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The Regulation of Deep-Well Injection: A Changing Environment Beneath the Surface

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ARTICLES

The Regulation of Deep-Well Injection: A Changing Environment Beneath the Surface

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I. Introduction

"America's journey to environmental awareness has been a relatively recent one. Not so many years ago, Americans were still living under the illusion that a land as vast as ours was blessed with indestructible natural resources and beauty."[1] The illusion could not last, and reality has set in. The economic and population growth of the nation and the improvements in the standard of living enjoyed by its citizens require increased industrial production. Technological pro-

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1. RUSSELL E. TRAIN, U.S. ENVIRONMENTAL PROTECTION AGENCY, LEGAL COMPILATION, USEPA-M-L52S, vol. 1 (Jan. 1974).

gress and improvements in methods of manufacturing, packaging, and marketing of consumer products result in an ever-increasing mass of waste, including hazardous waste.[2] Regardless of the waste disposal technology utilized, under the right conditions, waste or constituents of wastes, particularly liquid wastes, migrate.

Once hazardous waste enters a body of natural groundwater, it can move great distances, undetected and hidden from view. The ultimate destination of that contaminated water may be a well supplying drinking water.[3] Since about half of all Americans, and up to 95 percent of those in rural areas, rely on groundwater as their main source of drinking water, there is great concern for the ever-increasing contamination of groundwater by improper hazardous waste disposal.[4]

Environmentalists are particularly concerned with the potential for contamination of drinking water supplies caused by the practice of deep-well injection of hazardous wastes.[5] Industry is also concerned about this practice, but from a different perspective. For industry, deep-well injection is a precious, limited resource. There are only so many places in which hazardous wastes can be disposed of with confidence. Many people in industry believe properly managed deep-well

2. *See generally* Resource Conservation and Recovery Act of 1976 (RCRA), Pub. L. No. 94-580, 90 Stat. 2795 (codified as amended at 42 U.S.C. §§ 6901-6992 (1988 & Supp. IV 1992)).

3. *See* U.S. Environmental Protection Agency, Office of Solid Waste Management Programs, Report To Congress: Waste Disposal Practices And Their Effects On Ground Water, USEPA-M-W28, at 81 (Jan. 1977)[hereinafter Waste Disposal Practices And Their Effects On Ground Water].

4. *See* U.S. General Accounting Office, Hazardous Waste: Controls Over Injection Well Disposal Operations, Report to Chairman, Environment, Energy, and Natural Resources Subcommittee, Committee on Government Operations, House of Representatives, GAO/RCED-87-170, at 8 (Aug. 1987) [hereinafter Hazardous Waste: Controls Over Injection Well Disposal Operations].

5. *See Resource Conservation and Recovery Act Reauthorization: Hearings Before the Subcomm. on Commerce, Transp., and Tourism before the House Comm. on Energy and Commerce*, 97th Cong., 2d Sess. 258 (Mar. 31 and Apr. 21, 1982)(statement of Jane Bloom, Natural Resources Defense Council (NRDC)).

injection can be a useful tool, offering benefits that far outweigh its inherent risks.[6] With the ever-increasing mass of waste produced as a result of society's demand for consumer goods, deep-well injection is a mainstay method of hazardous waste disposal for which no true replacement technology currently exists. It has been estimated that deep-well injection of hazardous wastes disposes of up to 59 percent of the 290 million tons of hazardous wastes generated in the United States each year.[7]

Currently, an outright ban on all but the most harmful land disposal methods is not feasible because of technological and economic limitations.[8] Moreover, treatment does not necessarily result in the destruction of waste matter. Rather, its conversion to less toxic forms or non-toxic forms still requires proper disposal.[9] Further, many hazardous wastes are not easily handled or treated in a cost-effective manner.[10] For these reasons, deep-well injection of hazardous wastes, along with other existing land-based disposal methods, will remain a necessary, although disfavored, method of disposal until new approaches to treating hazardous waste are available.

As early as 1970, before the United States Environmental Protection Agency (EPA) was created, the Commissioner of the Federal Water Quality Administration issued a statement of federal policy concerning deep-well injection.[11] The

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6. *See* Stanley M. Greenfield, *EPA - The Environmental Watchman*, in UNDERGROUND WASTE MANAGEMENT AND ENVIRONMENTAL IMPLICATIONS 14 (T.D. Cook ed., American Association of Petroleum Geologists, Tulsa, Oklahoma 1972) [hereinafter Greenfield, *EPA - The Environmental Watchman*].

7. *See* HAZARDOUS WASTE: CONTROLS OVER INJECTION WELL DISPOSAL OPERATIONS, *supra* note 4, at 8.

8. *See* Conference, *Performance and Costs of Alternatives to Land Disposal of Hazardous Waste*, Transactions of an APCA Int'l. Conference 217 (E. T. Oppelt ed., Dec. 1986).

9. *See id.*

10. *See id.* at 22.

11. *See* Greenfield, *EPA - The Environmental Watchman*, *supra* note 6, at 15. "[The] statement of federal policy concerning deep-well injection was issued by David Dominick, Commissioner of the Federal Water Quality Administration [in October 1970]." *Id.* at 14, 15. The EPA was established on December 2, 1970.

statement concluded with a ringing declaration that subsurface injection is a technique that is limited in space and time, to be used with great caution and "only until better methods of disposal are developed."[12] It is within this context that Congress and the EPA have regulated deep-well injection.

II. Technology, Risks and Costs of Deep-Well Injection

"Underground injection" is the "subsurface emplacement of fluids through a bored, drilled or driven well; or through a dug well, where the depth of the dug well is greater than the largest surface dimension."[13] This general definition does not provide an in-depth explanation of the complex mix of technical and geologic factors to be considered in the debate over this method of hazardous waste disposal. Thus, it becomes necessary to understand the technical aspects, risks, and advantages of deep-well injection before discussing its regulation.

A. Growth of Deep-Well Injection

The injection of industrial and municipal waste into deep-wells has been practiced for almost fifty years.[14] Injection-well development was particularly rapid during the mid-1960s and 1970s.[15] Early EPA inventories indicated that the number of deep-injection wells was growing at a rate of twenty-three per year since 1964.[16] By the early 1970s, it

12. *Id.* at 15.

13. 40 C.F.R. § 260.10 (1992). An "injection well" is simply defined as "a well into which fluids are injected." *Id.* See 40 C.F.R. § 122.3 (1981) for the definition of "Well Injection."

14. *See* U.S. Envtl. Protection Agency, Compilation of Industrial and Municipal Injection Wells in the U.S., vol. 1, at 1 (1974) [hereinafter Compilation of Industrial Municipal Injection Wells in the U.S.].

15. *See id.* at 1, 8. "Prior to 1964, 67 deep waste injection-wells had been drilled . . . ." *Id.* With the rapid proliferation of deep-wells in the 1970s, federal, state and local governments became concerned as to the fate of hazardous wastes injected into the ground. *See id.*

16. *See id.* at 1. *See also* Office of Technology Assessment, Technologies and Management Strategies for Hazardous Waste Control 191 (Mar. 1983) [hereinafter Technologies and Management Strategies for Hazardous Waste Control]. As of 1985, of 533 Class I hazardous waste and industrial and municipal nonhazardous waste wells, only 181 were injecting

was estimated that there were a combination of 333 permitted industrial and municipal waste injection-wells in the United States, of which 278 were drilled and 178 were in operation.[17]

The overall annual growth rate of the number of injection-wells has gradually declined since the 1980s.[18] Although many generators are currently trying to scale back their injection of hazardous wastes in favor of recycling and regeneration,[19] the volume of injected waste is still growing.[20] The waste management industry has been hit hard by the current recession; however, it is predicted to rebound with the economy due to the increase in industrial waste volumes.[21] Some industry analysts predict a short-term growth in the hazard-

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hazardous waste. HAZARDOUS WASTE: CONTROLS OVER INJECTION WELL DISPOSAL OPERATIONS, *supra* note 4, at 13. By far the most common well type are Class II wells used for oil and gas production. *See id.* By 1985, there were an estimated 153,126 active Class II wells in operation. *See id.* For a detailed description of well classification under the Underground Injection Control program, see *infra* note 43.

17. *See* COMPILATION OF INDUSTRIAL MUNICIPAL INJECTION WELLS IN THE U.S., *supra* note 14, at 1.

18. *See* U.S. ENVIRONMENTAL PROTECTION AGENCY, OFFICE OF DRINKING WATER, REPORT TO CONGRESS: INJECTION OF HAZARDOUS WASTE, USEPA 570/9-85-003 at II-10 (May 1985) [hereinafter REPORT TO CONGRESS: INJECTION OF HAZARDOUS WASTE]. The largest yearly increases in injection-well population was from 1973-1975, possibly as a result of the implementation of the Federal Water Pollution Control Act Amendments of 1972. *See id. See also* Federal Water Pollution Control Act Amendments of 1972, Pub. L. No. 92-500, § 2, 86 Stat. 816 (codified as amended at 33 U.S.C. §§ 1251-1387 (1988 & Supp. V 1993)).

19. *See* Ronald Begley, *TRI Releases Down Sixth Year In A Row*, Chemical Week, Technology Newsletter 7, Apr. 20, 1994, *available in* Lexis, Environment Library, ALLNEWS file. Concerns of environmental activists and people living in the vicinity of plants, along with high Toxic Release Inventory (TRI) numbers associated with deep-well injection, are prompting many companies to stop injection in favor of recovery and regeneration. For example, Monsanto and DuPont plan to eliminate hazardous waste injection by the year 2000. *See* Elisabeth Kirschner, *An Anxious Industry Sees New Limits To Its Options*, Chemical Week, Aug. 18, 1993, at 23.

20. *See* Ronald Begley, *TRI Releases Down Sixth Year In A Row*, *supra* note 19, at 7. Although the chemical industry claims that TRI chemical discharges were reduced by up to 40% from 1987 and 4% from 1991, it noted that deep-well injection increased 1%. *See id.*

21. *See* Rick Mullin, *New Direction On Hazwaste*, Chemical Week, Jan. 20, 1993, at 26.

ous waste management market, with deep-well injection gradually expanding anywhere from 5 to 10 percent by the year 2000.[22]

B. Well Design

There is no standard injection-well design. However, all such wells have similar features.[23] The typical injection-well is constructed with three concentric casings: (1) the exterior surface casing, (2) the intermediate protective casing, and (3) the innermost casing.[24] The exterior surface casing is designed to protect freshwater in the aquifers through which the well passes and to prevent corrosion.[25] It extends from the surface to below the base of the deepest potable water aquifer, and is cemented along its full length.[26] The intermediate protective or "long string" casing extends from the surface through the top of the injection zone and is cemented along its full length.[27] The innermost casing is the injection tubing in which the waste is actually transported.[28] This casing extends from the top of the well into the top of the injection zone.[29]

Waste is injected through the injection tubing and exits through perforations at the bottom of the tubing. The injection tubing is sealed off from the intermediate casing, creating a space called the annulus that is filled with pressurized fluid containing corrosion inhibitors.[30] The annulus is closed off at the bottom end by a packer, a device that keeps injected

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22. *See id.* Industry sources also predict solid growth for incineration (20%-25%), landfill (15%-20%) and "aqueous treatment, solvent and oil recovery and other applications." *Id.* However, under current regulatory mandates such as RCRA, it is predicted that there will be a shift away from land disposal toward alternatives such as treatment and recycling. *See id.*

23. *See* Technologies and Management Strategies for Hazardous Waste Control, *supra* note 16, at 190 fig. 13.

24. *See id.* at 190.

25. *See id.*

26. *See id.*

27. *See id.*

28. *See* Technologies and Management Strategies for Hazardous Waste Control, *supra* note 16, at 190.

29. *See id.*

30. *See id.*

fluids from entering the annular space.[31] Since the pressure of the fluid in the annulus is known and can be controlled, the integrity of the well can be monitored.[32] If annular pressure is maintained higher than injection pressure, a drop in well annulus fluid indicates a leak in either the injection tubing or in the outer casing.[33] When a drop in pressure occurs, injection should cease until the leak is located and the well repaired.[34] After injection operations permanently cease, the well must be properly plugged to prevent migration of injected wastes from the injection zone.[35] The maintenance of pressure prevents the mixture of fluids from different geologic strata and the flow of liquids from the injection zone to the surface.[36] To control and monitor injection and annular pressure, the surface portion or wellhead contains various valves and gauges.[37]

Notwithstanding that there is no standard injection-well design, EPA regulations for deep-well injection do set forth general construction criteria and standards to be considered in the permitting of a specific injection-well. For example, general factors for the construction and completion of existing and new Class I hazardous waste injection-wells include design features that: "(1) [p]revent the movement of fluids into or between USDW's [Underground Sources of Drinking Water] or into unauthorized zones; (2) [p]ermit the use of appropriate testing devices and workover tools; and (3) [p]ermit continuous monitoring of injection tubing and long-string casing . . . ."[38]

Additionally, "all well materials must be compatible with fluids with which the materials may be expected to come into

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31. *See id.* at fig. 13.

32. *See id.* at 190.

33. *See* TECHNOLOGIES AND MANAGEMENT STRATEGIES FOR HAZARDOUS WASTE CONTROL, *supra* note 16, at 190.

34. *See id.*

35. *See id.*

36. *See id.*

37. *See* HAZARDOUS WASTE: CONTROLS OVER INJECTION WELL DISPOSAL OPERATIONS, *supra* note 4, at 9.

38. 40 C.F.R. § 146.65 (1993).

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Article Title

The Regulation of Deep-Well Injection: A Changing Environment Beneath the Surface [1]

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Abstract

Deep-well injection has been a mainstay of hazardous waste disposal for over 70 years. Before the U.S. Environmental Protection Agency (EPA) was created, there were concerns as to the proper place for deep-well injection as a waste management technique. Over the years, environmentalists have been concerned with the potential for contamination of drinking water supplies from deep-well injection. Industry has also shown concern about -deep-well injection, but from a different perspective. To industry, deep-well injection is a precious, limited resource. It is within this context that Congress and the EPA have regulated deep-well injection. It is that process of regulation and the development of deep-well injection policy which is the focus of this article.

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known, the best security measure is not to install injection wells in areas of extensive oil exploration. Unfortunately, these are the same areas best suited to injection, and therefore, this caution has not been followed.[49] Underground injection uses porous rock strata, which is commonly found in oil producing states, to hold liquid waste.[50] The porous rock formations naturally contain both gases and liquids under pressure caused by overlying strata.[51] Such pressures can vary significantly, depending on the rock formation.[52]

Underground injection entails drilling a well to the depth needed to intersect a suitable geologic formation known as an injection zone.[53] This formation must be carefully selected using the following criteria:

(1) The formation should not contain a valuable resource, such as a source of drinking water or hydrocarbons;
(2) The injection formation must have sufficient porosity and size to accept the volume of liquids that is anticipated;
(3) The formation should be sealed both above and below by containment formations strong enough to prevent migration of waste from the disposal zone; and
(4) The disposal zone should be in a location with little seismic activity, in order to minimize the risk of earth-

49. *See* U.S. ENVIRONMENTAL PROTECTION AGENCY, OFFICE OF RESEARCH AND DEVELOPMENT, ASSESSING THE GEOCHEMICAL FATE OF DEEP-WELL-INJECTED HAZARDOUS WASTE: SUMMARIES OF RECENT RESEARCH, EPA 625/ 6-81025b, at 68 (July 1990) [hereinafter GEOCHEMICAL FATE OF DEEP-WELL-INJECTED HAZARDOUS WASTE]. Approximately two-thirds of deep-injection wells are located in Texas and Louisiana. *See id.* These wells receive 90% of injected wastes. *See id.* The injection zones of these Class I wells are normally in deep sedimentary basins composed of sand and sandstone aquifers, confined by clay and shale strata that may range from tens to hundreds of feet thick. *See id.*

50. *See* TECHNOLOGIES AND MANAGEMENT STRATEGIES FOR HAZARDOUS WASTE CONTROL, *supra* note 16, at 189.

51. *See id.*

52. *See id.*

53. *See* 40 C.F.R. § 146.3 (1993). "Injection zone means a geological 'formation', group of formations, or part of a formation receiving fluids through a well." *Id.*