylvania Department of Environmental Protection data reveals radium levels in brine of the Marcellus formation far exceeds the UIC limit—averaging 9,330 pCi/L, and reaching as high as 28,500 pCi/L.[90] Existing data for oil and gas-bearing geologic formations across the nation reveals radium in brine is consistently over the threshold that would define it as radioactive waste under the SDWA.[91] What has America done with all of this waste, a good portion of which would be radioactive waste under the SDWA? We have swept it under the carpet.[92]

Figure 1. Maximum radium levels, and average radium levels (when available), in oilfield brine for oil and gas formations across the United States as recorded in various academic, government, and industry papers.

Name of Formation or Oilfield	Maximum Radium Level (Ra-226+Ra-228) / Avg	Source
Unnamed Michigan formation	29,000 pCi/L	K.P. SMITH ET AL., RADIOLOGICAL DOSE ASSESSMENT RELATED TO

86. Analyzing the number of barrels per year, converted to miles using the barrel's height, the distance covered equates to 28.6 trips to the moon and back, as the average distance to the moon is 238,855 miles. *How Far Away Is the Moon?*, ROYAL MUSEUMS GREENWICH, https://www.rmg.co.uk/stories/topics/how-far-away-moon# (last visited Apr. 6, 2025).

87. NOBEL, *supra* note 5, at 208.

88. *See* 40 C.F.R. § 146.3 (2024) (defining "radioactive waste" as "any waste which contains radioactive material in concentrations which exceed those listen in 10 CFR part 20, appendix B, table II column 2"). Radium-226 and radium-228, individually and combined, appear in the table with a limit of 60 picocuries per liter. 10 C.F.R. pt. 20, app. B tbl. 2, col. 2 (2024).

89. PERMAFIX, TECHNOLOGICALLY ENHANCED NATURALLY OCCURRING RADIOACTIVE MATERIALS 72 (TENORM) STUDY REPORT, (2016).

90. *Id.*

91. NOBEL, *supra* note 5, at 57, 190–91, 307–08, 310.

92. ALL CONSULTING, *supra* note 4 (i.e., it is injected).

		MANAGEMENT OF NATURALLY OCCURRING RADIOACTIVE MATERIALS GENERATED BY THE PETROLEUM INDUSTRY 14 (Sept. 1996).
Marcellus formation, Pennsylvania	28,500 pCi/L / 9,330 pCi/L	PERMAFIX, PENN. DEP'T OF ENV'T PROT., TECHNOLOGICALLY ENHANCED NATURALLY OCCURRING RADIOACTIVE MATERIALS (TENORM) STUDY REPORT 14 (2016).
Venango formation, Pennsylvania	25,408 pCi/L	*U.S. Geological Survey National Produced Waters Geochemical Database*, DEP'T OF THE INTERIOR, (Dec. 27, 2023), https://www.usgs.gov/tools/us-geological-survey-national-produced-waters-geochemical-database-viewer.[93]

93. Data on interactive map: Click "Launch Viewer" at left; at right under Formation, click off "All" so there are no formations listed; then type "Venango" into search and click box so only Venango formation emerges in viewer; zoom in so data points from Venango formation in western PA come clearly into view; at bottom of screen see chart and entry points under headings Y-axis and X-axis; adjust variables to display data points on graph thus: on Y-axis scroll down to Ra226 (radium-226), on X-axis scroll down to Ra228 (radium-228); hold cursor over that value and see the X-axis, or Ra228, is 24,000 pCi/L, and the Y-axis, or Ra226, is 1408 pCi/L, so total Ra226 + Ra228 readings are 25,408 pCi/L/.

Antrim formation, Michigan	22,358 pCi/L / 5,416 pCi/L	Wenjia Fan, Kim F. Hayes & Brian R. Ellis, *Estimating Radium Activity in Shale Gas Produced Brine*, 52 ENV'T SCI. & TECH. 10839 (2018) (Supporting Information on file with author).
Texas Panhandle	10,640 pCi/L	R. STEPHEN FISHER, NATURALLY OCCURRING RADIOACTIVE MATERIALS (NORM) IN PRODUCED WATER AND SCALE FROM TEXAS OIL, GAS, AND GEOTHERMAL WELLS 26 (1995).
Clinton formation, Ohio	9,602 pCi/L	Memorandum, Ohio Dep't of Nat. Res., Div. of Oil & Gas, Radium Testing Results for Conventional Brine (2018) (on file with author).
Bakken formation, North Dakota	6,490 pCi/L / 3,632 pCi/L	E-mail from Jay C. Almlie, Principal Eng'r, Energy & Enf't Rsch. Ctr., Univ. N.D., to Justin Nobel, author (Nov. 27, 2019, 9:52 AM) (on file with author).
Helderberg Ls formation, New York	3,900 pCi/L	*U.S. Geological Survey National Produced Waters Geochemical Database*, DEP'T OF THE INTERIOR, (Dec.

		27, 2023), https://www.usgs.gov/tools/us-geological-survey-national-produced-waters-geochemical-database-viewer.[94]
Gulf Coast, US	2,801 pCi/L	Earl S. Snavely, Jr., *Radionuclides in Produced Water*, AMERICAN PETROLEUM INSTITUTE 79 (Aug. 16, 1989) (on file with author).
San Joaquin Basin, California	2,111 pCi/L	TASHA STOIBER & BILL WALKER, ENV'T WORKING GRP., TOXIC STEW: WHAT'S IN FRACKING WASTEWATER 9 (2015).
Paluxy formation, Mississippi	2,099 pCi/L	*U.S. Geological Survey National Produced Waters Geochemical Database*, DEP'T OF THE INTERIOR, (Dec. 27, 2023), https://www.usgs.gov/tools/us-geological-survey-national-produced-waters-

94. Data on interactive map: Click "Launch Viewer" at left; at right under Formation, click off "All" so there are No formations listed; then type into search "Helderberg" and click box so only Helderberg formation emerges in viewer; zoom in so data points from Helderberg formation in western NY, come clearly into view; at bottom of screen, see chart and entry points under headings Y-axis and X-axis; adjust variables to display data points on graph thus: on Y-axis scroll down to Ra226 (radium-226) and on X-axis scroll down to Ra228 (radium-228). Note that few sample of wells in the Helderberg formation with radium data will appear on the graph, and note the data point all the way to the left, with very high Ra226 values. Hold cursor over that value and see the X-axis, or Ra228, is 100 pCi/L, and the Y-axis, or Ra226, is 3800 pCi/L, so total Ra226 + Ra228 readings are 3,900 pCi/L/.

		geochemical-database-viewer.[95]
Cherokee Platform, Oklahoma	2,020 pCi/L	B.F. Armbrust & P.K. Kuroda, *On the Isotopic Constitution of Radium (Ra-224/Ra-226 and Ra-228/Ra-226) in Petroleum Brines*, 37 TRANSACTIONS AM. GEOPHYSICAL UNION 37 (1956).
Permian Basin in Texas and New Mexico	1,247 pCi/L	Punam Thakur, Anderson L. Ward & Tanner M. Schaub, *Occurrence and Behavior of Uranium and Thorium Series Radionuclides in the Permian Shale Hydraulic Fracturing Wastes*, 29 ENV'T SCI. & POLLUTION RSCH. 43058, 43063 (2022).
Denver-Julesburg Basin, Colorado	598 pCi/L	COLO. DEP'T OF PUB. HEALTH AND ENV'T, TENORM REPORT FOR THE STATE OF COLORADO 389 (2019).
Fayetteville Shale, Arkansas	294 pCi/L	*U.S. Geological Survey National Produced Waters Geochemical Database*, DEP'T OF

95. Data on interactive map: Click "Launch Viewer" at left; at right, under Formation, click off "All" so there are No formations listed; type into the search "Paluxy" and click box so only Paluxy formation emerges in viewer; zoom in so data points from the Paluxy formation, in Mississippi, come clearly into view; at bottom of screen, see chart and entry points under headings Y-axis and X-axis; adjust variables to display data points on graph thus: on Y-axis scroll down to Ra226 (radium-226) and on X-axis scroll down to Ra228 (radium-228). Note that few samples of wells in Paluxy formation with radium data will appear on the graph and note the sample on the far-right side of the graph; the X-axis or Ra228 is 1054.6, and the Y-axis or Ra226 is 1044.26.

		THE INTERIOR, (Dec. 27, 2023), https://www.usgs.gov/tools/us-geological-survey-national-produced-waters-geochemical-database-viewer.[96]

IV. THE HISTORY OF OIL AND GAS WASTE DISPOSAL AND THE RISE OF UNDERGROUND INJECTION

America's first commercial oil well was drilled in 1859 in Titusville, Pennsylvania, and the disposal of produced water from oil and gas production has posed a problem ever since.[97] For over 100 years, the industry's copious stream of oilfield brine was simply discharged into unlined pits, ditches, swamps, streams, bays, and bayous—practices that caused considerable contamination to farmland, estuaries, and water supplies.[98] The exceptional salt levels in oilfield brine alone make land stained with brine unproductive for agriculture. This is a significant problem in oil and gas states like North Dakota, which is 90% farmland, yet millions of gallons of oilfield brine are spilled annually.[99] More recently, the industry has come to rely on a different disposal technique—injection wells.[100] Here, oilfield brine and other toxic liquids brought to the surface in the oilfield are injected deep into the earth. EPA, whose regulations govern the practice, supports it with the belief that this waste will remain locked "almost indefinitely" within a specific deeply-buried geologic layer.[101] "Injection wells are often located many miles from the oil and gas wells that produce the waste and can be located out of the oilfield entirely."[102]

96. Data on interactive map: Click "Launch Viewer" at left; at right under Formation, click off "All" so there are No formations listed; type into search "Paluxy" and click box so only Paluxy formation emerges in viewer; zoom in so data points from Paluxy formation, in Mississippi, come clearly into view; at bottom of screen see chart and entry points under headings Y-axis and X-axis; adjust variables to display data points on graph thus: on Y-axis scroll down to Ra226 (radium-226) and on X-axis scroll down to Ra228 (radium-228). Note that few samples of wells in Paluxy formation with radium data will appear on the graph, and note the sample on the far right side of the graph, the X-axis or Ra228 is 1054.6 and the Y-axis or Ra226 is 1044.26.

97. NOBEL, *supra* note 5, at 106.

98. ENV'T PROT. AGENCY, *supra* note 61, at 5.

99. Deborah Sontag & Robert Gebeloff, *The Downside of the Boom*, N.Y. TIMES (Nov. 22, 2014), https://www.nytimes.com/interactive/2014/11/23/us/north-dakota-oil-boom-downside.html.

100. ENV'T PROT. AGENCY, *supra* note 61, at 8.

101. *Id.* at 30.

102. NOBEL, *supra* note 5, at 45.

To understand injection wells' rise in popularity, go back to June 22, 1969, when sparks from a diesel locomotive passing over the Norfolk & Western Railroad Trestle on the south side of Cleveland ignited a slick of oil and debris on the surface of the Cuyahoga River.[103] The fire, according to an assessment made the following day by Cleveland's Department of Public Safety, "flared up and mushroomed instantaneously."[104] It was the 13th fire on the Cuyahoga, and this time a photo was captured and published in Time Magazine.[105] The image would come to symbolize the transformation of the nation's rivers by American industry into free-flowing sewers of toxic waste. In December 1970 EPA was formed, and in 1972 Congress signed the Clean Water Act, which aimed to eliminate "the discharge of pollutants into the navigable waters."[106] But where would it all go? America's new home for liquid industrial waste would be underground.

In 1950, there were four recorded injection wells in the United States.[107] In 1967 there were 110.[108] When Congress passed its UIC program to govern the practice in 1974, there were already 322 wells drilled, with 290 operating.[109] Today, just counting injection wells that deal with the oil and gas industry's waste, EPA figures indicate there are 181,431[110] (or roughly 11 injection wells for every U.S. Starbucks).[111] If you drove from New York City to Los Angeles at 65 miles per hour and lined the highway with them, an oil and gas wastewater injection well would emerge every nine-tenths of a second. An EPA website states: "Injection proved to be a safe and inexpensive option for the disposal of unwanted and often hazardous industrial byproducts."[112] Today, approximately 96% of America's reported oilfield wastewater will be disposed at Class II injection wells,[113] where high pressure pumps inject the waste deep underground.

Despite EPA formally regulating underground injection through its UIC program for more than 40 years, the program continues to fall short of addressing the tremendous risks of injecting waste underground. Moreover, these risks have long been on the radar of U.S. federal agencies.

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103. NOBEL, *supra* note 5, at 219.

104. *Cuyahoga River Fire,* OHIO HIST. CENT. (2021) https://web.archive.org/web/20190906165648/https://ohiohistorycentral.org/w/Cuyahoga_River_Fire.

105. *Id.*

106. Federal Water Pollution Control Act, 33 U.S.C. §§ 1251–1387 (2002).

107. ENV'T PROT. AGENCY, *supra* note 61, at 5.

108. *Id.*

109. *Id.*

110. *Underground Injection Control Program,* ENV'T PROT. AGENCY (2020), https://www.epa.gov/sites/default/files/2020-04/documents/uic_fact_sheet.pdf.

111. *Starbucks Statistics: How Many Starbucks Are There in the United States?*, CAFELY, https://cafely.com/blogs/research/starbucks-statistics? (last visited Apr. 4, 2025).

112. *General Information about Injection Wells*, ENV'T PROT. AGENCY, https://www.epa.gov/uic/general-information-about-injection-wells (last visited Apr. 20, 2025).

113. ALL CONSULTING, *supra* note 4, at 2, 4.

A 1929 report on Disposal of Oil-Field Brines reads: "there is always the danger of subsequent contamination."[114] The report, authored by Ludwig Schmidt, a petroleum engineer, and John Devine, an organic chemist, both with the U.S. Bureau of Mines Petroleum Experiment Station in Bartlesville, Oklahoma, states that, "[i]f this method is used care must be taken that the brines are delivered to a reservoir formation from which migration can not take place with detrimental effect to sources of fresh-water supply."[115]

In the 1980s, EPA's Environmental Research Lab in Ada, Oklahoma extensively researched injection wells. A report produced by this lab states that, "[u]nfortunately, hazardous wastes are complex mixtures of materials" which makes it "difficult to predict exactly the action or fate of wastes after their injection."[116] A problem, researchers note, is when one hazardous waste stream is "combined with other mixed waste streams, the potential number of interactions increase factorially."[117] Because "subsurface environments often take many years to reach chemical and biological equilibrium, predicting exactly what will happen *a priori* may be nearly impossible."[118]

EPA's observation that predicting the fate of wastes injected underground "may be nearly impossible" becomes particularly important and concerning. In the age of modern fracking, as oilfield wastewater disposed of at injection wells includes not just brine, but flowback. Flowback is an industry term referring to the toxic—and sometimes entirely unknown—chemicals that surge back to the surface in the fracking process.[119] Former Marcellus brine hauler Richard Cummins stated that "brine haulers don't just haul brine, we haul whatever the [f***] they want off that pad and will fit in my truck."[120] This means that brine haulers take all sorts of fluids to Class II wells for injection, including, among other things, fluids from compressor stations and condensate.[121] This waste evades regulation as "hazardous waste" under RCRA as a result of the famed Bentsen Amendment.[122] However, it is widely acknowledged by EPA that some portion of this waste exhibits "hazardous waste characteristics."[123]

114. *Disposal of Oil Field Brines*, 28 OIL & GAS J., at 110 (1929).

115. *Id.*

116. ARDEN STRYCKER & A. GENE COLLINS, EPA, PROJECT SUMMARY, STATE-OF-THE-ART REPORT: INJECTION OF HAZARDOUS WASTES INTO DEEP WELLS 1, 2 (1987).

117. *Id.* at 2.

118. *Id.*

119. NOBEL, *supra* note 5, at 308.

120. Interview with Richard Cummins, Brine Hauler, Marcellus (Feb. 10, 2021).

121. *Id.* at 65–66.

122. *Id.* at 46.

123. *See, e.g.*, Regulatory Determination for Oil and Gas and Geothermal Exploration, Development and Production Wastes, 53 Fed. Reg. 25446, 25446 (July 6, 1988) ("It is clear that some portions of both the large-volume and associated waste would have to be treated as hazardous if the Subtitle C exemption were lifted. EPA estimates that approximately 10 to 70 percent of large-volume

How are all of these different chemicals and compounds mixing in the high-heat, high-pressure, and largely-unknown chemical environment of the subterranean? No one really knew then[124] and, at least as far as research for this article has shown, no one really knows now.[125]

A report prepared by EPA and the Department of Energy published in 1987 presented four main ways that hazardous waste injected down wells might contaminate groundwater.[126] First, an accidental spill at the surface. Second, old oil and gas wells that were never plugged or plugged incompetently provide "an escape route whereby the waste can enter an overlying potable ground water aquifer."[127] Third, waste is injected at such great pressure that it fractures the rocks deep in the earth, "whereby a communication channel allows the injected waste to migrate to a fresh water aquifer."[128] Fourth, the piping and cement that forms the injection well itself corrodes apart, enabling "the waste to escape and migrate" back up to an aquifer.[129]

These early papers appear to fracture the notion that injection wells are a safe storage locker for complex industrial waste streams—or any waste streams at all. In October 1970, David Dominick, Commissioner of the Federal Water Quality Administration, warned that injection was a short-term fix to be used with caution and "only until better methods of disposal are developed."[130] When EPA laid out its proposed policy on injection wells in 1974 the agency echoed Dominick's concern. The agency stated in an internal statement on the subject that EPA's "policy considers waste disposal by [deep] well injection to be a temporary means of disposal."[131] The statement continues: "Should a more environmentally acceptable means of disposal become available, change to such technology would be required."[132] Again, presently the U.S. has 181,431 Class II injection wells, yet EPA never trusted that they would work, or last.

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wastes and 40 to 60 percent of associated wastes could potentially exhibit RCRA hazardous waste characteristics under EPA's regulatory tests.").

124. *See* STRYCKER & COLLINS, *supra* note 116, at 4 (demonstrating lack of understanding on how chemicals and compounds in waste might react in unknown subterranean environments).

125. NOBEL, *supra* note 5, at 79.

126. A. GENE COLLINS & M.E. CROCKER, NAT'L INST. FOR PETROLEUM & ENERGY RSCH., PROTOCOL FOR LABORATORY RESEARCH ON DEGRADATION, INTERACTION, AND FATE OF WASTES DISPOSED BY DEEP WELL-INJECTION 1 (1987).

127. *Id.*

128. *Id.*

129. *Id.*

130. Earle A. Herbert, *The Regulation of Deep-Well Injection: A Changing Environment Beneath the Surface*, 14 PACE ENV'T L. REV. 169, 171–72 (1996) (quoting STANLEY M. GREENFIELD, UNDERGROUND WASTE MANAGEMENT AND ENVIRONMENTAL IMPLICATIONS: EPA—THE ENVIRONMENTAL WATCHMAN, 14, 15 (T.D. Cook ed., 1972)).

131. *Id.* at 189.

132. *Id.*

In fact, top EPA officials in the early 1970s, as injection wells began to proliferate across the nation, were skeptical of the process, believing injection to be a technology of avoiding problems, not solving them. "We really do not know what happens to the wastes down there," stated EPA Assistant Administrator Stanley Greenfield in 1971, "we just hope."[133]

Greenfield spoke these words at a symposium on "Underground Waste Management and Environmental Implications," held in 1971 in Houston, Texas. The symposium was hosted by the U.S. Geological Survey together with the American Association of Petroleum Geologists. Some attendees expressed optimism about the practice. Vincent McKelvey, Director of the U.S. Geological Survey and the symposium's keynote speaker, was among the optimists. He believed society should assign value to the "natural pore space" in underground rock layers.[134] "On the whole," said McKelvey, "we are looking at an underutilized resource with a great potential for contribution to national needs."[135] But largely, the symposium's speakers expressed concern and laid out an eerily accurate prediction of the issues to come.[136]

"It is clear," said Theodore Cook, who was with the American Association of Petroleum Geologists, "that this method is not the final answer to society's waste problems."[137] Utah geologist Henri Swolfs explained that injecting chemical-filled waste deep into the earth could affect the strength of rocks and alter their frictional characteristics.[138] "The result could be earthquakes," he said, creating fractures that channel waste out of the injection zone.[139] Tsuneo Tamura, with the Department of Energy, said the disposal of radioactive liquid wastes posed "a particularly vexing problem," even in low concentrations.[140] "My message to you is not a cheerful one," Frank Trelease, a Wyoming law professor, told symposium attendees.[141] "It is simply this: if you goop up someone's water supply with your gunk; if you render unusable a valuable resource a neighboring landowner might have

133. STANLEY M. GREENFIELD, *EPA—The Environmental Watchman*, in UNDERGROUND WASTE MANAGEMENT & ENVIRONMENTAL IMPLICATIONS 14, 17 (T.D. Cook ed., 1972).

134. V. E. MCKELVEY, *Underground Space—An Appraised Resource*, in UNDERGROUND WASTE MANAGEMENT & ENVIRONMENTAL IMPLICATIONS 1, 1–2(T.D. Cook ed., 1972).

135. *Id.* at 4.

136. *See generally*, in UNDERGROUND WASTE MANAGEMENT & ENVIRONMENTAL IMPLICATIONS (T.D. Cook ed., 1972).

137. T. D. COOK, *Foreword*, in UNDERGROUND WASTE MANAGEMENT & ENVIRONMENTAL IMPLICATIONS VII (T.D. Cook ed., 1972).

138. HENRI S. SWOLFS, *Chemical Effects of Pore Fluids on Rock Properties*, in UNDERGROUND WASTE MANAGEMENT & ENVIRONMENTAL IMPLICATIONS 224 (T.D. Cook ed., 1972).

139. *Id.*

140. TSUNEO TAMURA, *Sorption Phenomena Significant in Radioactive-Waste Disposal*, in UNDERGROUND WASTE MANAGEMENT & ENVIRONMENTAL IMPLICATIONS 318 (T.D. Cook ed., 1972).

141. FRANK J. TRELEASE, *Liability for Harm from Underground Waste Disposal*, in UNDERGROUND WASTE MANAGEMENT & ENVIRONMENTAL IMPLICATIONS 369 (T.D. Cook ed., 1972).

recovered; or if you 'grease' the rocks, cause an earthquake, and shake down his house—the law will make you pay."[142]

Another attendee at that 1971 symposium, U.S. Geological Survey research hydrologist John Ferris, dismantled the central thesis of injection wells: that waste could be held in virtual perpetuity in a specific geologic layer deep in the earth because the layers above and below acted as a cork to seal it off. "The term 'impermeable' is never an absolute,"[143] said Ferris, because "all rocks are permeable to some degree."[144] So, the idea that any rock layer could act as a cork to seal off waste was simply wrong. "Waste will always and inevitably escape the injection zone," said Ferris, and "engulf everything in its inexorable migration toward the discharge boundaries of the flow system."[145]

V. PREDICTED HARMS NOW A REALITY: PRESENT DAY IMPACTS OF UNDERGROUND INJECTION OF OIL AND GAS WASTE

Federal agencies' well-documented concerns regarding underground injection are now playing out across the nation, with documented instances in Ohio and Texas.[146] Fracking wastewater shot down injection wells is traveling miles through the earth and spouting back to the surface at conventional oil and gas wells.[147] As the hydrologist John Ferris recognized in 1971, these conduits are exactly where to expect waste leaking deep underground to breach the surface.[148]

A. A Brief Story of Two Bobs: Conventional Oil and Gas Operators Adversely Impacted by Class II Injection Wells

About five years ago, a pair of independent oil and gas operators from rural Ohio named Bob noticed some of their gas wells were over-pressured,

142. FRANK J. TRELEASE, *Liability for Harm from Underground Waste Disposal*, in UNDERGROUND WASTE MANAGEMENT & ENVIRONMENTAL IMPLICATIONS 369 (T.D. Cook ed., 1972).

143. JOHN G. FERRIS, *Response of Hydrologic Systems to Waste Storage*, *in* UNDERGROUND WASTE MANAGEMENT AND ENVIRONMENTAL IMPLICATIONS 126, 128 (T.D. Cook ed., 1972).

144. *Id.* at 132.

145. Kiley Bense, *Peering Inside the Pandora's Box of Oil and Gas Waste*, INSIDE CLIMATE NEWS (July 9, 2024), https://insideclimatenews.org/news/09072024/oil-gas-waste-investigation-book/.

146. ROLAND BLAUER & NAING AYE, WASHINGTON COUNTY PRODUCED WATER INVESTIGATION 4 (2020); Vamshi Karanam et al., *Investigation of Oil Well Blowouts Triggered by Wastewater Injection in the Permian Basin, USA*, 51 GEOPHYSICAL RSCH. LETTERS 1, 1 (2024).

147. Naing Aye & Roland Blauer, *Washington County Produced Water Investigation Prepared for Ohio Department of Natural Resources Division of Oil & Gas Management by Resource Services International (RSI)*, OHIO DEPT. OF NAT. RES. (June 2020), https://ohiodnr.gov/discover-and-learn/safety-conservation/about-odnr/oil-gas/oil-gas-resources/washington-county-investigation.

148. FERRIS, *supra* note 143, 126.

and one was spewing an extremely salty liquid more than 50 feet in the air.[149] They suspected leaking fracking waste from nearby injection wells had found its way into their gas wells.[150] Being tax-paying citizens of this country, the Bobs expected the government would be concerned and help them with their problem.[151] The Bobs went to the Ohio Department of Natural Resources, the Ohio Environmental Protection Agency, and EPA. And, the Bobs say, no one took them seriously—until they called Felicia Mettler, the former Ohio elementary school archery instructor and Torch CAN DO co-founder.[152]

In June 2021, one of this article's authors met at a roadside rest stop opposite an injection well with Felicia and the Bobs. Two important points were discussed. One: people in rural, conservative areas may—despite climate change and other harms—be pro-oil and gas, but they are concerned and critical of having fracking wastewater injected deep beneath their communities.[153] Two: they are well aware of bedrock legal documents that support their outrage.[154]

Because the Bobs' gas wells have become overrun with oil and gas wastewater, these wells are no longer usable, and the men have lost an important source of income.[155] "Initially we thought we could talk to the state, tell them what was happening, and they would be reasonable and compensate us," Bob 2 explained at the meeting.[156] "But they didn't want to hear it."[157]

"I paid a million dollars or more in taxes over the years, and that festers me," Bob 1 said, "because I pay taxes to be protected. What they done is criminal."[158]

The enemy to the Bobs is not necessarily the people who drilled the wells producing the waste, but the injection well operators and regulators. "Our biggest problem," said Bob 2, "is I don't think the state of Ohio has permission to give them rights to pump brine under my property."[159]

Bob 1 mentioned that he has been reflecting about the 14th Amendment since his ordeal began.[160] He recited:

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149. Interview with Bob Lane & Felicia Mettler, Oil & Gas Operators (June 20, 2021) (on file with author).
150. *Id.*
151. *Id*.
152. *Id*.
153. NOBEL, *supra* note 5, at 174.
154. *Id.* at 179.
155. Lane, *supra* note 149.
156. *Id*.
157. *Id*.
158. *Id*.
159. *Id*.
160. *Id*.

> No state shall make or enforce any law which shall abridge the privileges or immunities of citizens of the United States; nor shall any state deprive any person of life, liberty, or property, without due process of law; nor deny to any person within its jurisdiction the equal protection of the laws.[161]

Bob 1 continued his reflection. "Right in that Constitution it says if you impinge upon a man's property you owe him due compensation, and we here are the one's suffering and it has ruined our property. So, if we can't rely on that Constitution, then I don't know what we can rely on."[162]

Bob 1 certainly has a philosophical point, but does he have a legal one? Can people whose property or business interests suffer contamination from fracking wastewater leaking out of injection wells hold the oil and gas operators that initially produced the waste liable? Can the communities and the general public whose local water sources and environment may be contaminated by this waste hold oil and gas operators accountable? Numerous lawsuits address these questions.[163] However, this article focuses on other more overlooked questions regarding Class II injection wells. Can you really inject radioactive waste into Class II injection wells—wells never intended to receive radioactive materials—simply because that radioactive waste was at some point associated with oil and gas production? Can communities use existing SDWA regulations to better protect their groundwater resources from contamination by oil and gas waste?

VI. WHAT THE SAFE DRINKING WATER ACT HAS TO SAY ABOUT RADIOACTIVITY, OIL AND GAS WASTE, AND UNDERGROUND INJECTION

EPA's rules implementing the SDWA's UIC program state: "Radioactive Waste means any waste which contains radioactive material in concentrations which exceed those listed in 10 CFR part 20, appendix B, table II, column 2."[164] The Nuclear Regulatory Commission created these tables based on levels intended to protect public health, covering hundreds of different radioactive elements and their various isotopes.[165] The values listed for both radium-226 and radium-228 are 60 pCi/L.[166] Thus, under federal

161. Lane, *supra* note 149 (quoting U.S. CONST. amend. XIV, § 1).
162. *Id*.
163. *See, e.g.*, Complaint at ¶¶ 23–144, Standard Oil Co. V. Redbird Dev., LLC, No. 24CI0186 (Athens C.P. Ohio July 22, 2024) (claiming the contamination from fracking wastewater resulted in common law tortious conduct); Complaint, Anderson v. Redbird Dev., LLC, No. 24CI0183 (Athens C.P. Ohio July 22, 2024).
164. 40 C.F.R § 146.3.
165. 10 C.F.R. § 20 (2025).
166. 40 C.F.R § 146.3.

regulations, any liquid containing radium-226 or radium-228 above 60 pCi/L meets the SDWA's definition of "radioactive waste."[167]

In early 2020, the authors of this article ran this assertion by EPA for confirmation, and in an email message sent on January 13, 2020, EPA stated: "As indicated in the Federal regulations, liquid waste containing radium-226 above 60 pCi/L or radium-228 above 60 pCi/L is defined as radioactive."[168]

EPA's position on what constitutes "radioactive waste" under SDWA regulations is clarified in the 2005 document, "A Regulators' Guide to the Management of Radioactive Residuals from Drinking Water Treatment Technologies." EPA states: "Under the UIC regulations, 'radioactive' refers to any waste containing radioactive concentrations that exceed those listed in 10 CFR 20, Appendix B, Table 2, Column 2. These concentrations are 60 pCi/L for radium-226, 60 pCi/L for radium-228."[169] And according to the Unity Rule, as well as defined in this 2005 EPA report, if the levels of two radionuclides present together add up to more than 60 pCi/L, then this waste is also considered "radioactive."[170]

As mentioned above, according to the Pennsylvania Department of Environmental Protection, radium levels in oilfield brine in the Marcellus formation average 9,330 pCi/L and can be as high as 28,500 pCi/L.[171] Clearly, Marcellus oilfield brine meets EPA's definition of "radioactive waste." But the Marcellus is the nation's most radioactive oil and gas formation.[172] Still, as shown in Figure 1, data for every oil field studied shows radium levels exceeding 60 pCi/L.[173]

In 2014, the Energy and Environmental Research Center at the University of North Dakota found the average radium levels in the brine of North Dakota's Bakken oilfield to be 3,618 pCi/L and as high as 6,760 pCi/L.[174] A 2018 paper published by researchers in University of Michigan's Department of Civil and Environmental Engineering found average radium levels in brine of Michigan's Antrim formation to be 5,416 pCi/L, and as high as 22,358 pCi/L.[175] And on it goes. The Ohio Department of Natural Resources in 2019 detected radium in brine of Ohio's Clinton formation, a

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167. ENV'T PROT. AGENCY, OFF. OF WATER, A REGULATORS' GUIDE TO THE MANAGEMENT OF RADIOACTIVE RESIDUALS FROM DRINKING WATER TREATMENT TECHNOLOGIES 19 (2005).

168. E-mails from Angela Hackel, EPA Spokesperson, to Megan. M. Hunter, author (Jan. 13, 2020–Feb. 6, 2020) (on file with author).

169. ENV'T PROT. AGENCY, OFF. OF WATER, *supra* note 167.

170. *Id.*

171. PERMAFIX, *supra* note 89, at 72.

172. NOBEL, *supra* note 5.

173. *See supra* Figure 1.

174. E-mail from Jay C. Almlie, Principal Eng'r, Energy & Env't Rsch. Ctr., Univ. N.D., to Justin Nobel, author (Nov. 27, 2019, 9:52 AM) (on file with author).

175. Wenjia Fan, Kim F. Hayes & Brian R. Ellis, *Estimating Radium Activity in Shale Gas Produced Brine*, 52 ENV'T SCI. & TECH. 10839, 10845 (2018) (Supporting Information on file with author).

conventional gas formation, as high as 9,602 pCi/L.[176] Radium in oilfield brine of Gulf Coast formations has been found as high as 2,801 pCi/L,[177] California's San Joaquin Basin as high as 2,111 pCi/L,[178] and Colorado's Denver-Julesberg Basin as high as 598 pCi/L.[179] An exhaustive literature search demonstrates that the levels for combined radium-226 and radium-228 in oilfield brine in formations across the United States are regularly greater than 60 pCi/L—often astonishingly greater. Therefore, these values would be defined by SDWA regulations as "radioactive waste."[180]

The vital question now emerges in full. If much of America's oilfield brine has more than enough radium to meet the SDWA's definition of radioactive waste, how is radioactive waste being regularly put in a truck and taken to be injected down Class II injection wells, when radioactive waste can only be injected down Class I injection wells?

The authors of this article put this question to EPA, and the agency replied—without providing any legal support—that while 60 was indeed the limit, injection wells "may receive radioactive wastes under certain conditions."[181] Given that no statute or regulation allows for wells other than Class I wells to receive "radioactive wastes under certain conditions," the authors asked EPA just what the certain conditions it referred to would be.[182] Again, citing no statute or regulation, EPA responded that there were "site-specific" conditions when an "injection well would receive a permit for radioactive waste."[183] Given that there is no statutory or regulatory process for granting wells other than Class I wells permits or permission to receive radioactive waste, the authors asked just how often these site-specific permits for radioactive waste EPA granted for Class II oilfield waste injection wells.[184] EPA is yet to reply to this question.

The oil and gas industry, however, has long known what type of injection well its waste, given its radioactivity profile, would need to go down under SDWA regulations. The next section explains some of what is publicly documented about that knowledge and history.

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176. Memorandum, Ohio Dep't of Nat. Res., Div. of Oil & Gas, Radium Testing Results for Conventional Brine (2018) (on file with author).

177. Earl S. Snavely, Jr., *Radionuclides in Produced Water*, AM. PETROLEUM INST. 79 (Aug. 16, 1989) (on file with author).

178. TASHA STOIBER & BILL WALKER, ENV'T WORKING GRP., TOXIC STEW: WHAT'S IN FRACKING WASTEWATER 8 (2015).

179. COLO. DEP'T OF PUB. HEALTH AND ENV'T, TENORM REPORT FOR THE STATE OF COLORADO 389 (2019).

180. 40 C.F.R. § 146.3 (2024); 10 C.F.R. pt. 20 app. B tbl. 2, col. 2.

181. E-mails from Angela Hackel, EPA Spokesperson, to Megan. M. Hunter, author (Jan. 13, 2020–Feb. 6, 2020) (on file with author).

182. *Id.*

183. *Id.*

184. *Id.*

A. A Brief History: The Oil and Gas Industry's Understanding of Its Radioactive Waste Program

Canadian scientists discovered radon in natural gas in 1904,[185] and in the 1920s scientists in Soviet Russia showed oilfield brine contained unusually high concentrations of radium.[186] In 1953, the U.S. Geological Survey found a radioactive mineral scale had accumulated on piping that lined an oil and gas well.[187] In 1956, the notable nuclear chemist Paul Kazuo Kuroda published findings in the journal of the American Geophysical Union reporting significant amounts of radium in brines from the oilfields of Oklahoma and Arkansas.[188]

The pivotal moment occurred in 1981, when Occidental Petroleum discovered radioactivity in the oilfield piping on the Piper Alpha Platform in the North Sea.[189] Brian Heaton founded a Scotland-based company to handle North Sea radioactivity issues called Aberdeen Radiation Protection Services.[190] He explained in one legal deposition:

> When the scale was finally analyzed . . . it was shown to come within the U.K. regulations dealing with radioactive materials; and so we had to start to instigate procedures with regard to the disposal of this material as radioactive waste and, by necessity, how to deal with it, with regard to the occupational exposures.[191]

Initially, industry scientists like Heaton thought radioactive scale might be a problem limited to the North Sea, but they soon realized they were wrong. "I think it is now recognized that scale can—or radioactive scales can be formed in virtually any oilfield operation in the world," said Heaton.[192] E&P Forum, a London-based oilfield group, created a task force to assess the issue of scale in oilfield piping.[193] An Amoco official chaired the task

185. E.F. BURTON, UNIV. OF TORONTO, A RADIOACTIVE GAS FROM CRUDE PETROLEUM 9 (1904).

186. W.A. Kolb & M. Wojcik, *Enhanced radioactivity due to natural oil and gas production and related radiological problems*, 45 SCI. TOTAL ENV'T 77, 77 (1985).

187. GARLAND B. GOTT & JAMES W. HILL, DEP'T OF THE INTERIOR, RADIOACTIVITY IN SOME FIELDS OF SOUTHEASTERN KANSAS: A CONTRIBUTION TO THE GEOLOGY OF URANIUM 71 (U.S. Gov't Printing Off. 1953).

188. Bernard F. Armbrust Jr. & P.K. Kuroda, *On the Isotopic Constitution of Radium (Ra-224/Ra-226 and Ra-228/Ra-226) in Petroleum Brines*, 37 TRANSACTIONS AM. GEOPHYSICAL UNION 216 (1956).

189. Brian Heaton Dep., at 11:58, Lester v. ExxonMobil Corp., No. 2002-19657, at 11 (La. C.C. 2011).

190. *Id.* at 6.

191. *Id.* at 23.

192. *Id.* at 32.

193. Memorandum from Joseph E. Howard, Exec. Sec'y, Energy & Petroleum F. to All Members Comm. F., on "Low Specific Activity Radioactivity Scale" at 1 (Jan. 7, 1986) (on file with author).

force.[194] A letter of the E&P Forum, dated January 7, 1986, reads: "With the prospect of ever tightening safety and environmental regulatory controls on the handling and disposal of these materials, continued problems are anticipated."[195]

Right around the same time, in April 1986, Chevron found radioactive scale on the production tubing during routine maintenance on a well in the Raleigh oilfield in Mississippi.[196] This survey was done at the prompting of a Chevron engineer who had recently returned from working in the North Sea.[197] The levels were high, the risks were real, and there was already a lawsuit underway at a state courthouse in Hattiesburg, Mississippi. The case concerned Winston Street's oilfield pipe-cleaning operation, which New Orleans attorney Stuart Smith eventually took over.[198] Other liabilities loomed. And the American Petroleum Institute established the API Ad Hoc Committee on Low-Specific Activity (LSA) Scale.[199] At 9:30 a.m. on Thursday, November 20, 1986, they held their first meeting at the offices of the Sun Exploration & Production Company in Dallas, Texas.[200] Representatives from Shell, Chevron, Exxon, Mobil Oil, Conoco, Texaco, Phillips Petroleum, Amoco, Pennzoil, and ARCO Oil & Gas were present.[201] They signed their names on an attendance sheet.[202]

The meeting's organizers handed out tasks and set an ambitious timetable. J.C. Martin, of Mobil Oil, and J.M. Spanhel, of the American Petroleum Institute, were to develop an issue paper.[203] Paul V. Pavlov, of Mobil Oil, was to develop measurement protocol.[204] Mark Withers, of Sun Exploration & Production, was to analyze existing legislation on the topic.[205] By June 30, 1987, the committee was to have a final report ready for distribution.[206]

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194. Memorandum from Joseph E. Howard, *supra* note 193.

195. *Id.*

196. David L Martindale, *NORM - Science, Regulations*, *Litigation*, 41 ANN. INST. ON MIN. L. 160, 160 (1994).

197. *Id*. at 176.

198. STUART H. SMITH, CRUDE JUSTICE: HOW I FOUGHT BIG OIL AND WON, AND WHAT YOU SHOULD KNOW ABOUT THE NEW ENVIRONMENTAL ATTACK ON AMERICA 26 (Benbella Books Inc., 2015).

199. Meeting Minutes of Ad Hoc Comm. on Low Specific Activity (LSA) Scale, Sun Expl. & Prod. Co., Dall., Tex. (Nov. 20, 1986) (on file with author).

200. *Id.*

201. *Id.*

202. *Id.*

203. *Id.*

204. Meeting Minutes of Ad Hoc Comm. on Low Specific Activity (LSA) Scale, *supra* note 199.

205. *Id.*

206. *Id.*

Another industry group, the Mid-Continent Oil & Gas Association, was also assessing the radioactivity issue, and formed their own subcommittee.[207] A letter on Exxon letterhead by one John Rullman reads:

> I would like to have the fourth meeting of the Mid-Continent Oil and Gas Association (Mississippi/Alabama Division) Ad Hoc Subcommittee for Naturally Occurring, Low Level Radioactive Material on Thursday, December 11, 1986, beginning at 10:30 a.m. at Exxon's New Orleans office at 1555 Poydras Street. Go to the 22nd floor lobby and call Anne Mannina at extension 3477 for entry.[208]

The two groups had crossover. At the American Petroleum Institute meeting, the same John Rullman provided a briefing on radioactivity and its presence in the oilfield.[209] He discussed alpha particles, beta particles, and gamma rays with the oil and gas officials; explained terms like half-life and picocurie; and gave a rundown of some of the most concerning oilfield radionuclides and their hazards.[210] Radium-226, he noted, could cause "bone cancers."[211] Radon had been "[p]roven to cause cancer in uranium miners" and presented a "[s]erious lung hazard."[212] Rullman pointed out there was "not much known about . . . food chain uptake," including the uptake of radioactivity in the marine environment and landfills that were used for agriculture.[213] This was possibly a reference to the practice of land-spreading, in which drilling waste is applied directly to pastureland, a practice common in Oklahoma, Texas, and elsewhere.

The committee was aware that additional risks might lie lurking, including health risks, regulatory risks, and potential liabilities. "The strategy outlined below is predicated upon the premise that industry does not have definitive data to address this issue," the November 20 meeting minutes explained.[214] The committee's research and report were of great importance.

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207. Meeting Minutes of Ad Hoc Comm. on Low Specific Activity (LSA) Scale, *supra* note 199.

208. Letter from John D. Rullman to Members of the Mid-Continent Oil & Gas Association (Mississippi/Alabama Division) Ad Hoc Subcomm. for Naturally Occurring, Low Level Radioactive Material, at 1 (Nov. 5, 1986) (on file with author).

209. Outline Notes, John Rullman, Briefing Presentation to the Am. Petroleum Inst., Dall., Tex. (Nov. 20, 1986) (on file with author).

210. *Id.*

211. *Id.*

212. *Id.*

213. *Id.*

214. Meeting Minutes of Ad Hoc Comm. on Low Specific Activity (LSA) Scale, *supra* note 199.

On May 29, 1987, a draft was ready.[215] The group could have gone in many directions, but the product delivered was a regulatory analysis.[216]

The American Petroleum Institute report begins: "The issue of naturally occurring radioactive material is one which could be substantially impacted by regulatory enactments."[217] The main concern all along has not necessarily been for the public, or the environment, or even the oil and gas industry's workers, it has been for the industry's own neck. This report is about the oil and gas industry's liability and risk. It is broken into six sections, and discusses federal legal issues, state issues, employee issues, transportation issues, licensing issues, and the UIC program.[218]

The Marcellus brine hauler Richard Cummins once asked, "why the hell are we driving unmarked trucks and given no training?"[219] Part of the answer is that although the sludge and scale accumulated in the bottom of the truck's tanks may actually be above legal limits for radioactivity, the Department of Transportation is not testing.[220] But there is another part to the answer, and it is in the American Petroleum Institute's report from May 29, 1987.[221] They also reference the Nuclear Regulatory Commission radioactivity limits of 60 pCi/L for radium-226 and radium-228 and state: "Wells injecting water in excess of this concentration clearly fall into Class IV."[222]

Class IV wells, originally designated for radioactive waste, are banned and only exist as a category used for enforcement purposes. Class IV designations are used to ensure the closure of any remaining wells and prevent their future construction, due to the unacceptably high risk such wells pose to groundwater sources.[223] Thus, it appears that the oil and gas industry knew back in 1987 that oilfield brine was too radioactive to inject down Class II injection wells.

This again begs the question: If much of the billions of gallons of oilfield brine injected daily down Class II injection wells has enough radium to meet the SDWA's definition of radioactive waste, then how can operators lawfully

215. Draft of Am. Petroleum Inst., *Regulatory Analysis*, report on naturally occurring material in the oil and gas industry, at 1 (May 29, 1987) (on file with author).

216. *Id.*

217. *Id.*

218. *Id.*

219. NOBEL, *supra* note 5, at 214.

220. *See* 49 C.F.R § 172.101 (listing materials regulated as hazardous materials by Department of Transportation); 49 C.F.R § 173.436 (identifying limits for radium concentrations and total consignment activity for radium-226 and radium-228 under hazardous materials regulations); *see also* Mohsen M. M. Ali et. al., *Concentrations of TENORMs in the Petroleum Industry and Their Environmental and Health Effects*, 9 RSC ADV. 39201, 39210 (2019) (showing levels of radium-226 and radium-228 in measured oil and gas industry scales and sludge exceeding aforementioned federal hazmat limits).

221. Draft of Am. Petroleum Inst., *Regulatory Analysis*, report on naturally occurring material in the oil and gas industry (May 29, 1987) (on file with author).

222. *Id.*

223. ENV'T PROT. AGENCY, *supra* note 61, at 51.

inject this waste into Class II wells? In answering this question, this article revisits the language of the SDWA governing Class II wells.

B. Class II Wells: Only for the Injection of Conventional Waste

It is a foundational concept of regulatory interpretation that every word of a law has meaning.[224] Looking at the SDWA, there is another problem with injecting fracking wastewater into Class II wells. According to the rules of EPA's UIC program, only *conventional* oil and gas wastewater can be injected into Class II wells.[225] Specifically, the regulation reads that only fluids "[w]hich are brought to the surface in connection with *conventional* oil or natural gas production" may be injected down Class II injection wells.[226]

Conventional and unconventional are terms that have long been used in the oil and gas industry to distinguish between oil and gas reservoirs. In conventional reservoirs, "oil and gas pathways are better connected and can be produced either/or by vertical/slanted wells."[227] Unconventional reservoirs "are geologically complex" and "exhibit very low permeability (near absence of connected pores for oil and gas to flow to the drilled well bore)" and thus "need to be hydraulically fractured to created oil and gas flow-pathways."[228] Further, to extract oil and gas from unconventional reservoirs, "well bores are designed to be drilled as horizontals."[229] Modern "fracking," as that term is used colloquially and throughout the oil and gas industry, involves a combination of hydraulic fracturing and horizontal drilling to access unconventional reservoirs.[230] Accordingly, based on the plain language of SDWA regulations, none of the brine and flowback from the nation's unconventional wells, drilled and brought online with the techniques of modern fracking, should be injected into Class II wells.[231]

In 2021, one of this article's authors asked EPA how it is permissible to inject *unconventional* oil and gas wastewater down Class II wells when the

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224. Williams v. Taylor, 529 U.S. 362, 404 (2000) (O'Connor, J., concurring) (quotations omitted).

225. 40 C.F.R. § 146.5(b)(1).

226. *Id.* (emphasis added).

227. *Shale Research & Development*, U.S. DEP'T OF ENERGY, https://www.energy.gov/fecm/shale-research-development (last visited May 15, 2025).

228. *Id.*

229. *Id.*

230. *See* ENV'T PROT. AGENCY ET AL., FEDERAL MULTIAGENCY COLLABORATION ON UNCONVENTIONAL OIL AND GAS RESEARCH: A STRATEGY FOR RESEARCH AND DEVELOPMENT 2 (July 18, 2014) (explaining how deploying hydraulic fracturing and horizontal drilling to extract from unconventional reservoirs has dramatically increased oil and gas production in the United States); *see also The Process of Unconventional Oil and Gas Production*, ENV'T PROT. AGENCY, https://www.epa.gov/uog/process-unconventional-natural-gas-production (last visited February 9, 2025) (explaining that hydraulic fracturing and horizontal drilling enabled the "relatively new" extraction from unconventional reservoirs).

231. 40 C.F.R. § 146.5(b)(1) (defining Class II wells as "Wells which inject fluids: (1) Which are brought to the surface in connection with *conventional* oil or natural gas production").

rules say only conventional wastewater can be injected.[232] The agency has yet to respond. However, EPA provided its reasoning on the matter in a recent EPA Environmental Appeals Board case out of southwestern Pennsylvania oil and gas country, in the heart of the Marcellus, *In re Penneco Environmental Solutions, LLC*.[233]

Petitioners in *Penneco* alleged that EPA Region 3 had unlawfully issued a Class II underground injection permit to Penneco Environmental Solutions, LLC. The permit allowed the conversion of an existing gas production well into a Class II disposal well and operation for the disposal of fluids from oil and gas production wells—including unconventional ("fracking" or "horizontal" wells).[234] In its briefing, EPA took the position that "the scope of the definition of conventional oil or natural gas production is not clear from the UIC regulations or the relevant regulatory history," and that EPA "has developed and consistently applied a broad but reasonable interpretation of the ambiguous phrase 'conventional oil or natural gas production' . . . ."[235] EPA noted that the agency added the word "conventional" to modify the phrase "oil and gas production" between its initial rule proposal in 1979 and the final adoption in 1980 without explaining the reasoning behind the addition of the word "conventional" in the preamble to its rulemaking.[236]

Despite what appears to be the very intentional addition of the word "conventional" between the proposed rule and the final adopted rule—and despite the rules of regulatory interpretation—in its briefing in *Penneco*, EPA adopted the stance that the word "conventional" in the Class II well definition in 40 C.F.R. § 146.5(b) is essentially meaningless.[237] To justify its reading-out of the word, EPA pointed to the absence of the terms "conventional" and "unconventional" in the SDWA, as well as the Act's pervasive express carve-outs for oil and gas production waste.[238] This includes a streamlined process for states to receive primary permitting and enforcement authority over Class II wells under Section 1425.[239] An additional carve-out is the SDWA's prohibition on EPA or delegated states prescribing requirements which "interfere with or impede [] the underground injection of brine or other fluids

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232. E-mails from Angela Hackel, *supra* note 168.

233. In re Penneco Env't. Sols., LLC, PAS2D702BALL (EAB 2024) [hereinafter *Penneco*].

234. *Id.*

235. Region 3's Response to the Petition for Review, at 29–30, *Penneco Env't Solns, LLC*, 205 A.3d 401 (2019) (No. 931 C.D. 2018) [hereinafter EPA Region 3 Response].

236. *Id*. at 33.

237. *See id*. at 35–41 (arguing "the SDWA and its legislative history do not provide a meaning for 'conventional oil or natural gas production'" and therefore the term must be read expansively enough to include all oil and gas extraction wastewater, regardless of whether the formation or extraction techniques employed were conventional or unconventional).

238. *Id*. at 34.

239. *Id*.

which are brought to the surface in connection with oil or natural gas production . . . ."[240]

As additional support for its contention that the term "conventional" has no meaning, EPA argued the wastewater from conventional and unconventional wells is similar, providing no justification for injecting unconventional wastewater into Class I wells, while injecting conventional wastewater into Class II wells.[241] Further, EPA argued, requiring conventional wastewater to be injected into Class I wells "could lead to an increase in aboveground disposal, such as land application or discharge into surface waters, which may have increased adverse impacts to the environment."[242] Lastly, EPA argued that evolving drilling technique applications over the years complicates interpreting the terms "conventional" and "unconventional" because "the unconventional has become the conventional," with fracking now "a standard industry technique."[243] Still, none of EPA's arguments reckon with the basic issue: "conventional" is a word in the regulation, and the rules of regulatory interpretation instruct us that "conventional" must mean something.[244]

Despite Petitioners not having raised the issue of the SDWA's definition of "radioactive waste" in the *Penneco* petition, EPA also briefly addressed the issue in its own briefing. EPA noted that when it changed the classification for radioactive disposal wells from Class V to Class I in 1999, the preamble to its notice of rule change allowed operators to continue to inject radioactive material found in oil and gas waste into Class II wells:

> EPA wishes to clarify that this reclassification of Class V radioactive waste disposal wells does not affect the disposal of naturally occurring radioactive material (NORM) in Class II wells as part of oil and gas field operations. The injection of fluids associated with oil and natural gas production, including such fluids containing NORM, would continue to be regulated under existing Class II UIC requirements or under applicable regulations prescribed by the Primacy State agency.[245]

240. EPA Region 3 Response, *supra* note 235, at 37; 42 U.S.C. § 300h(b)(2)(A).

241. EPA Region 3 Response, *supra* note 235, at 41.

242. *Id.* at 42.

243. *Id*. at 43.

244. 40 C.F.R. § 146.5(b)(1); *Williams v. Taylor*, 529 U.S. 362, 404, 120 S.Ct. 1495, 146 L.Ed.2d 389 (2000) (quoting *United States v. Menasche*, 348 U.S. 528, 538–39, 75 S.Ct. 513, 99 L.Ed. 615 (1955)) (internal quotations omitted).

245. EPA Region 3 Response, *supra* note 235, at 41; Revisions to the Underground Injection Control Regulations for Class V Injection Wells, 64 Fed. Reg. 68545, 68558 (Dec. 7, 1999).

EPA also pointed to its 1988 determination, which references Class II UIC wells as a disposal method despite oil and gas waste having "hazardous and radioactive components."[246]

On November 24, 2024, the Environmental Appeals Board rejected the petition for review in *Penneco*, finding that Petitioners had failed to preserve their argument regarding Class II wells being limited to the disposal of "conventional" oil and gas waste by not raising the issue during the public comment period.[247] However, the Board still elected to provide dicta on the matter, opining that the term "conventional" was not intended to prohibit injection of "fracking fluids."[248]

We observe that the premise of Petitioners' argument—that fracking is not "conventional oil or gas production"—seems to be incorrect.

> Fracking, which originated in the mid-1800s, is the practice of injecting high-pressure fluids and solids to break open impermeable rock formations to allow oil and gas to flow into a well. Because modern production techniques (i.e., unconventional production) did not exist in the 1800s, the use of fracking during that time period would mean fracking was used with traditional production techniques (i.e., conventional production). Thus, the inclusion of "conventional" in 40 C.F.R. § 144.6(b)(1) would not have been intended to prohibit injection of fracking fluids in Class II wells as Petitioners argue.[249]

Rather than focus on the distinction between *conventional* and *unconventional*, the Board's opining focuses on the specific technique of hydraulic fracturing. They argued that because it can be used to retrieve oil and gas from either a conventional or an unconventional formation, EPA could not have intended to exclude waste associated with fracking from injection into Class II wells.[250] Like EPA's briefing, the Board's dicta fails to reckon with the critical question: what does "conventional" mean as it appears in 40 C.F.R. § 144.6(b)(1) if not to limit waste disposal in Class II wells to waste produced from conventional oil and gas wells as opposed to *unconventional* wells?

EPA defines "unconventional oil and gas" elsewhere in its regulations. Pretreatment standards promulgated under the Clean Water Act state, "[u]nconventional oil and gas means crude oil and natural gas produced by a well drilled into a shale and/or tight formation (including, but not limited to,

246. EPA Region 3 Response, *supra* note 235, at 40.
247. *Penneco, supra* note 233, at 19–20.
248. *Id.* at 18.
249. *Id.* at 20.
250. *Id.* at 20.

shale gas, shale oil, tight gas, tight oil)."[251] These tight shale formations can only be accessed through modern fracking techniques (the combination of hydraulic fracturing and horizontal drilling).[252] Further, EPA regulations expressly address "wastewater pollutants associated with production, field, exploration, drilling, well completion, or well treatment for *unconventional* oil and gas extraction," prohibiting the direct discharge of these pollutants into publicly-owned treatment works.[253] Notably, no such standards exist for pollutants associated with *conventional* oil and gas production. EPA's 2020 study into oil and gas extraction wastewater management practices under the Clean Water Act expressly states it is a study of wastewater management from "both conventional and unconventional onshore oil and gas extraction."[254] Thus, the words "conventional" and "unconventional" have meaning, as those in the shale fields well know, but also as EPA's own regulations and publications directly indicate. The Board did not comment on the radioactivity issue, which Petitioners also had not raised in their petition, despite EPA's nod to the issue in their own briefing.

VII. Oil and Gas Waste Meets the Safe Drinking Water Act Definition of Radioactive Waste And Should be Regulated Accordingly

EPA's briefing in *Penneco* frames the definition of Class II wells in the SDWA as functioning as an exemption—the Class II Loophole. The Class II Loophole described in EPA's *Penneco* briefing is that *any* liquid wastes associated with oil and gas production can go down a Class II well, no matter the waste's constituents, and no matter if it is "radioactive waste" as defined in the SDWA.[255] The Class II Loophole means copious amounts of radioactive waste is injected annually into wells that were never designed or intended to receive it.

Despite its pervasive use, the Class II Loophole is not in fact written anywhere. Instead, the Class II Loophole's very existence relies on ignoring words contained in existing regulations. Such a reading is not supported by basic, longstanding tenets of statutory construction, which similarly apply to regulatory construction. These tenets generally hold that: (1) every clause and word of a law must be given effect; (2) similarly, a law must be construed

251. 40 C.F.R. § 435.33(a)(2).

252. NOBEL, *supra* note 5, at 149.

253. 40 C.F.R. § 435.33(a)(1) (emphasis added).

254. ENV'T PROT. AGENCY, EPA-821-S19-001, SUMMARY OF INPUT ON OIL AND GAS EXTRACTION WASTEWATER MANAGEMENT PRACTICES UNDER THE CLEAN WATER ACT 1, 5 (2020).

255. *See* EPA Region 3 Response, *supra* note 235, at 39 (emphasis added) (noting EPA "consistently views Class II wells as the correct classification of wells for the disposal of wastewater from *all* oil and natural gas production").

such that no clause, sentence, or word is superfluous, void, or insignificant; and (3) where possible, provisions should be read so as not to create a conflict.[256] As with statutory interpretation, "the starting point for interpreting a regulatory provision is its plain meaning."[257] The Class II Loophole defies each of these tenants, instead relying seemingly on whims of industry and EPA practices with no grounding in long-established SDWA regulations.

As EPA has readily acknowledged, the SDWA's definition of "radioactive waste" plainly includes oil and gas wastes with radium levels in excess of 60 pCi/L—and most produced water meets this definition.[258] The SDWA's definition of "radioactive waste" includes no language exempting oil and gas waste from this definition. Plainly, "radioactive waste" may only be disposed of in Class I wells. In addition, the SDWA defines Class II wells as being for fluids "[w]hich are brought to the surface in connection with *conventional* oil or natural gas production."[259]

EPA and industry have a demonstrated record of interpreting the Class II definition to function as a loophole allowing the injection of *any* fluids brought to the surface in connection with *any* oil and gas production. This interpretation goes against the plain language of the regulation, which limits fluids injected into Class II wells to those connected with *conventional* production. EPA's Class II Loophole gives the term "radioactive waste" no effect. Likewise, EPA's interpretation gives the term "conventional" no effect. By giving no effect to both of these terms, the Class II Loophole violates well-established rules of regulatory interpretation.[260]

In reading SDWA regulations, one must seek to harmonize the SDWA's provisions, as opposed to reading them in conflict with one another. The Class II Loophole defies this rule of regulatory construction because it unnecessarily creates a conflict between the SDWA as it defines "radioactive waste" and SDWA regulations for liquids brought to the surface in connection with oil and gas production.

Well-recognized principles of regulatory construction require reading the SDWA as affording the terms "radioactive waste" and "conventional"

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256. Williams v. Taylor, 529 U.S. 362, 404 (2000) (O'Connor, J., concurring); TRW Inc. v. Andrews, 534 U.S. 19, 31 (2001); Karczewski v. DCH Mission Valley L.L.C., 862 F.3d 1006, 1016 (9th Cir. 2017).

257. Intermountain Ins. Serv. of Vail Liab. Co. v. Comm'r, 134 T.C. 211, 218 (2010) (citing Walker Stone Co. v. Sec'y of Lab., 156 F.3d 1076, 1080 (10th Cir. 1998)).

258 . ENV'T PROT. AGENCY, OFF. OF WATER, *supra* note 167.

259. 40 C.F.R. § 146.5(b)(1) (2024) (emphasis added).

260. Williams, 529 U.S. at 404 (O'Connor, J., concurring) (quotations omitted) (quoting United States v. Menasche, 348 U.S. 528, 538–39 (1955)); TRW Inc. v. Andrews, 534 U.S. 19, 31 (2001) (quotations omitted) (quoting Duncan v. Walker, 533 U.S. 167, 174 (2001)); Walker Stone Co. v. Sec'y of Lab., 156 F.3d 1076, 1080 (10th Cir. 1998) ("When the meaning of a regulatory provision is clear on its face, the regulation must be enforced in accordance with its plain meaning.").

meaning and reading the regulations together as a harmonized whole. The result of such a reading would at the *very least* be that fluids brought to the surface with *unconventional* oil and gas production can only be injected down Class I wells designed to accept radioactive waste.

Rather than abide by the plain letter of its own regulations, EPA has used the Class II Loophole to turn a blind eye to years of fracking companies disposing of radioactive waste unlawfully. However, an agency cannot rewrite a regulation through interpretation.[261] While "the longstanding practice of the government—like any other interpretive aid—can inform a court's determination of what the law is,"[262] courts will not affirm blatant defiance of the plain language of EPA regulations.[263]

To the authors' knowledge, no one has attempted to enforce SDWA requirements that radioactive waste only be injected into Class I injection wells upon operators injecting radioactive fracking waste into Class II wells. EPA could take such action at any time. The SDWA also contains a citizen suit provision that allows "any person" to bring a lawsuit "against any person . . . who is alleged to be in violation of any requirement prescribed by or under [the SDWA]."[264] For those suffering the impacts of injection of radioactive fracking waste into Class II wells, the citizen suit provision may provide a route of enforcing existing SDWA regulations that prohibit this practice. In other words, closing the Class II Loophole is purely a matter of enforcement.

CONCLUSION

There is a certain irony here, and to understand, one can return to what V.L. Martin, with the Prairie Oil & Gas Company out of Independence, Kansas, told a meeting of oil and gas officials on April 12, 1932:

> Regardless of whether or not we consider our wastes objectionable or liable to cause damage to our neighbors or the public, the statutes of the several states make it obligatory on the producer to prevent the escape of waste from our properties. In many instances the courts have allowed damages because of the escape of such wastes. Apparently, it is only a question of time until the opposition to the

261. *See* Mullins Coal Co. of Va. v. Dir., Off. of Workers' Comp. Programs, 484 U.S. 135, 170 (1987) (Marshall, J., dissenting) ("An agency must abide by its regulations as written until it rescinds or amends them." (citing United States v. Nixon*,* 418 U.S. 683, 695–96 (1974))).

262. Loper Bright Enters. v. Raimondo, 603 U.S. 369, 386 (2024) (quotation omitted).

263. *See* Legal Env't Assistance Found., Inc. v. U.S. EPA., 276 F.3d 1253, 1263 (11th Cir. 2001) ("We cannot avoid the conclusion that EPA's construction of its classification scheme runs afoul of the plain language of the regulations and is therefore contrary to law.").

264. 42 U.S.C. § 300j-8(a)(1).

> escape of our waste will become strong enough to force us, as an economical measure, to dispose of them in such a manner as will not be objectionable to anyone, and, without doubt, such disposal will also be effected at a profit.[265]

Martin's final line reads: "It is also apparent that we cannot escape the moral responsibility for the effect of such wastes as may interfere with the orderly conduct of business, private or public, for after all we are the public which is affected."[266]

The story of the Bobs, gasmen in rural Ohio, appears to fulfill this prophecy. The Ohio Department of Natural Resources has now come to understand that at least four different injection well complexes across the state are leaking fracking wastewater, and the state has taken the extraordinary step of investigating the harms and shutting the wells down.[267] One such culprit was the Redbird injection well facility. A June 2020 report the Department produced on the facility determined the fracking waste that was contaminating the Bobs' gas wells had traveled one-third of a mile vertically, and *more than five miles* laterally through the earth.[268] The report stated, "naturally occurring fissures exist between the Ohio Shale formation and the Berea Sandstone formation, allowing wastewater to migrate."[269]

In a separate event, an injection well leaked brine into a conventional gas well and waste spewed out at the surface, ran down a hill, and contaminated a stream near Crooked Tree, Ohio. In January 2023, the Ohio Department of Natural Resources issued a letter to the company responsible, DeepRock Disposal Solutions, suspending operations at two of their injection wells in southern Ohio.[270] "If the Wells continue to operate, additional impacts may occur in the future and are likely to contaminate the land, surface waters, or subsurface waters," the state concluded.[271] "Thus, the continued operation of the Wells presents an imminent danger to the health and safety of the public and is likely to result in immediate substantial damage to the natural resources of the state."[272] Again, considering there are 181,431 oil and gas wastewater injection wells in America, and without them the industry would overnight be deluged with three billion gallons of toxic waste a day and nowhere to put it all, this simple admission has fantastic implications.

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265. V.L. Martin, *Disposal of Production Division Wastes* 3 (1932).
266. *Id.*
267. NOBEL, *supra* note 5, at 228.
268. Aye & Blauer, *supra* note 147, at 2.
269. *Id*. at 1.
270. Ohio Dep't of Nat. Res., Order No. 2032-02, Order by the Chief: Suspension of Injection Operations (Jan. 9, 2023).
271. *Id.*
272. *Id.*

In June 2023, the Ohio Department of Natural Resources issued another letter, suspending operations at the injection well near Felicia Mettler.[273] Her worst fears had been realized. Here too, waste was leaking out from the injection zone and entering nearby oil and gas wells, then flowing back out at the surface. This transformed them into surface-contaminating conduits for injected fracking waste. Earlier in 2024, these injection wells, operated by a company called K & H, and the ire of young Lexie Mettler's speech to her third-grade class, were shut down too. It was the hard work of not just Felicia, Autumn, and Lexie, but her environmental organizing mentor Roxanne Groff, and many, many other environmental organizers across Ohio that made this happen. Still, a stunning question remains.

If the practice of injecting oilfield wastewater deep underground at injection wells is scientifically meritless, was doubted in its conception even by the agency that currently regulates it, and typically involves injection of copious amounts of "radioactive waste" down wells explicitly not permitted to receive radioactive waste, why does this practice continue unabated across America?

273. Ohio Dep't of Nat. Res., Order No. 2023-139, Order by the Chief: Suspension of Injection Operations (June 26, 2023).