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I. INTRODUCTION

When the modern era of major federal environmental regulation began twenty years ago, relatively little emphasis was placed on hazardous or toxic pollutants.[1] Provisions dealing with the subject in major environmental statutes were "added, almost as an afterthought."[2] However, today, "few would challenge the prediction that pollution by hazardous substances will dominate the agendas of the environmental agencies into the late 1980s and the 1990s."[3] Law review articles,[4] legislative hearings,[5] and

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1. For purposes of this article, the term hazardous pollution includes any substance in the environment which is reasonably likely to cause or contribute to serious illness or death in humans. This definition is narrow enough that it would be encompassed by the narrowest statutory definition in any major federal environmental statute. The exact statutory definitions vary from statute to statute. *See, e.g.*, Clean Air Act, 42 U.S.C. § 7412(a)(1) (1982) (substances which "may reasonably be anticipated to result in an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness"); The Clean Water Act, 33 U.S.C. § 1362(13) (1982) (substances which "will . . . cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions . . . or physical deformations"); Toxic Substances Control Act, 15 U.S.C. § 2605(a) (1982) (substances that "present an unreasonable risk of injury to health or the environment"); Solid Waste Disposal Act, 42 U.S.C. § 6903(5) (1982) (substances that "may—(A) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or (B) pose a substantial present or potential hazard to human health or the environment"). The Comprehensive Environmental Response, Compensation and Liability Act, 42 U.S.C. § 9601(14) (1982) incorporates the above definitions and adds, in § 9602(a), those substances which "may present substantial danger to the public health or welfare or the environment. . . ."

2. F. ANDERSON, D. MANDELKER & A. TARLOCK, ENVIRONMENTAL PROTECTION: LAW AND POLICY 449 (1984) [hereinafter ENVIRONMENTAL PROTECTION].

3. 2 W. RODGERS, ENVIRONMENTAL LAW: AIR AND WATER § 4.33 (1986).

pieces in popular news magazines[6] all attest to the high level of public interest in the regulation of hazardous pollution. The dramatic increase in interest and legislation concerning hazardous pollution demonstrates a major shift in environmental law priorities during these last twenty years.

Despite the increased attention and activity, there continue to be valid concerns that current legislation does not provide an adequate scheme for the prevention of harm from hazardous pollutants.[7] Environmental nightmares involving the potentially devastating impact of toxic pollutants remain too real for many.[8]

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4. *See, e.g.*, Ferrey, *The Toxic Time Bomb: Municipal Liability for the Cleanup of Hazardous Waste*, 57 GEO. WASH. L. REV. 197 (1988); Foster, *A Case Study in Toxic Tort Causation: Scientific and Legal Standards Work Against Recovery for Victims*, 19 ENVTL. L. 141 (1988); Gordon & Westendorf, *Liability Coverage for Toxic Tort, Hazardous Waste Disposal and Other Pollution Exposures*, 25 IDAHO L. REV. 567 (1988); Oleinick, Fodor & Susselman, *Risk Management for Hazardous Chemicals: Adverse Health Consequences of Their Use and the Limitations of Control Standards*, 9 J. LEGAL MED. 1 (1988).

5. *See, e.g.*, *Hazardous Waste Contamination of Water Resources: Hearing Before the Subcomm. on Investigations and Oversight of the House Comm. on Public Works and Transportation*, 99th Cong., 1st Sess. 1 (1985) [hereinafter *Hazardous Waste Contamination Hearing*] ("hazardous waste contamination of the Nation's surface and grounds waters" is "along with acid rain, . . . perhaps the most significant and most important environmental issue facing the Nation today"); *Hazardous Waste Disposal: Our Number One Environmental Problem: Hearing Before the Subcomm. on Transportation and Commerce of the Comm. on Interstate and Foreign Commerce, House of Representatives*, 96th Cong., 2d Sess. (1980) [hereinafter *Hazardous Waste Disposal Hearing*].

6. *See, e.g.*, Easterbrook, *Cleaning Up*, NEWSWEEK, July 24, 1989, at 26; Morgenthau, *Don't Go Near the Water*, NEWSWEEK, Aug. 1, 1988, at 42; Bordeswich, *The Lessons of Bhopal*, ATLANTIC, March 1987, at 30; Magnuson, *A Problem that Cannot Be Buried*, TIME, October 14, 1985, at 76; *The Toxic Waste Crisis*, NEWSWEEK, March 7, 1983, at 20.

7. *See, e.g.*, Latin, *Ideal Versus Real Regulatory Efficiency: Implementation of Uniform Standards and "Fine-Tuning" Regulatory Reforms*, 37 STAN. L. REV. 1267, 1270 (1985) ("there is widespread agreement that some alternative must be preferable to the current regulatory system"); Note, *Encouraging Safety Through Insurance-Based Incentives: Financial Responsibility for Hazardous Wastes*, 96 YALE L.J. 403, 414 (1986) ("direct regulation has failed to achieve, or even to approach, adequate control of hazardous waste management"); Note, *Legal Incentives for Reduction, Reuse, and Recycling: A New Approach to Hazardous Waste Management*, 95 YALE L.J. 810, 831 (1986) ("Although hazardous waste is one of the nation's most serious problems, neither the states nor the federal government has developed an optimal solution"). The Office of Technology Assessment concluded in a 1988 study that "Superfund remains largely ineffective and inefficient" and noted that this view is "shared by most observers." OFFICE OF TECH. ASSESSMENT, ARE WE CLEANING UP? 10 SUPERFUND CASE STUDIES—SPECIAL REPORT 1 (June 1988).

8. The mere mention of places such as Love Canal, Times Beach, Bhopal, and more recently, Rocky Flats, conjures up graphic images of the problems that hazardous pollutants can pose.

Society is still searching for more acceptable ways of immunizing itself from the hazardous pollution it creates.

This article briefly reviews the shift in priorities that has occurred in hazardous pollution regulation over the last twenty years and outlines some of the inadequacies in the current regulatory system. The article next discusses four reasons why the regulatory schemes resulting from that evolutionary process have proven less than adequate. Finally, it forecasts some future regulatory changes that will likely occur as the public and Congress increasingly recognize and appreciate the limitations which have prevented policymakers from crafting more satisfactory responses to this major environmental problem.

II. Shifting Priorities: A Brief Overview of the Recent History and Current Status of Federal Hazardous Substances Regulation

One possible measure of the importance the general public attaches to an issue is the amount of legislation and administrative regulation addressing the subject.[9] If this measure is used to evaluate public priorities in environmental law over the past twenty years, it is clear that public concern over hazardous substances has escalated dramatically. In the first five years of that period, Congress failed to enact a major federal act dealing exclusively with hazardous substances.[10] The portions of the major acts which did address hazardous or toxic substances were minor pieces of the legislation.[11] By contrast, two of the three pieces of major federal environmental legislation enacted in the last five years[12] dealt solely with the regulation of hazardous substances,

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9. As an issue comes to the forefront of the public's mind, pressure naturally builds on legislators and other governmental regulators to deal with it through governmental action.

10. The Federal Insecticide, Rodenticide, and Fungicide Act (FIFRA) was amended in 1972 to give EPA extensive authority over the use of pesticides. However, those amendments dealt not only with substances that posed serious health hazards to humans, but also with those which threatened the environment in general. *See*, 7 U.S.C. § 136 (1982). Moreover, the 1972 FIFRA amendments did not receive nearly as much attention as did the National Environmental Policy Act, the 1970 Amendments to the Clean Air Act, or the 1972 Amendments to the Federal Water Pollution Control Act--the most highly publicized pieces of legislation enacted in the early 1970s.

11. The hazardous pollution provisions of the Clean Water and Clean Air Acts of the early 1970s have been described as "[b]rief statutory provisions" which were "added, almost as an afterthought." Environmental Protection, *supra* note 2, at 449.

12. Hazardous and Solid Waste Amendments of 1984, Pub. L. No. 98-616, 98 Stat. 3221 (1984); Superfund Amendments of Reauthorization Act of 1986, Pub. L. No. 99-499,

and a major portion of the third act[13] focused on the regulation of hazardous pollutants.[14] Provisions now exist to regulate or ban hazardous substances on the land,[15] in the air,[16] and on the sea.[17]

The same shift in public priorities is demonstrated by a review of the nature of environmental catastrophes which have prompted the enactment of various federal environmental statutes over the past two decades.[18] One of the first major triggering events in the modern era of environmental law occurred in early 1969 when an oil well located in the Santa Barbara Channel off the California coastline blew out. Even though there was no loss of human life or permanent impairment of human health, the event was critical to the environmental movement because, in the words of the President's Council on Environmental Quality, it "brought home to a great many Americans a feeling that protection of their environment would not simply happen, but required their active support and involvement."[19] The result was a flurry of environmental legislation. The National Environmental Policy Act[20] was enacted in 1969, and the Clean Air Act and the Clean Water Act underwent major overhauls in 1970 and 1972 respectively.[21]

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100 Stat. 1613 (1986).

13. Water Quality Act of 1987, Pub. L. No. 100-4, 101 Stat. 60 (1987).

14. *Id.* at §§ 308, 519, 101 Stat. 7, 38, 87.

15. Resource Conservation and Recovery Act (RCRA) §§ 3001-13, 42 U.S.C. §§ 6921-34 (1982 & Supp. V 1987) (RCRA amended and generally encompassed the Solid Waste Disposal Act in 1976); Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) §§ 103-10, 42 U.S.C. §§ 9603-9610 (1982 & Supp. V 1987).

16. Clean Air Act § 112, 42 U.S.C. § 7412 (1982).

17. Clean Water Act § 307, 33 U.S.C. § 1317 (1982).

18. As Professor Ora Fred Harris has observed:

> [P]erhaps the ideal teaching method to communicate . . . the hazards of toxic substance exposure must entail the use of concrete, tangible, and highly dramatic environmental events that reflect the dire risk associated with toxic substance exposure. . . . [S]tudents learn (as do people in general) when the risk is brought home to them directly.

Harris, *Communicating the Hazards of Toxic Substance Exposure*, 39 J. LEGAL EDUC. 97, 102 (1989). The truth of this observation is borne out by the fact that major legislation followed each of the events described in the text. Unfortunately, a system which merely reacts to catastrophic events will probably not effectively deal with environmental problems because in a complex industrial society the roots of such problems are often already firmly established when the event occurs.

19. COUNCIL ON ENVTL. QUALITY, ENVIRONMENTAL QUALITY—1979: THE TENTH ANNUAL REPORT 11.

20. Pub. L. No. 91-910, 83 Stat. 852 (1970).

21. Pub L. 92-500, 86 Stat. 820 (1972); Pub. L. 91-604, 84 Stat. 1676 (1970).

In part because the oil spill did not involve an immediate threat to human health, the primary focus of this early federal legislation was on protecting the environment from man's activities. By 1972, many believed that the tools existed to make the environment safe from man.[22]

Six years later, after billions of government and industry dollars had been spent to clean up the environment under the legislation of the early 1970s, a healthy nineteen-year-old truck driver in Iberville Parish, Louisiana died while discharging waste from his truck into an open pit.[23] The coroner's report indicated that he died from inhaling toxic fumes caused by liquid wastes mixing in the open pit.[24] Even though the condition was life-threatening, there was no clear-cut federal mechanism for effectuating a comprehensive clean-up.[25] Frustrated by the state's failure to remedy the problem under existing state laws, local citizens burned the only bridge that led to the facility.[26]

Less than two weeks later, New York public health officials announced that a state of emergency existed in the Love Canal area near Niagara Falls.[27] The allegedly hazardous conditions were created by activities which violated no federal law when they occurred.[28] The state boarded up 239 homes, closed a school, and enclosed the area with a barbed wire fence.[29] In part as a result of these two incidents, the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)[30] was passed in 1980, creating a mechanism for cleaning up existing hazardous waste problems.[31]

Four years later a release of methyl isocyanate at Union Carbide's plant in Bhopal, India, caused the death of more than

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22. 1973 EPA REP. TO CONG. 62 (existing laws are adequate for air and point source water pollution).

23. *Hazardous Waste Disposal Hearing*, *supra* note 5, at 85 (testimony of Audrey Zapp).

24. *Id.*

25. Even though the Resource Conservation and Recovery Act (RCRA) had been enacted in 1976, "[h]azardous waste enforcement at the EPA did not begin in a formal, institutional sense until mid-1979." Mintz, *Agencies, Congress and Regulating Enforcement: A Review of EPA's Hazardous Waste Enforcement Effort, 1970-1987*, 18 ENVTL. L. 683, 689 (1988).

26. *Hazardous Waste Disposal Hearing*, *supra* note 5, at 85.

27. M. BROWN, LAYING WASTE 28 (1979).

28. N.Y. Times, Aug. 8, 1978, at A1, col. 1.

29. Silverman, *Love Canal: A Retrospective*, 20 Env't Rep. (BNA) 835, 838 (Sept. 15, 1989).

30. Pub. L. No. 96-510, 94 Stat. 2767 (1980).

31. 42 U.S.C. §§ 9601-9675 (1982 & Supp. V 1987).

2,000 people.[32] Concern over a potential repeat performance in the United States focused attention on the community's right to be informed about the nature of hazardous chemicals being used at local plants and resulted in the passage of the Emergency Planning and Community Right-to-Know Act (EPCRTKA).[33]

By the late 1980s, it was therefore clear that the ambitious federal legislation of the early 1970s had not adequately anticipated the hazardous pollution tragedies that would follow. It was also clear that the initial focus on protecting the environment from man's activity would have to give way to protecting man from his environment, or more accurately, protecting man from the hazardous pollution he had created.[34]

Thus, both the amount of legislation over the last twenty years and the type of events which served to focus public attention on the need for such legislation demonstrate that regulation of hazardous pollution, a matter which was a mere legislative afterthought in the early 1970s, has become "our number one environmental problem."[35] A concern which twenty years ago was near the bottom of the environmental agenda, now heads the list. The last truly has become the first.[36]

However, success in dealing with an issue cannot be measured solely by the amount of federal legislation or public concern it engenders. A review of the actual situation reveals that, with respect to hazardous pollution regulation, what you see in the statutes is not necessarily what you get in practice. For example, although the 1970 Clean Air Act contained provisions au-

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32. Bordeswich, *supra* note 6, at 30.

33. 42 U.S.C. §§ 11001-11050 (Supp. V 1987). *See* Harris, *supra* note 18, at 110 ("community right-to-know and emergency response provisions of the 1986 amendments to Superfund (SARA), stem[] from the fatalities in Bhopal, India").

34. In fairness to the supporters of the early legislation, it should be pointed out that both the Clean Air Act and the Clean Water Act contained provisions authorizing especially stringent regulation of hazardous pollutants. Pub. L. No. 91-604, § 4(a), 84 Stat. 1676, 1685 (1970) (Clean Air Act); Pub. L. No. 92-500, § 2, 86 Stat. 816, 856 (1972) (Clean Water Act). Moreover, the Resource Recovery Act of 1970 directed the EPA to study the feasibility of a system of national hazardous waste disposal sites. Although this Act did not authorize any regulatory activities, it indicated that Congress was aware that there might be a problem out there somewhere. *See* 1973 EPA REP. TO CONG. 23. Finally, in a 1973 report to Congress, the EPA recommended passage of hazardous waste legislation with the provisions eventually employed three years later in the Resource Conservation and Recovery Act. However, the same 1973 report boldly asserted that with passage of such legislation "no further Government intervention [was] appropriate at [that] time." 1973 EPA REP. TO CONG. 62.

35. *Hazardous Waste Disposal Hearing*, *supra* note 5, at 1.

36. *See Matthew* 20:16.

thorizing stringent regulation of hazardous air pollutants,[37] seven years after its enactment, the EPA had issued regulations for only four substances.[38] Emission standards for three of these were not promulgated until after the EPA was under a court order to do so.[39] Final standards for the fourth substance, vinyl chloride, have still not been promulgated and approved, even though it has been nineteen years since enactment of the legislation and thirteen years since standards were first proposed.[40] Moreover, the EPA has still developed emission standards for only seven hazardous air pollutants even though more than 200 potential candidates have been identified.[41]

Similarly, the 1972 Federal Water Pollution Control Act (Clean Water Act) directed the EPA to publish a list of toxic pollutants and set especially stringent effluent standards for those pollutants.[42] Five years later, Congress noted with regret, that only six toxic chemicals had been regulated.[43] As a result, litigation once again ensued, and the EPA was ordered to develop standards for sixty-five pollutants.[44] In 1977, Congress amended the Clean Water Act to make it easier for the EPA to regulate toxic pollutants.[45] However, eight years later, there were still between 100 to 1000 pounds of toxics entering the Boston Harbor each day without violating federal standards.[46]

Even more recent statutes, like the Resource Conservation Recovery Act (RCRA)[47] and CERCLA, which were designed specifically to deal with the hazardous waste problem, proved less

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37. 42 U.S.C. § 7412 (1982).

38. ENVIRONMENTAL PROTECTION, *supra* note 2, at 510.

39. *See* EDF v. Ruckelshaus, 3 Envtl. L. Rep. (Envtl. L. Inst.) 20,173 (D.D.C. 1973).

40. *See* NRDC v. EPA, 824 F.2d 1146 (D.C. Cir. 1987) (remanding proposed standards to agency for reconsideration).

41. Cortese, *Preventing Hazardous Air Pollution*, ENVTL. F., Nov./Dec. 1988, at 22, 24.

42. *See* The Federal Water Pollution Control Act Amendments of 1972, Pub. L. No. 92-500, § 307, 86 Stat. 816, 856 (1972).

43. A LEGISLATIVE HISTORY OF THE CLEAN WATER ACT OF 1977, 96th Cong., 2d Sess. 327 (1978).

44. NRDC v. Train, 8 Env't. Rep. Cas. (BNA) 2120 (D.D.C. 1976).

45. Pub. L. No. 95-217, §§ (a), (b), 54(a), 91 Stat. 1589-91. *See* A LEGISLATIVE HISTORY OF THE CLEAN WATER ACT OF 1977, *supra* note 43, at 459-460.

46. A 1985 Greenpeace study of Boston Harbor found that 100 to 1,000 pounds of toxics entered the harbor each day from non-point sources. GREENPEACE, BOSTON HARBOR TOXICS PROJECT: REPORT ON TOXIC DISCHARGES INTO BOSTON HARBOR AND TRIBUTARIES 4 (Oct. 1986). Prior to 1987, there was no federally-mandated program for restricting water pollution from non-point sources.

47. The Resource Conservation and Recovery Act of 1976, Pub. L. No. 94-580, 90 Stat. 2795 (1976).

than adequate, as evidenced by the recent amendments to those two statutes.[48] In 1984, eight years after initial enactment of RCRA, Congress noted that "an amount of hazardous waste equal to that which is currently regulated . . . (40 million metric tons per year) is escaping control through various loopholes."[49] CERCLA's reviews were no more impressive. Six years after that statute was passed, Congress observed that "the resources given to EPA were simply inadequate to fulfill the promises that were made to clean up abandoned hazardous wastes in this country. . . . EPA was virtually guaranteed to fail from the moment CERCLA passed in 1980."[50]

The question which naturally arises from this thumbnail sketch of the evolution and current status of hazardous pollution regulation is why have these legislative schemes not been more effective? The complete answer to that question will take years to discover. However, the answers that are already available provide insight into the kinds of changes which are likely to take place as the battle to control hazardous pollution moves into the 1990s.

III. Why Haven't We Done Better: The Problems with Governmental Efforts to Regulate Hazardous Pollution

Although numerous causes have hindered the efforts to deal more effectively with hazardous pollution problems,[51] failure to appreciate four important factors has significantly contributed to a less-than-stellar performance. These factors are 1) the high level of scientific uncertainty concerning the effects of hazardous

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48. *See* The Hazardous and Solid Waste Amendments, Pub. L. No. 98-616, 98 Stat. 3221 (1984); The Superfund Amendments and Reauthorization Act, Pub. L. No. 99-499, 100 Stat. 1615 (1986).

49. H.R. Rep. No. 98-198, 98th Cong., 2d Sess. 19, *reprinted in* 1984 U.S. Code Cong. & Admin. News 5576, 5578.

50. H.R. Rep. No. 99-253, 99th Cong. 2d Sess. 55, *reprinted in* 1986 U.S. Code Cong. & Admin. News 2835, 2837.

51. *See, e.g.*, Cortese, *supra* note 41, at 24.

> The difficulties of controlling hazardous air pollutants are the result of several problems: a strict reading of the statute that does not allow cost and technological feasibility to be considered in establishing emission standards; imprecise quantitative risk assessment techniques; the utilization of risk assessment techniques as the only decisionmaking tool; the drive by environmental groups to impose the strictest emission controls; and industry's effort to avoid costly controls without demonstrated health benefits.

Id. Politicization of the enforcement process has also hampered effective regulation. *See* Mintz, *supra* note 25, at 715-743.

pollutants on humans, 2) the high cost of regulating hazardous pollutants, 3) the unanticipated scope of the hazardous pollution problem, and 4) the intermedia nature of the problem. Legislative ignorance or underestimation of these four factors has greatly limited the effectiveness of the resulting regulatory programs. The increased recognition of each of these factors, resulting in mounting efforts to change the regulatory system, suggests the course that hazardous pollution regulation will take in the future.

A. Scientific Uncertainty: Shooting in the Dark

One of the greatest difficulties facing those attempting to regulate hazardous pollution is the high degree of scientific uncertainty concerning the effects these substances have on humans. Failure to fully appreciate the extent of this problem has led to the enactment of statutory schemes which encourage inaction on the part of regulators and lengthy and ultimately unproductive court battles on the part of environmentalists and industry.

The hazardous pollution provisions in the early statutes like the Clean Air Act and the Clean Water Act reflect what, in retrospect, is a naive view that hazardous substances can be definitively identified and a safe exposure level determined by the application of existing scientific knowledge. For example, under the Clean Air Act, the EPA is directed to determine which air pollutants "may reasonably be anticipated to" cause death or serious illness,[52] and then to set emissions standards which provide "an ample margin of safety" for preventing such harms.[53] The original toxic pollution provisions of the 1972 amendments to the Clean Water Act were similarly premised on the belief that the EPA could identify hazardous water pollutants and then determine what level of exposure to those substances would be safe.[54]

Engineers have longed used this so-called "safety factor" approach.[55] To design a safe bridge, engineers conservatively calculate the load likely to be experienced by the bridge and then

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52. 42 U.S.C. § 7412(a)(1) (1982).

53. 42 U.S.C. § 7412(b)(1)(B) (1982).

54. The Federal Water Pollution Control Act Amendments of 1972, Pub. L. No. 92-500, 86 Stat. 816, 856 (1972).

55. Whipple, *Fundamentals of Risk Assessment in Dealing with Risk: The Courts, the Agencies and Congress*, 4-5 (ABA 1985).

fashion the bridge to carry a load two or three times greater than that.[56] In other words, the engineers determine a safety threshold and then provide an ample margin of safety beyond the threshold to account for any unknown variables. Congress created statutory schemes which envisioned the same kind of approach for hazardous air and water pollutants: the EPA was directed to identify those substances which could cause death or serious illness to humans, determine the lowest level of exposure at which those drastic consequences would occur, and then set emission or discharge standards at a level which would ensure that humans would not be subjected to exposure at anywhere close to those levels.[57]

Unfortunately, it is difficult, if not impossible, to determine a safety threshold for human exposure to most hazardous substances because the causal relationship between exposure to a substance and harm to human health is extremely difficult to establish. Scientists have not developed tests which can concretely identify the effects of various substances on human beings, especially the long term effects. A review of the level of uncertainty existing in some of the scientific methods currently used to establish the impact of chemicals on human health illustrates the difficulties in ascertaining a safety threshold for human exposure to hazardous substances.

1. *Scientific methods employed to ascertain health risks*

a. Animal studies. Because controlled studies on human beings are not feasible, one of the leading methods currently used to ascertain the impact of a substance on humans is controlled animal studies. The EPA relied primarily on data from such studies when it ranked wastes in order of their toxicity under the Hazardous and Solid Waste Amendments (HSWA).[58] Likewise, "[s]tudies on rodents are the major source of data on the carcinogenicity of chemicals."[59] Yet, there is considerable disa-

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56. *Id.* at 4.

57. "Congress directed EPA to protect public health with an ample margin of safety. This framework assumes that there is a threshold level of air pollution below which any adverse health effects are unlikely." Cortese, *supra* note 41, at 22.

58. EPA REP. TO CONG., MINIMIZATION OF HAZARDOUS WASTES, Appendices at D-11 (Oct. 1986) [hereinafter MINIMIZATION OF HAZARDOUS WASTES]. *See* Pub. L. No. 98-616, 98 Stat. 3248 (1984).

59. Doniger, *Federal Regulation of Vinyl Chloride: A Short Course in the Law and Policy of Toxic Substances Control*, 7 ECOLOGY L.Q. 500, 512 (1978) (citing COUNCIL ON ENVTL. QUALITY, ENVIRONMENTAL QUALITY—1975: THE SIXTH ANNUAL REPORT 28-32). *See*

greement within the scientific community over the validity of such studies as a predictor of the effect of hazardous substances on humans.[60]

Uncertainties concerning the reliability of such studies stem from numerous sources. As one scientist noted:

> Uncertainties arise from the relative sensitivity of various species to specific toxic agents (hamsters, for example, are far more sensitive to dioxin than rats) and from the question of how to scale for dose given the great differences in size between humans and test animals. . . . Uncertainties also arise from the fact that test animals have different natural patterns of cancer than do humans. For example, the significance of an increase in mouse liver cancer in a test will be disputed, since cases are common in unexposed mice, yet relatively rare in other animals. An additional difficulty is that the human population is far more genetically diverse than the animal strains used in toxicological tests. . . . The diversity of other agents to which humans are exposed (e.g. differences in diet, occupational exposures, smoking, etc.) adds to the likelihood that human sensitivity will vary more than that of test animals.[61]

Moreover, some have asserted that the cells of long-lived animals, such as humans, "are far less active in converting chemicals into carcinogens than are the cells of short-lived animals" and that humans are therefore "far more resistant to the risk of carcinogenicity than [mice]."[62] There is also some disagreement over the number of species that must be tested before a reliable carcinogenic finding can be made.[63] The uncertainties

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also, Mantel & Schneiderman, *Estimating "Safe" Levels, A Hazardous Undertaking*, 35 CANCER RES. 1379, 1381 (1975) (noting that experiments are often performed on animals and "we assume that results on animals are directly convertible to man").

60. For a general discussion of the controversy and possible sources of errors involved in using animal studies to determine carcinogenic effects in humans, see E. EFRON, THE APOCALYPTICS 244-265 (1985).

61. Whipple, *supra* note 55, at 8.

62. E. EFRON, *supra* note 60, at 244 (citing J. CAIRNS, CANCER: SCIENCE, AND SOCIETY 101 (1978)).

63. *See* E. EFRON, *supra* note 60, at 244-45.

> Issac Berenblum says that to be "at all reliable" a carcinogenic finding must be made in "at least three different species." Norbert Page of the NCI [National Cancer Institute] says that at least two species must be tested. The NCI officially requires two or more species. Others, however [including OSHA and National Institute of Health officials], deny the necessity of multiple species and multiple experiments and claim that one good experiment—i.e., an experiment in one species—is sufficient.

Id. (citations omitted).

involved in animal studies are so great that to demonstrate with ninety-five percent confidence that a given low dose of just one substance causes fewer than one cancer in a million subjects would require a test involving at least six million animals.[64] Such "mega-mouse" experiments are not feasible for each substance, in part because of the enormous cost involved.[65] Moreover, even if feasible, the experiments would be "vulnerable to laboratory errors that can destroy the statistical reliability of the results."[66] Accordingly, scientists have to rely on models which project results from smaller animal studies involving larger doses. This further complicates the problem because these models are based on differing assumptions which vary among themselves by a factor of 100,000 on the size of dose that creates the risk of one cancer in a million.[67]

Not surprisingly, studies with such high levels of uncertainty produce results that are subject to a wide variety of interpretations. In one study involving trichloroethylene, predictions concerning the hazards posed by the substance varied by many millions, prompting one group to observe that the uncertainty was "equivalent to not knowing whether one has enough money to buy a cup of coffee or pay off the national debt."[68] The use of animal studies to establish the effects of chemicals on human beings is subject to such high levels of uncertainty that some courts have refused to admit expert testimony based on animal studies, concluding that the studies "are of so little probative force" on the causation issue and "so potentially misleading as

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64. Doniger, *supra* note 59, at 513.

65. Bioassay costs are reported to be approximately $1,000 per animal. Schwartzberger & Shindell, *Cancer and the Adjudicative Process: The Interface of Environmental Protection and Toxic Tort Law*, 14 AM. J.L. & MED., 1, 10 n.36 (1988). Thus, bioassay costs for a study involving 6 million mice would total approximately $6 billion.

66. Doniger, *supra* note 59, at 513 (citing Mantel & Schneiderman, *Estimating "Safe" Levels, a Hazardous Undertaking* 35 CANCER RES. 1379, 1383 (1975)). Many scientists have expressed serious doubts about the reliability of *any* conclusions based on the study of mice. *See, e.g.*, 45 Fed. Reg. 5085 (1980) ("doubts about the validity of the mouse liver tumor system are fairly widely held, and . . . several reports of scientific committees issued in the past two years have reflected the controversy"). *See also*, E. EFRON, *supra* note 60, at 245-46.

67. Doniger, *supra* note 59, at 513 (citing Cornfield, *Carcinogenic Risk Assessment*, 198 SCIENCE 693, 694 (1977)).

68. Latin, *Good Science, Bad Regulation, and Toxic Risk Assessment*, 5 YALE J. ON REG. 89, 92 (1988) (quoting Cothern, Coniglio & Marcus, *Estimating Risk to Human Health*, 20 ENVTL. SCI. & TECH. 111, 113-15 (1986)).

to be inadmissible" under Federal Rule of Evidence 403 and "an [un]acceptable predicate for [expert] opinion under Rule 703."[69]

b. Epidemiological studies. Similar uncertainties exist in other methods used to evaluate the toxicity of a substance. For example, epidemiological studies are often touted as the most reliable indicators of the effects of a substance on humans. However, these studies usually involve workers or others who experience high levels of exposure to the substance. Such studies generally require extrapolation from high-dose to low-dose exposure since the vast majority of the population is not exposed to the substance nearly as much as individuals from the study group. This again requires the use of mathematical models. "Unfortunately, neither current theory nor empirical evidence provides unambiguous support for any one model."[70] Moreover, it is often necessary to make assumptions about the level of exposure which the study group itself has experienced because most epidemiological studies are post-hoc evaluations of problems that have already occurred. Scientists differ considerably on what exposure levels should be assumed, as well as other factors critically affecting the results of the studies.[71]

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69. In re Agent Orange Prod. Liab. Litig., 611 F. Supp. 1223, 1241 (E.D.N.Y. 1985). *See also* Richardson v. Richardson-Merrell, Inc., 857 F.2d 823, 830 (D.C. Cir. 1988) (evidence of animal studies not a sufficient basis for opinion that Bendectin causes birth defects in humans); In re Paoli R.R. Yard PCB Litig., 706 F. Supp. 358, 368 (E.D. Pa. 1988) (animal studies not a proper basis for the diagnosis of the cause of a disease in humans). *But see* Wells v. Ortho Pharmaceutical Corp., 788 F.2d 741 (11th Cir.), *cert. denied*, 479 U.S. 950 (1986); Ferebee v. Chevron Chem. Co., 736 F.2d 1529 (D.C. Cir.), *cert. denied*, 469 U.S. 1062 (1984); Villari v. Terminix Int'l, Inc., 663 F. Supp. 727 (E.D. Pa. 1987).

Of course, even if such studies are not sufficiently reliable to serve as the basis for testimony establishing a causal connection between exposure to chemicals and injury to particular human beings in a traditional tort trial (an issue on which the courts are divided, as noted above), that does not mean that legislatures and administrative agencies cannot, or should not, rely on them in creating an appropriate regulatory response to those substances. Those involved in prospective policy-making choices may have greater leeway than those imposing specific liability for harms that have already occurred. *See*, In re Agent Orange Prod. Liab. Litig., 597 F. Supp. 740, 781-82 (E.D.N.Y. 1984), *aff'd*, 818 F.2d 145 (2d Cir. 1987); Schwartzberger & Shindell, *supra* note 65, at 15-21. However, the uncertainty is so great and the regulatory costs so high that even prospective regulators are often hesitant to act. *See infra* section III.B.

70. Haigh, Harrison, & Nichols, *Benefit-Cost Analysis of Environmental Regulation: Case Studies of Hazardous Air Pollutants*, 8 HARV. ENVT'L L. REV. 395, 422 (1984) [hereinafter *Benefit-Cost Analysis*].

71. *See, e.g., id.* at 424 (noting that estimates concerning the risk of exposure to benzene differed by more than a factor of ten even though based on the same raw data from three epidemiological studies). *See also* Doniger, *supra* note 59, at 511-12 (describing other limitations on the reliability of epidemiological studies).

2. *The effect of scientific uncertainty*

This high level of scientific uncertainty concerning the impact of a substance on humans renders regulatory decisions under a threshold-type statute subject to attack from both sides. On the one hand, industry is very willing to challenge a decision setting low exposure limits. Such attacks occasionally succeed. When the Consumer Products Safety Commission sought to ban urea-formaldehyde foam insulation in residences and schools, utilizing a computer risk assessment model to substantiate its findings, the Fifth Circuit struck down the regulation, concluding that it was not supported by substantial evidence.[72] The court held that a cancer risk assessment based largely on a single animal study involving exposure levels substantially higher than the anticipated human exposure could not meet even the deferential substantial evidence test.[73] Both the Occupational Safety and Health Administration and the EPA have also been rebuffed for basing regulations on assumptions rather than scientific data.[74]

On the other hand, the same scientific uncertainty renders regulatory findings susceptible to challenges from environmental

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The problem of scientific uncertainty in determining the effect of a substance on humans is magnified by disputes concerning the methods used for estimating actual levels of exposure. For example, the dispersion models EPA uses to estimate exposure to air pollutants have been criticized as unreliable because of uncertainties in determining 1) the relationship between ambient concentrations and emissions from individual sources, 2) dispersion patterns, and 3) how much time people spend outdoors. The models have also been criticized because of the lack of plant specific data on such determinative variables as stack height, exit velocity, gas temperature and local meteorological data. *See Benefit-Cost Analysis, supra* note 70, at 420-21.

72. Gulf S. Insulation v. United States Consumer Safety Prods. Comm'n, 701 F.2d 1137 (5th Cir. 1983).

73. *Id.* at 1146. The court explained that "it is not good science to rely on a single experiment, particularly one involving only 240 subjects, to make precise estimates. . . ." *Id.*

74. In Industrial Union Dep't v. American Petroleum Inst,, 448 U.S. 607 (1980), the Supreme Court invalidated OSHA's efforts to lower the standard for permissible benzene concentrations in work place ambient air because OSHA assumed that no level of exposure to benzene was safe unless industry proved otherwise.

The EPA learned a similar lesson when it promulgated a secondary ambient air standard for sulfur dioxide. When industry challenged the standard, the EPA hoped to prevail by relying on the rule of deference to agency expertise because it had little else to go on. The Court refused to give the EPA carte blanche, demanding at least *some* scientific evidence and vacating the proposed standard. *See* Kennecott Copper Corp. v. EPA, 462 F.2d 846 (D.C. Cir. 1972). Although sulfur dioxide was not being regulated as a hazardous substance, the EPA was thereby warned that the courts would not merely rubberstamp its conclusions concerning the effect of a substance on human health.

groups who think the permissible exposure levels are too high. Once a substance is listed as hazardous, it is very easy to argue that the "adequate margin of safety" is not being provided because, in the words of David Doniger, Senior Attorney for the Natural Resources Defense Council, the one "conclusion that may be drawn [from animal studies] . . . is that no level of exposure to [a] chemical [causing harm to animals] . . . is *sure* to be safe."[75]

The high level of scientific uncertainty thus invites litigation. Neither side is willing to concede much to the regulators because the perceived costs (both economic and health) are too high and because the standards are so difficult to change once they are set. Yet, the resulting litigation often benefits neither side in the long run. The litigation deprives industry of the certainty that is critical to future planning and environmentalists of the interim environmental benefits that would result from having *some* standard in place, even one less stringent than desired.[76] Accordingly, failure directly to address the problem of scientific uncertainty in the statute often produces the worst of both worlds.

The problems of scientific uncertainty are especially difficult for environmental regulators who deal with carcinogenic substances because "[c]urrent scientific knowledge does not permit a finding that there is a completely safe level of human exposure to carcinogenic agents."[77] That conclusion, though perhaps scientifically accurate, is legally unacceptable for a safety-threshold statutory scheme. As one environmental medicine specialist observed:

> When the conclusion is reached that, in some instances, there is probably no [safe] threshold, one has to acknowledge that some degree of danger exists. If there is, in fact, a finite risk at every conceivable dosage level of a chemical carcinogen, the traditional safety-factor approach simply will not work.[78]

The reason such an approach will not work when there is a finite risk at every conceivable level is that the only emission standard which would, *with certainty*, provide an "ample mar-

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75. Doniger, *supra* note 59, at 514 (emphasis added).

76. The vinyl chloride case provides a clear example of the latter. *See supra* text accompanying notes 37-40.

77. NRDC v. EPA, 824 F.2d 1146, 1147 (D.C. Cir. 1987).

78. Whipple, *supra* note 55, at 11 (comment by N. Nelson in panel discussion).

gin of safety" is one set at zero. Using a zero emission standard for suspected carcinogens under the Clean Air Act would result in the elimination of such activities as "the generation of electricity . . . [by] either coal-burning or nuclear energy; the manufacturing of steel; the mining, smelting, or refining of virtually any mineral . . . the manufacture of synthetic organic chemicals; and the refining, storage, or dispensing of any petroleum product."[79] Our actions indicate that we are not ready to accept such results. Yet, that is what the hazardous air pollution statutory scheme seems to demand.

The problem has only been exacerbated by scientific advances which have increased the ability to detect extremely small amounts of substances,[80] thereby greatly increasing the number of potential sources, the level of regulation, and the regulatory costs which accompany the decision to list a substance as hazardous. Facing the prospect of valid challenges from both sides, the EPA has often opted to do nothing. That decision is usually difficult to overturn in light of well established principles of deference to agency discretion and the high level of scientific uncertainty involved.[81]

Courts have occasionally provided some measure of relief to the agencies by liberally interpreting a statute to permit a more flexible approach than might be suggested by strict threshold-type language. For example, while precluding the EPA from considering economic and technological feasibility in determining what is a safe emissions level for a hazardous air pollutant under the Clean Air Act, the D.C. Circuit clarified that "safe" does not mean "risk-free" and that the EPA's finding need not be "free from uncertainty."[82] However, courts have not always been so flexible,[83] and even the added elbow room provided under the

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79. 44 Fed. Reg. 58,642, 58,660 (1979).

80. Scientific techniques can currently detect parts per trillion. *Hazardous Waste Contamination Hearing*, *supra* note 5, at 17. Scientists liken the existence of 1 part per trillion to "a unit train of tankcars, a mile and a half long, in which all the tankcars are loaded with gin, in which you dump a cupful of vermouth." *Id.*

81. *See supra* text accompanying notes 52-71.

82. NRDC v. EPA, 824 F.2d 1146, 1164 (D.C. Cir. 1987).

83. Indeed, four years prior to the D.C. Circuit's decision in *NRDC*, one commentator indicated that the courts were the last barriers to the elimination of the threshold approach: "[H]ealth effects thresholds do not exist for most pollutants. While most scientists agree on this and congressional committees have conceded that the health effects threshold is little more than a myth, the courts continue to insist upon a 'health only' approach that rests on the threshold assumption." R. MELNICK, REGULATION AND THE COURTS: THE CASE OF THE CLEAN AIR ACT 356 (1983).

hazardous air pollution portions of the Clean Air Act has not eliminated the problem, as evidenced by the continuing controversy and allegations of heel-dragging associated with the EPA's efforts to promulgate hazardous air pollutant standards for benzene.[84]

While added flexibility in the regulation of hazardous substances may make the regulator's task easier, large barriers to a completely effective hazardous pollution system will continue to exist as long as the present scientific uncertainty continues. Unfortunately, neither legislation nor public resolve can, by itself, eliminate that uncertainty.[85] However, legislation that expressly recognizes and takes into account the limits of current scientific knowledge will make the task more manageable.[86]

B. The High Cost of Regulating Hazardous Substances: Putting Our Money Where Our Mouth Is

A second reason for the less-than-stellar performance in regulating hazardous substances is the failure to accurately predict, or fully take into account, the enormous costs involved in achieving the goals Congress set. CERCLA provides a prime example of the difficulties in accurately predicting the cost of regulation at the time a statute is initially drafted. Prior to the passage of CERCLA in 1980, the Chemical Manufacturers Association reportedly estimated that it would cost approxi-

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84. Benzene was first identified as a hazardous air pollutant in 1977. 42 Fed. Reg. 29,332 (June 8, 1977). Initial emission standards were promulgated in 1984. 49 Fed. Reg. 23,498 (June 6, 1984). New proposed standards were developed following the *NRDC* vinyl chloride decision. Yet two years later, standards were still not in place. On April 5, 1988, Lee Thomas, then EPA Administrator, released a draft proposal on benzene standards. On July 28, 1988, the EPA proposed four approaches to benzene regulation. 53 Fed. Reg. 28,496 (1988). Four members of the Senate Environment and Public Works Committee attacked the proposal as "an extraordinary departure from public health principles." 19 Env't Rep. (BNA) 91 (May 27, 1988). The Natural Resources Defense Council also criticized the proposals. The EPA then sought extensions for final rule deadlines because it was awaiting the appointment of a new Administrator and was still analyzing the results of the public comments. 19 Env't Rep. (BNA) 1492 (Nov. 25, 1988). An extension to August 31, 1989 was granted. *Id.* The EPA announced its final regulations for some benzene emission sources on August 31, 1989, but predicted that it would be sued by both environmentalists and industry over risk assessment decisions it made in developing the regulations. 20 Env't Rep. (BNA) 789 (Sept. 8, 1989).

85. Indeed, some have concluded that issues concerning the existence of safety thresholds for hazardous substances are "trans-scientific"—that is "beyond the foreseeable ability of science to resolve." J. MENDELOFF, THE DILEMMA OF TOXIC SUBSTANCE REGULATION: HOW OVERREGULATION CAUSES UNDERREGULATION AT OSHA 13 (1988).

86. *See infra* sections IV.A. & IV.D.

mately $1 million to remedy a typical abandoned hazardous waste site.[87] By 1986, the average Superfund cleanup bill was $9 million. Estimates of average clean-up costs now reach $30 million to $40 million per site, and if groundwater problems are present, the cost may go as high as $300 to $600 million.[88] Similar underestimations have occurred in other hazardous pollution legislation as well.

Partly because of the failure to adequately anticipate the level of expense involved in regulating hazardous pollutants, some statutes, like the Clean Air Act, the 1972 version of the Clean Water Act, and, to some extent, even the more recently enacted CERCLA, seem to require that regulators completely ignore these costs in creating a program to deal with hazardous substances. Such a cost-oblivious approach may make sense when the expense involved is manageable and the benefits tangible. However, when those costs are extremely high and the resulting benefits somewhat speculative, or if more certain, relatively small, an administrator finds it very difficult to ignore them.

For example, the EPA has considered listing acrylonitrile, a feedstock for producing chemicals used to make rugs, clothing, plastic pipes, and automobile hoses, as a hazardous air pollutant. Extensive evidence suggests acrylonitrile is carcinogenic.[89] Using the best existing technology available to reduce acrylonitrile emissions would cost $29 million a year in 1982 dollars.[90] The resulting reduction in emissions would avoid an estimated one case of cancer every five years.[91]

While it may be preferable to list acrylonitrile as a hazardous air pollutant (since it has been linked to cancer to virtually the same extent as other regulated substances) and then consider economic costs and technological feasibility in deciding an adequate level of safety, the Clean Air Act prohibits such an approach. For example, when the Reagan Administration considered costs in establishing a safe level of vinyl chloride emissions, the D.C. Circuit rebuffed it, stating that in keeping with the lan-

87. *Hazardous Waste Disposal Hearing*, *supra* note 5, at 51.

88. *Superfund II: A New Mandate, A BNA Special Report*, 17 Env't Rep. (BNA) 121 (Fed. 13, 1987) [hereinafter *Superfund II*].

89. *Benefit-Cost Analysis*, *supra* note 70, at 410-411. However, as might be anticipated from a review of the preceding subsection, these findings are not free from doubt or controversy.

90. *Id.*

91. *Id.* at 411.

guage and structure of the Clean Air Act, the "determination must be based solely upon the risk to health. The Administrator cannot under any circumstances consider cost and technological feasibility at this stage of the analysis."[92] Although the court permitted the EPA to consider economic and technological feasibility factors in determining what constituted an "ample margin of safety *below* the safety level,"[93] when a hazardous substance designation effectively eliminates all cost consideration in deciding a safe exposure level, any regulating agency aware of the economic and social repercussions of shutting down an industry will be sorely tempted to reserve that designation for situations in which it is clear that such impacts are truly necessary. Given the scientific uncertainty that exists concerning the effect of hazardous substances, the result is a bias against regulation. As one EPA official admitted:

> [A] literal interpretation of [the hazardous air pollution provision] would not preclude open-ended control requirements or the possibility of zero emission goals, regardless of the control costs. Given this potential and the apparent lack of flexibility regarding the removal of substances from the list of hazardous pollutants or the exclusion of source categories from control requirements, *the Agency has . . . been reluctant to list pollutants as hazardous without some reasonable assurance that subsequent regulation would convey health benefits that are not grossly disproportionate to the costs of control.*[94]

A similar temptation must be felt by EPA officials charged with choosing the appropriate remedial action for superfund sites under section 121 of CERCLA.[95] Although the statute directs the EPA to evaluate the "cost effectiveness of the proposed alternative remedial actions" in making its determination,[96] the Conference Report makes it clear that Congress did not intend for such considerations to come into play until *after* the level of cleanup (which, like the hazardous air pollutant emission standard, determines the future level of human exposure to the substance) has been determined solely on the basis of health factors:

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92. NRDC v. EPA, 824 F.2d 1146, 1165 (D.C. Cir. 1987).

93. *Id.*

94. *Benefit-Costs Analysis*, *supra* note 70, at 403 (quoting D. Patrick, Air Toxics: Regulation & Research 3 (speech delivered April 6, 1982) (emphasis added)).

95. 42 U.S.C. § 9621 (Supp. V 1987).

96. *Id.* at § 9621(a).

> The term "cost-effective" means that in determining the appropriate level of cleanup the President[97] *first* determines the appropriate level of environmental and health protection to be achieved *and then* selects a cost-efficient means of achieving that goal. *Only after* the President determines, by the selection of applicable or relevant and appropriate requirements, that adequate protection of human health and the environment will be achieved, is it appropriate to consider cost effectiveness.[98]

Although agency officials in charge of selecting the appropriate remedial action under CERCLA do not have the same "do-nothing" option available to their colleagues who regulate hazardous air pollution,[99] there must still be some urge to alter the pure health findings used to determine the appropriate level of cleanup to reflect "impermissible" concerns over whether the additional cleanup is worth the effort, especially given the high price tag that will likely be attached to the project.[100] As noted in the previous subsection, the level of scientific uncertainty involved in determining the health impacts of a hazardous substance is so great that the regulating agency usually has great discretion with respect to such findings.

When not regulating is a viable option, as it is under the Clean Air Act, the end result of a scheme which imposes high regulatory costs but precludes consideration of those costs is, as one author observed, a system in which overregulation leads to underregulation.[101] The high cost of strictly regulating the few pollutants that are currently regulated causes the regulating agency to leave many substances unregulated. In much the same way that a nation which relies almost exclusively on nuclear weapons finds itself unable to deal effectively with anything less than all-out war, we have often found ourselves unable to respond to many aspects of the hazardous pollution problem because the potential economic effect of pulling the regulatory trigger is too devastating. Ironically, the incentive for underregulation only increases as it becomes more clear that the hazardous

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97. The President has delegated his authority under CERCLA to the EPA Administrator. *See* Exec. Order No. 12,580, 52 Fed. Reg. 2,923 (1987).

98. *Superfund II*, *supra* note 88, at 139-40 (reprinting Conference Report on SARA) (emphasis added).

99. Regulators implementing the Clean Air Act can simply choose not to list the pollutant as hazardous, thereby avoiding all regulation. *See supra* text accompanying note 94.

100. *See supra* text accompanying notes 87-88.

101. *See* J. MENDELOFF, *supra* note 85.

pollution problems are worse than we thought and the costs of resolving those problems higher than expected.

Even when the "no action" alternative is unavailable, as under CERCLA, failure to adequately predict or permit consideration of the costs involved can render the protection provided by the statutory scheme largely illusory and distort the priorities of the regulators.

The illusory nature of the protection granted to the public by CERCLA was made evident by J. Winston Porter, then head of EPA's Office of Solid Waste and Emergency Response, when he

> stated publicly that, despite the requirement [in the provisions of the 1986 Superfund Amendment and Reauthorization Act (SARA)] that cleanups be permanent wherever possible, the high cost of complete cleanups will result in many interim rather than permanent cleanups, and predicted there probably will never be adequate resources to clean up all the sites permanently.[102]

In other words, the 1986 legislation promised something it could not deliver because the cost was too high. The obvious danger of such illusory protection is that it can lull the public into thinking that the statute provides adequate protection (because it purports to require permanent solutions), when in reality it does not. The remedy's practical inadequacies may not be revealed until years later, creating a need for another dramatic statutory change to deal with problems ostensibly solved.

Failure to fund a hazardous pollution program adequately can also distort the regulator's priorities. Instead of focusing its efforts on determining which sites present the greatest health risks, the EPA may be tempted to look for CERCLA sites which involve financially-stable, responsible parties because that is one way to accomplish the most clean ups (in terms of quantity) with the least strain on the tight budget. The concern thus shifts from the greatest health threats to the sites which can be cleaned up with the least governmental expense.[103] The result is a

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102. *Superfund II*, *supra* note 88, at 121.

103. One observer has concluded that in the early years of CERCLA "the 'Superfund approach' that was followed . . . was based on the preference of EPA's top management for strict conservation of the $1.6 billion CERCLA trust fund." Mintz, *supra* note 25, at 729. Although Professor Mintz attributed the motivation for this approach to a desire to ensure that the Act not be renewed, a similar shift in priorities might develop even if the agency were trying to implement the program as fully as

scheme which purports to be cost-oblivious but is in fact cost-driven.

In short, by ignoring or failing to comprehend the high costs of regulating hazardous pollutants, we have too often created statutory schemes that cannot deliver as promised. Future regulatory schemes will be improved only when the costs involved are more openly considered.[104]

C. *Underestimating the Size of the Problem: The Tip of the Iceberg*

Underestimating the costs of regulating hazardous substances is related to the third reason why hazardous pollution regulation has been less than admirable—underestimating the scope of the problem itself. As already noted, early legislation seemed to reflect the belief that there were only a few hazardous substances and that these could be identified and controlled.[105] This led to the enactment of unrealistic goals. In 1972, Congress felt that all navigable waters could be made "fishable and swimmable" by 1983 and that the discharge of all pollutants (not just toxic ones) could be *completely* eliminated by 1985.[106] In retrospect, it is clear that this goal severely underestimated the scope of the problem, as well as the ability to correct it.

Nor did the policymakers' crystal ball become any clearer when they acted later. When Congress passed RCRA in 1976, the House reports boldly stated that the statute would "eliminate the last remaining loophole in environmental law."[107] Four years later, when Congress passed CERCLA, it was obvious that the comprehensive solution contained in RCRA completely ignored the massive problems created by inactive disposal sites.

Even those involved in the creation of CERCLA severely underestimated the problem with which that statute deals. In spite of a 1981 Government Accounting Office (GAO) report which "concluded that little was known about the adverse health and environmental effects of hazardous waste sites" and that "[n]ew sites were being discovered faster than they could be in-

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possible.

104. See *infra* section IV.A.

105. *See supra* text accompanying notes 52-54.

106. 33 U.S.C. § 1251(a)(1)-(2) (1982).

107. H.R. REP. No. 1491, HOUSE COMM. ON INTERSTATE AND FOREIGN COMMERCE, 94th Cong., 2d Sess. 4 (1976).

vestigated and evaluated,"[108] " 'the Administration thought Superfund would be a five-year program and that's all it would be.' "[109]

No aspect of environmental law more graphically illustrates this iceberg phenomenon better than CERCLA's recent history. Prior to the passage of CERCLA in 1980, the EPA estimated that there were 1,200 to 2,000 significant hazardous waste problem sites in the country.[110] One agency official stated that the EPA would focus its efforts on fewer than 1,000 sites if the bill passed.[111] By 1985, the GAO estimated that the number of sites could be as high as 4,000.[112] That same year, the Office of Technology Assessment stated that 10,000 sites might be discovered.[113] As of 1988, the EPA had conducted preliminary investigations at 24,000 sites and was adding approximately 2,000 sites per year to its list of sites to be studied.[114] A 1988 GAO report estimated that there were 425,380 sites in need of cleanup.[115]

The adverse effects of this dramatic underestimation of the scope of the problem on our ability to deal with hazardous substances are numerous. First, it soon becomes obvious that statutory deadlines and goals are unrealistic. Those goals then lose their importance because they are not taken seriously.[116] Second, the funding and staffing provided to the regulatory agency often prove to be woefully inadequate, thereby hindering enforcement of the scheme and achievement of the statutory goals.[117] Third,

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108. *Superfund II*, *supra* note 88, at 10 (citing *Hazardous Waste Sites Pose Investigation, Evaluation, Scientific, and Legal Problems*, CED-81-57, GAO, April 24, 1981).

109. *Id.* (quoting William N. Hedeman Jr., former director of the EPA's Office of Emergency and Remedial Response).

110. *Id.* at 9 (citing 11 Env't. Rep. (BNA) 75 (May 23, 1980)).

111. *Id.*

112. GOV'T ACCOUNTING OFFICE, CLEANING UP HAZARDOUS WASTES: AN OVERVIEW OF SUPERFUND REAUTHORIZATION ISSUES (March 1985).

113. OFFICE OF TECH. ASSESSMENT, SUPERFUND STRATEGY (April 1985).

114. 18 Env't Rep. (BNA) 2043 (Jan. 22, 1988).

115. *Id.*

116. A prime example of this problem is the enforcement of the primary national ambient air quality standards (naaqs) for carbon monoxide and ozone. The original statutory deadline for compliance with these standards was 1975. That deadline was extended in 1977 (two years after compliance was to have been achieved) until 1982, with a provision for further extension until 1987. When the 1987 deadline passed without compliance by a single major metropolitan area, Congress extended the deadline until 1988 to give it time to decide what to do. That deadline has now passed with no significant increase in the level of compliance or serious threat of implementation of all the remedies that were to attach to areas not in compliance with the original 1975 deadline.

117. During congressional deliberations of the Superfund Amendments and Reauthorization Act (SARA), EPA officials noted that funding slowdowns in prior years

the costs of achieving the regulatory goals increase, thereby exacerbating the impact noted in the prior section.[118] Fourth, frustration over the lack of progress escalates pressure to impose even more stringent and sometimes more unrealistic goals.[119] Finally, because the agency is often legislatively instructed to resolve *all* the *anticipated* problems, it is given no guidance on how to use its limited budget and resources when the problems are significantly greater than expected. The agency's discretion is thereby expanded, and the potential for abuse of that discretion is increased.[120]

Our inability fully to predict and comprehend the extent of the hazardous pollution problem has thus adversely affected our ability to deal with the problem in many ways. Merely acknowledging that our initial estimates may be too low will not solve those problems, but increased recognition of the limits of our knowledge will enable us to set more achievable goals and to create solutions which deal with the problems in a more realistic manner.

D. Failure To Understand the Intermedia Nature of the Problem: There Is No Hiding Place

A fourth reason why the current hazardous pollution regulation schemes have not worked as well as expected is the failure to recognize fully that hazardous pollutants affect all environmental media and that the problem cannot be resolved by simply removing the substances to a new venue. Early efforts to control hazardous substances focused on air and water purification. Filters, scrubbers, stacks, and other devices were used to screen the substances out before they reached these two environmental media. Unfortunately, this did not eliminate the hazard-

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would make it difficult if not impossible to comply with the statutory mandate that the agency start 375 cleanup actions within three years of SARA's enactment. *See Superfund II*, *supra* note 88, at 122.

118. *See supra* text accompanying notes 94-104.

119. In an effort to speed up progress in the regulation of hazardous air pollutants, some suggested in 1983 that Congress legislatively mandate the listing and regulation of 37 substances. *Hearing Before the Subcommittee on Oversight and Investigations of the House Committee on Energy and Commerce* 18 (Nov. 7, 1983) (statement of William Ruckelshaus). However, as William Ruckelshaus noted in response to the proposal "the reasons for such delay will not vanish if some list became law." *Id.*

120. Early CERCLA enforcement was apparently hampered by "sweetheart deals" being offered to some responsible parties based on criteria unrelated to safety and health. *See* Mintz, *supra* note 25, at 725 & n.123.

ous substances, it merely transferred them to a different environmental medium.

Thus, efforts to remove hazardous pollutants from one environmental medium often merely resulted in the creation of a new hazardous pollution problem, and a new regulatory response, for another medium.[121] For example, when the oil industry responded to the Clean Water Act's demands and built facilities to treat oily waste water resulting from the refining process, the industry soon discovered that the treatment process itself emitted volatile organic compounds into the air. The EPA then had to propose regulations to control those emissions under the Clean Air Act.[122]

Unfortunately, the oil refinery example is not the only one; indeed not even the most pervasive one. The hazardous substances filtered out of the air and water in the 1970s often ended up as solid and liquid wastes, which were then deposited in landfills. At one major petroleum refinery "fully [sixty] percent of all hazardous wastes come from required air and water pollution control devices."[123] Waste from air pollution and water pollution control devices, such as baghouse dusts and sludge, accounted for twenty-five percent of the receipts of one major commercial hazardous waste landfill in 1984.[124] Thus, in the words of a 1976 House Report, "the federal government is spending billions of dollars to remove pollutants from the air and water only to dispose of such pollutants on the land in an environmentally unsafe manner."[125]

Subsequent efforts to clean up the landfills have not fared much better. Even after CERCLA and RCRA were enacted, too often the chosen remedy merely created a new problem at a new site. The existence of a "toxic merry-go-round," under which RCRA sites that received wastes from Superfund sites later be-

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121. A few researchers recognized and publicized the problems posed by the intermedia nature of pollution early in the modern environmental era. *See, e.g.*, A. KNEESE, R. AYRES & R. D'ARGE, ECONOMICS AND THE ENVIRONMENT: A MATERIALS BALANCE APPROACH (1970). They warned that environmental pollution "cannot be properly dealt with by considering environmental media such as air and water in isolation," *id.* at 14, and expressed concerns over "environmental controls which strive to deal with one problem but innocently cause another," *id.* at 119. Unfortunately, such warnings were not fully heeded.

122. 52 Fed. Reg. 16,334 (1987).

123. OFFICE OF TECH. ASSESSMENT, SERIOUS REDUCTION OF HAZARDOUS WASTE 18 (Sept. 1986) [hereinafter SERIOUS REDUCTION OF HAZARDOUS WASTE].

124. *Id.*

125. H.R. REP. No. 1491, 94th Cong., 2d Sess. 4-5 (1976).

came Superfund sites themselves,[126] would be comical were it not so discouraging.[127]

Even the most recent legislative solution to the landfill problem, the proposed elimination of landfill disposal,[128] continues to utilize the "media shift" approach. New regulations implementing this landfill ban for some hazardous wastes require that the wastes be incinerated, thereby creating the need for a new set of regulations to protect air quality.[129]

Failure to treat the hazardous substances problem as an intermedia, universal problem has left us with the frustration of one punching a pillow: for every dent we make in the problem in one area, we seem to cause an equal bulge in some other area. Like the characters in Dr. Seuss' *The Cat in the Hat Comes Back*, we scramble desperately to get rid of the spot, only to spread it to other materials.[130]

Unfortunately, psychological frustration is not the only adverse effect of failing to comprehend the intermedia nature of hazardous substances. That failure has created an additional barrier to the effective regulation of hazardous pollution: the problem of having more than one governmental agency with jurisdiction over the same substance. For example, vinyl chloride is regulated by five different agencies working under fifteen different statutes.[131] Cadmium is regulated under at least nine different statutes,[132] tri-chloroethylene under eight.[133] Because of

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126. *Superfund II*, *supra* note 88, at 17.

127. It is now increasingly clear that the problem has not stopped with contamination of the land. The hazardous substances which we have repeatedly moved are now starting to reach the groundwater as well. This realization is especially sobering because groundwater may be the most difficult environmental media to clean and is certainly one of the most important. *See infra* section IV.C.

128. The Hazardous and Solid Waste Amendments of 1984, Pub. L. No. 98-616, § 201(j), 98 Stat. 3221, 3232 (1984).

129. *See* 40 C.F.R. §§ 264.340-.351 (1988).

130. D. SEUSS, THE CAT IN THE HAT COMES BACK (1958). The cat in the story cleans up a pink bath tub ring by using a white dress, which is then stained with the pink material. The spot on the dress is eliminated by hitting the dress against the wall. The resulting spot on the wall is cleaned off with shoes. The spot continues to be moved from article to article until it is all over the yard, at which time "little cat Z" magically cleans up the entire mess. Unfortunately, we have not discovered the scientific analogue for "little cat Z" in the hazardous pollution arena.

131. Doniger, *supra* note 59, at 503-04.

132. SERIOUS REDUCTION OF HAZARDOUS WASTE, *supra* note 123, at 134.

133. *Id.* at 139.

significant differences in the authorizing legislation, it is sometimes impossible for the agencies to coordinate their efforts.[134]

Failure to view hazardous substances as a universal, intermedia problem which cannot be solved by shifting the substances around has prevented us from adopting an effective comprehensive solution to that problem. Increased recognition of this fact will permit us to improve future hazardous pollution regulatory schemes.

IV. WHERE DO WE GO FROM HERE: THE FUTURE OF HAZARDOUS SUBSTANCES REGULATION

The above discussion may leave the impression that nothing has been accomplished in the hazardous pollution regulatory area over the last twenty years or that we are doomed to failure in the future. The situation is not that bleak. Much has been accomplished, and the level of sophistication concerning hazardous pollution regulation has increased greatly over the last twenty years. However, there are lessons to be learned from our past experiences, lessons which could prove valuable in structuring the course of future hazardous pollution regulation. Because there is increasing recognition of the problems discussed above, there is some basis for forecasting a few of the positive changes that can and probably will be made in the near future as policymakers respond to those problems.[135]

A. Cost Consideration: Addressing the Unmentionable

An increased understanding of the high level of scientific uncertainty and an enhanced awareness of the enormous cost of

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134. As David Doniger has observed: the "EPA is required to balance risks and benefits [in regulating vinyl chloride in plastic pipe], but FDA is permitted to consider only health factors. Action that is required under one statute is illegal under the other." Doniger, *supra* note 59, at 651. Doniger also noted that

> [a]erosol products provide [another] example of the same problem in an area of abutting jurisdiction. . . . [M]uch may turn on whether a substance is classified a household product or a pesticide. For the former, CPSC [the Consumer Protection Safety Commission] is to consider only health factors; for the latter, EPA must balance risks and benefits. Again, the agencies have no statutory guidance as to which rule should govern those products near the jurisdictional line.

Id.

135. No specific legislative proposals are presented in this article. Instead, broader trends, which will in turn shape the more specific changes, are noted. As with all trends, there will be exceptions, as well as holdovers from the prior system.

regulation and scope of the hazardous pollution problem, will lead, almost inexorably, to more wide-spread acceptance of cost consideration in hazardous pollution regulatory schemes. As the public and Congress come to realize that billions of dollars are being spent[136] without any assurance that the right substances are being regulated in the right way, the question will increasingly be asked, is it worth it? Twenty years ago that question was unspeakable, if not unthinkable. During the Senate debate over the Clean Water Act in 1972, Senator Muskie captured the "control at any cost" feeling of the time when he asked, "Can we afford clean water?" and then answered, "Th[is] question deserve[s] no answer[] as we move to restore and renew [it]."[137] Now that billions of dollars have been spent attempting to achieve the goal of clean water with somewhat mixed results, the idea that costs must be considered, at least to some degree, in the regulatory formula is being accepted.

This is not to suggest that all decisions will or ought to be reduced to a cost-benefit equation. There are many values which are not adequately represented in a cost-benefit scheme.[138] These factors will still have to be taken into account in crafting regulatory responses. To ignore those factors would be every bit as grave an error as to ignore costs. Policymakers will need to debate and decide how to weigh human health and life, and other non-monetary benefits, and make other difficult decisions, before any kind of cost-benefit analysis can be utilized on a large scale. However, the present reluctance to discuss these issues, as reflected by cost-oblivious statutes, often leads to decisions on such important issues without any discussion or concrete information.[139] Society must, at a minimum, be willing to openly ac-

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136. One estimate put the national cost of environmental protection and compliance at well over $70 billion per year. SERIOUS REDUCTION OF HAZARDOUS WASTE, *supra* note 123, at 8. *See also* Biden, *A New Direction for Environmental Policy: Hazardous Waste Prevention, Not Disposal*, 17 Envtl. L. Rep. (Envtl. L. Inst.) 10,400, 10,400 (1987).

137. 1 LEGISLATIVE HISTORY OF THE WATER POLLUTION CONTROL ACT AMENDMENTS OF 1972, S. Rep. No. 1, 93d Cong., 1st Sess. 164 (1973).

138. *See* Baram, *Cost-Benefit Analysis: An Inadequate Basis for Health, Safety, and Environmental Regulatory Decisionmaking*, 8 ECOLOGY L.Q. 473, 480-92 (1980) (cost-benefit inadequately considers aesthetics, ecological change, human mortality, future social costs and benefits, and distribution of costs and benefits); Rodgers, *Benefits, Costs, and Risks: Oversight of Health and Environmental Decisionmaking*, 4 HARV. ENVTL. L. REV. 191, 194-95 (1980) ("many things, indeed, many of those we hold most dear, are not readily susceptible to valuation in [monetary] terms," noting as examples endangered species and wilderness areas).

139. Agencies have on their own already placed dollar values on human life, values

knowledge that regulations involve costs, both direct economic costs of compliance, as well as other less-direct, less-economic costs, such as adverse effects on "community stability, employment, natural resources, or the integrity of the ecosystem."[140]

Evidence that the trend toward more explicit use of cost-benefit or similar analyses has already started and will continue is abundant. The original toxic pollution control provisions of the Clean Water Act were amended in 1977 to give the EPA discretion to promulgate toxic effluent limitations based on the best available technology economically achievable, instead of toxic effluent standards, which are based solely on non-economic considerations.[141] President Reagan's executive order mandating cost-benefit review of all environmental regulations to the extent permitted by law was a further step toward increased acceptance of cost-benefit analysis.[142] Although a provision in the 1986 amendments to CERCLA (SARA) mandating cost-effectiveness review of all potential Superfund remedial actions does not completely incorporate cost-benefit analysis into the CERCLA scheme,[143] it does demonstrate an increased awareness of the need to take costs into account, even when highly toxic substances are involved. Even President Bush's recent proposal for amendment of the hazardous air pollutant provisions of the Clean Air Act moves one step away from the cost-oblivious scheme utilized under the present statute by calling for emission standards based on maximum achievable control technology.[144] While such standards do not require a formal cost-benefit analysis, the Administration would be required to take "into consideration the cost of achieving such emission reduction" under the new Act.[145] This trend is likely to continue as policymakers realize that failure to even consider costs has created the illusion that the problem of hazardous pollution is being adequately dealt with when it is not.

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which vary greatly from agency to agency. Shodell, *Risky Business*, SCIENCE, Oct. 1985, 43, 46-47 ("OSHA, for instance, has used a value of $3.5 million, and EPA estimates have ranged between $400,000 and $7 million per life.").

140. Ruckelshaus, *Risk in a Free Society*, 14 Envtl. L. Rep. (Envtl. L. Inst.) 10190, 10193 (1984).

141. Pub. L. No. 95-217, § 53(a)-(b), 54(a), 91 Stat. 1589-1591 (1977), *codified at* 33 U.S.C. § 1317(a)(2) (1982).

142. Exec. Order No. 12,291; 46 Fed. Reg. 13,193 (1981).

143. *See supra* text accompanying notes 95-98.

144. Clean Air Amendment Acts of 1989, § 301.

145. *Id.*

One of the main barriers to further development along these lines is a reluctance to admit that hazardous pollution problems cannot be solved painlessly by outlawing the pollution. Too often Congress has opted to enact schemes which are designed more to sound the trumpet than to win the war.[146] Such "symbolic" statutes are politically popular, but practically unrealistic. By our actions, or lack of action, in implementing present statutory schemes, we have implicitly indicated that we are unwilling to shut down entire industries or dramatically change our lifestyles if that is the required price for regulating hazardous pollution. However, the issue has never been directly faced because the current hazardous pollution scheme forbids such direct considerations. An explicit discussion of the costs and benefits of hazardous substances regulation, as well as of the range of risks involved, will at a minimum provide some basis for a more full and fair debate about what society is willing to do.

Contrary to what may appear to be the case at first glance, increased sensitivity to cost consideration will not necessarily result in less regulation. Americans may well be willing to trade economic benefits for environmental ones.[147] Moreover, open discussion of such matters may, in the long run, result in stricter control of hazardous pollutants in some situations. If the public or policymakers expressly determine that the environmental benefits outweigh the regulatory costs, regulators equipped with such a mandate may be more willing to deal harshly with violators than they currently are when the decision to regulate is based on inadequate information which has not received explicit public approval.

As the public becomes increasingly aware that science cannot definitively quantify the health hazards posed by various substances, and forthrightly admits that it is unwilling to shut down entire industries when the risks are uncertain, cost-benefit analysis will play an increasingly important role in the regulation of hazardous pollutants.

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146. This is perhaps symptomatic of larger problems with our legal system and culture, problems which Derek Bok asserts lead "officials to exaggerate the law's capacity to produce social change while underestimating the cost of establishing rules that can be enforced effectively throughout the society." Bok, *A Flawed System of Law Practice and Training*, 33 J. LEGAL EDUC. 570, 577 (1983).

147. Sixty-four percent of Americans indicated in a recent poll that they "[w]ould . . . be willing to pay higher state and local taxes to fund cleanup in [their local] area." Magnuson, *supra* note 6, at 77.

B. Waste Reduction: Nipping the Problem in the Bud

1. Hazardous waste reduction programs

The second trend likely to emerge as some of the obstacles outlined above are recognized is increased emphasis on programs to reduce the amount of hazardous pollutants we produce. Hazardous waste reduction programs are a logical reaction to our increased awareness of both the high cost of regulating hazardous pollutants and the intermedia aspect of those pollutants because waste reduction programs promise some relief from both these problems.[148]

In many instances hazardous waste reduction programs are much less expensive than the end-of-the pipe pollution control system on which we currently rely.[149] Waste reduction can be achieved through a number of different methods such as in-process recycling of wastes,[150] changes in technology and equipment,[151] more efficient management of plant operations and pro-

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148. It is important to distinguish true waste *reduction* programs from waste *minimization* programs. The latter includes the former, but it often is used to include waste *treatment*. As the EPA has noted, "[i]n the broadest sense, the HSWA defines waste minimization as any action taken to reduce the volume or [quantity and] toxicity of wastes. That definition includes the concept of waste treatment, which encompasses such technologies as incineration, chemical detoxification, biological treatments, and others." MINIMIZATION OF HAZARDOUS WASTE, *supra* note 58, at ii-iv.

The distinction is important because some forms of waste *minimization*, such as incineration, do little to resolve the intermedia problem of hazardous pollution. Moreover, some forms of minimization, such as concentrating the waste stream to reduce the volume of waste, may result in an increased health risk because it makes the waste stream more hazardous and disposal more difficult. *See* Hahn, *An Evaluation of Options for Reducing Hazardous Waste*, 12 HARV. ENVT'L L. REV. 201, 219 n.58 (1988). Although waste minimization is also likely to play an increasing role in hazardous pollution regulation, the discussion in this section is limited to the more narrow concept of waste reduction, *i.e.*, reducing the actual amount of hazardous pollutants produced.

149. Researchers at Resources for the Future, Inc., highlighted the economic and environmental benefits of waste reduction programs early in the modern environmental era. *See* A. KNEESE, R. AYRES, & R. D'ARGE, *supra* note 121.

150. The recycled wastes can be used for energy recovery, as feedstock in the production of another product, or in the same production process. *See* MINIMIZATION OF HAZARDOUS WASTES, *supra* note 58, at A-73. Moreover, not only can the hazardous substances themselves be reused through recycling, thereby reducing the amount of waste produced by an operation, some recycling can also prevent the waste from ever being created. A Du Pont plant making Freon eliminated hydrochloric acid waste by installing a unit to change anhydrous hydrogen chloride into chlorine, which is recycled back into the process, and hydrogen, which is used as a fuel in the plant. SERIOUS REDUCTION OF HAZARDOUS WASTE, *supra* note 123, at 78.

151. One example of changes in process technology and equipment is the Hill Air Force Base experience cited below. *See infra* text accompanying note 158. There are, of course, others. *See*, SERIOUS REDUCTION OF HAZARDOUS WASTE, *supra* note 123, at 79-80.

duction methods,[152] changes in raw materials,[153] and the use of different end products.[154] Each of these changes can, under proper circumstances, result in cost savings in the production processes themselves.[155] In addition, by reducing the amount of hazardous waste, all these changes reduce the costs of storing, treating, transporting, or otherwise disposing of the wastes. Hazardous waste reduction also results in costs savings from "pollution control facilities that [do] not have to be built; . . . reduced pollution control operating costs; . . . and retained sales of products that might have been taken off the market as environmentally unacceptable."[156]

Concrete examples demonstrate that cost savings from waste reduction programs can be dramatic. By recycling 2.6 million pounds of methylene chloride per year, one pharmaceutical manufacturer saved twenty-four cents per pound in raw materials and thirty-five cents per pound in incineration costs.[157] Similarly, by using a sandblasting process instead of the conventional solvent method for stripping paint from aircraft, Hill Air Force Base in Utah reduced its waste management costs (including transportation and wastewater treatment) from $2,452 to $32 per plane. The new process also reduced raw materials costs for each plane from $5,422 to $346 and created an energy savings of

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152. Unnecessary hazardous waste generation can be reduced by the implementation of such "good housekeeping practices" as employee training, management initiatives, inventory control, waste stream segregation, spill and leak prevention, and preventive maintenance. *See* MINIMIZATION OF HAZARDOUS WASTE, *supra* note 58, at 49. These changes are often very simple. Standayne Co.'s metal plating operation reduced waste by introducing a pause into the machine that moves parts in and out of tanks, thereby allowing dragout solution to drip back into the process tank rather than pollute the rinsing tank. SERIOUS REDUCTION OF HAZARDOUS WASTE, *supra* note 123, at 81.

153. For example, water can replace organic solvents for degreasing applications, *see* SERIOUS REDUCTION OF HAZARDOUS WASTE, *supra* note 123, at 82, or less toxic chemicals can be used in place of chromate corrosion inhibitors in cooling towers, *see*, MINIMIZATION OF HAZARDOUS WASTES, *supra* note 58, at 47.

154. *See* MINIMIZATION OF HAZARDOUS WASTE, *supra* note 58, at 49 ("substitution of concrete pilings for creosote-treated timbers eliminates wastes from the manufacture of the creosote-treated pilings").

155. Of course, such changes can also increase production costs while only minimally reducing hazardous wastes. *See id.* at 47. ("Raw materials that are directly synthesized . . . into a product can be purified prior to processing to reduce waste generation but, . . . the use of a more costly, purer, propylene feed in the synthesis of acrylonitrile does not result in an appreciable decrease in the volume of waste that is generated").

156. SERIOUS REDUCTION OF HAZARDOUS WASTE, *supra* note 123, at 7 (quoting M.D. Koenigsberger, 3M, paper presented at Governor's Conference on Pollution Prevention Pays, Nashville, Tenn., March 1986).

157. SERIOUS REDUCTION OF HAZARDOUS WASTE, *supra* note 123, at 87.

$96 per plane.[158] Although such anecdotal evidence cannot serve as the sole basis for any definitive conclusion as to the cost effectiveness of waste reduction in all industries,[159] there is a general consensus that waste reduction will usually be the least expensive hazardous pollution control system.[160]

Hazardous waste reduction also effectively deals with the intermedia problem of hazardous substances pollution by eliminating the need to search for a suitable resting place for those substances. Again, specific examples demonstrate the enormous reductions that can be achieved. The paint stripping process adopted at Hill Air Force Base not only resulted in cost savings, it also completely eliminated the 200,000 gallons of wastewater per plane produced by the conventional method and reduced the amount of hazardous solid waste produced from 9,767 to 320 pounds per plane.[161] The 3M Company recently reported that the use of 1,900 waste reduction programs resulted in "eliminating *annually* the discharge of almost 110,000 tons of air pollutants, over 13,000 tons of water pollutants, and over 260,000 tons of sludge of which over 18,000 tons are hazardous—along with the prevention of approximately 1.6 billion gallons of wastewater."[162] The Office of Technology Assessment has observed that the possibility of eliminating the cross-media transfer of

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158. *Id.* at 80. The new process did require an initial capital investment of $647,389 for a stripping hangar, but the investment was recovered in just over 1 month of operation cost savings. *Id.*

159. As the Office of Technology Assessment has observed:

> Optimism about future potential does not mean that every waste generator can immediately reduce its waste generation. In some cases, R[esearch] & D[evelopment] may first be necessary in order for economic benefits to be attained at specific plants. Some industries have less potential for waste reduction than others, either because of the age or type of their production processes, because of past reduction efforts, or because of variable capacity to innovate related to corporate styles, cultures, and strategies.

OFFICE OF TECH. ASSESSMENT, FROM POLLUTION TO PREVENTION 16 (June, 1987) [hereinafter FROM POLLUTION TO PREVENTION].

160. *See id.* at 1, 42; SERIOUS REDUCTION OF HAZARDOUS WASTE, *supra* note 123, at 3, 100-02; MINIMIZATION OF HAZARDOUS WASTES, *supra* note 58, at 15-26.

161. SERIOUS REDUCTION OF HAZARDOUS WASTE, *supra* note 123, at 80. The hazardous solid waste produced by the conventional method was in the form of sludge. That produced by the new method is dry waste.

162. *Id.* at 7 (quoting M.D. Koenigsberger, 3M, paper presented at Governor's Conference on Pollution Prevention Pays, Nashville, Tenn., March 1986). The 3M company estimated that adoption of the various programs resulted in a total cost savings of more than $292 million. *Id.*

hazardous pollution "is an important reason for giving primacy to waste reduction."[163]

Thus, hazardous waste reduction is an especially likely and promising trend because it represents "an opportunity for public policy to combine the environmentalism of the 1960s with the economic sensibilities of the 1980s."[164]

2. *Federal and state trends toward waste reduction*

Given the potential benefits of hazardous waste reduction schemes, it is not surprising that there is already some movement at both the federal and state levels toward replacing pollution control with waste reduction as the primary tool of hazardous pollution regulation. The 1984 amendments to RCRA created a voluntary waste reduction certification program for hazardous waste generators.[165] That program is more symbolic than substantive, however, because the generator has to certify only that a waste reduction program is in place which the *generator* believes is "economically practicable."[166] However, some states have gone a step further. For example, California requires that generators of wastes deemed recyclable either recycle those wastes or submit a formal, complete and detailed statement explaining why it did not do so.[167] By 1986, seven states had enacted recycling exemptions or variances to regulation schemes and land disposal restrictions in order to encourage waste reduction rather than waste disposal.[168] Other states have enacted large hazardous waste taxes or fees for the same purpose.[169] Several states have also adopted technical and informational assis-

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163. *Id.* at 18.

164. FROM POLLUTION TO PREVENTION, *supra* note 159, at 8. Senator Joseph Biden has observed that "[r]eduction of all wastes cuts the expense of environmental compliance to industry, lowers enforcement costs for government, and provides a more permanent level of protection for the public." Biden, *supra* note 136, at 10400. One congressional staff member noted that waste reduction programs have so many potential benefits that they are "[l]ike mom and apple pie." 19 Env't Rep. (BNA) 36 (May 13, 1988).

165. 42 U.S.C. § 6922 (Supp V 1987).

166. 42 U.S.C. § 6922(b)(1) (Supp. V 1987). Further action at the federal level is likely. The EPA has drafted a "Pollution Prevention and Recycling Act" that would, among other things, establish an office of pollution and allow companies to avoid some permit requirements if the waiver results in a reduction of overall, cross media discharges of hazardous waste. 20 Env't Rep. (BNA) 823 (Sept. 15, 1989).

167. CAL. HEALTH & SAFETY CODE § 25,175 (Deering 1988).

168. MINIMIZATION OF HAZARDOUS WASTES, *supra*, note 58, at 61.

169. FROM POLLUTION TO PREVENTION, *supra* note 159, at 52-54.

tance plans, as well as loan programs, to facilitate individual plant waste reduction programs.[170] Although mandatory waste reduction is generally disfavored at this time,[171] even that may be adopted if other methods fail to provide sufficient impetus for waste reduction.

As society more fully realizes that there is no safe place to store hazardous pollutants, it seems inevitable that more and more governmental regulatory efforts will be designed to encourage hazardous waste reduction rather than to control hazardous pollution after it is created. Garrett Hardin's prediction concerning the contents of a future museum of antiquities may yet come to pass:

> Inside there will be thousands of old and often puzzling objects, including corset stays, bed-warmers, hurricane lamps, hourglasses, Persian wells, muzzle-loaders, torture racks, Iron Maidens, and chastity belts. Outside, in a courtyard, visitors will encounter a carefully reassembled tapered tube of bricks, seventy-five feet high. Out of the top of this there will come a plume of steam, to which a harmless, decomposable black dye has been added to make it look like industrial smoke. Busloads of schoolchildren will be brought from great distance to view this incredible object. On its base there will be a large bronze plaque:
>
> Smokestack
>
> Quaint device used by our pre-ecologic ancestors, in the superstitious belief that there was an "away" to throw things to.[172]

C. Groundwater: The Last Frontier

Our growing understanding of the intermedia nature of the hazardous pollution problem will, in all likelihood, lead to a third trend in the future course of hazardous pollution regulation—increased efforts to protect the one environmental medium which, until recently, has largely escaped the regulatory protective net—groundwater.

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170. *Id.* at 63-65.

171. "Both [EPA and OTA] reports recognize that a traditional regulatory approach to, in some way, prescribe industrial waste reduction is not now practical or feasible." *Id.* at 19.

172. G. HARDIN, EXPLORING NEW ETHICS FOR SURVIVAL: THE VOYAGE OF THE SPACESHIP BEAGLE 20-21 (1972).

In part because groundwater was unseen and assumed to be protected from man's activities by layers of geologic material, it has historically been viewed as pristine and immune from major pollution problems. Thus, it is not surprising that groundwater contamination has historically received much less attention than the more visible surface water problems.[173] Currently, there is no comprehensive federal policy for dealing with groundwater pollution.[174] Activity at the state level is increasing dramatically, but is still inadequate in most states. Yet, it is becoming increasingly clear that efforts to remove hazardous pollutants from other media are resulting in significant harm to this most important resource, harm that cannot be allowed to continue without disturbing current lifestyles.

Groundwater is, in many areas, the prime source of water for domestic uses. It is currently the source of about fifty percent of the drinking water in the United States.[175] In some areas of the country, groundwater withdrawals constitute seventy-five percent of the public water supplies.[176] Some major metropolitan areas are almost completely dependant on groundwater for survival.[177] Thus, even though most studies estimate that only one to two percent of the nation's groundwater is contaminated, the problem is larger than those estimates might imply because the "contamination is often near heavily populated areas and groundwater is being increasingly relied on for a variety of uses."[178] Moreover, because no systematic inventory of the na-

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173. OFFICE OF TECH. ASSESSMENT, PROTECTING THE NATION'S GROUNDWATER FROM CONTAMINATION 20 (1984) [hereinafter PROTECTING THE NATION'S GROUNDWATER].

174. The EPA Office of Ground-Water Protection was formed in 1984 to coordinate all EPA groundwater activities. EPA, A GROUNDWATER PROTECTION STRATEGY FOR EPA (1984) [hereinafter PROTECTION STRATEGY]. However, as the Office of Technology Assessment noted in 1986, "[p]rotection of groundwater is not covered comprehensively by any one Federal law; nor is one Federal agency or office responsible for overseeing or coordinating all groundwater programs and activities." PROTECTING THE NATION'S GROUNDWATER, *supra* note 173, at 64. Moreover, as of June 12, 1987, the EPA had 270 programs and activities that involved the protection of groundwater. 18 Env't Rep. (BNA) 586 (June 12, 1987). At least in part because of this fractured approach to groundwater protection, the National Water Alliance recently urged the Bush administration to develop a comprehensive groundwater policy. 19 Env't Rep. (BNA) 2604-05 (April, 14, 1989).

175. PROTECTING THE NATION'S GROUNDWATER, *supra* note 173, at 19.

176. *Id.*

177. Aquifers in the following states recently have been designated by the EPA as sole sources of drinking water under the Safe Drinking Water Act Amendments of 1986: Arizona, California, Idaho, Indiana, Louisiana, Maine, Mississippi, Montana, New Jersey, New York, Ohio, Rhode Island, Texas, and Washington. For a listing of specific citations for each state, see 19 Env't Rep. (BNA) Annual Index Summary at 3 (1989).

178. PROTECTING THE NATION'S GROUNDWATER, *supra* note 173, at 21.

tion's groundwater has been performed, most of the estimates are likely to be unrealistically low,[179] especially in light of past inadequate estimates of the size of hazardous waste problems in media more visible than ground water.[180]

It is becoming increasingly clear that past hazardous pollution regulatory activities have imperiled this critical resource. Serious toxic chemical groundwater contamination problems from landfills, surface impoundments, and waste piles have been identified in at least thirty-four states.[181] Another significant source of toxic groundwater contamination is leaking underground tanks.[182] Many of these tanks were constructed pursuant to state and local laws requiring underground storage of toxic chemicals to guard against fire and explosion.[183] Some groundwater contamination is the result of misdirected efforts to directly inject hazardous wastes into the earth for long term storage.[184] Even the clean-up of hazardous groundwater pollution

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179. As the Office of Technology Assessment observed:

> Descriptions of groundwater quality problems often include anecdotal or noncomparable data, making them difficult to interpret and analyze. In addition, much of the current information on the extent and magnitude of contamination reflects only the nature of the investigations—where and which substances have been looked for and where they have been found. For example, groundwater that is not used for public drinking water supplies is not always tested. . . . Further, substances known to contaminate groundwater are used throughout society; thus, more widespread detection of contamination can be expected as efforts increase to monitor known, as yet undetected, and potential problems.

Id. at 21.

180. *See supra* text accompanying notes 105-15.

181. PROTECTING THE NATION'S GROUNDWATER, *supra* note 173, at 21 (citing COUNCIL ON ENVIRONMENTAL QUALITY—1981: THE TWELFTH ANNUAL REPORT). Health harm from toxic chemicals in groundwater can occur in a number of ways. "[F]ive possible pathways of human exposure have been identified:

1. direct ingestion through drinking;
2. inhalation of contaminants (e.g., during showering);
3. skin absorption from water;
4. ingestion of contaminated food; and
5. skin absorption from contaminated soil."

Id. at 32.

182. Harris, *Leaking Underground Storage Tanks—The New Federal Requirements Amendments to RCRA of 1985*, 1985 PRAC. L. INST. 77, 79-80 (August).

183. In the mid-1970s, IBM's San Jose operations stored toxic chemicals in underground storage areas to comply with state and local safety laws. In the early 1980s, leaks resulting in contamination of nearby drinking water wells were discovered. *Hazardous Waste Contamination Hearing*, *supra* note 5, at 82-84. As of 1985, IBM had spent more than $25 million to monitor and clean up the groundwater. *Id.* at 85.

184. PROTECTING THE NATION'S GROUNDWATER, *supra* note 173, at 45.

problems has caused further groundwater contamination.[185] Although hazardous groundwater contamination stems from many sources other than failed storage, disposal and clean-up efforts, twelve of the thirty-three sources of groundwater contamination identified by the Office of Technology Assessment involve the storage, treatment or disposal of hazardous substances.[186] As sensitivity to the intermedia nature of the hazardous pollution problem increases, so will efforts to protect the groundwater resource which too often serves as the final repository for hazardous residue.

Heightened activity in protecting groundwater from hazardous pollution will also be spurred by increased cost sensitivity because groundwater clean-up is generally more expensive than remedial actions in other media. The restoration of contaminated groundwater is often the most expensive and complex part of a Superfund cleanup.[187] The need to permanently remedy hazardous groundwater contamination can escalate clean-up costs from $30 million to as much as $300 million per site.[188] In most instances, preventing the problem from occurring initially will be much more cost-effective.

Once again, there is substantial evidence that this forecasted trend has already begun and will continue in the future. The EPA has attempted to coordinate its groundwater protection efforts by formulating a groundwater resource management plan,[189] and federal groundwater legislation has been proposed over the past few years.[190]

However, a uniform *national* approach to the problem is unlikely in the near future because "[e]fforts to detect, correct,

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185. When Trichloromethane (TCA) leaked from an underground storage tank and contaminated drinking water wells in Santa Clara County, California, the contaminated water was pumped into storm drains in an effort to clean up the well. The storm drainage emptied into a storm drain with a concrete bottom and dirt sides. Officials later determined that the contaminated storm drain water was seeping back underground, where it contaminated the well field of a different water company. *Hazardous Waste Contamination Hearing*, *supra*, note 5, at 8.

186. PROTECTING THE NATION'S GROUNDWATER, *supra*, note 173, at 45. Two of the six main categories of groundwater contamination identified by OTA were "[s]ources designed to discharge substances" and "[s]ources designed to store, treat, and/or dispose of substances; discharge through unplanned release." *Id.*

187. *Superfund II*, *supra*, note 88, at 121.

188. *Id.*

189. PROTECTION STRATEGY, *supra* note 174.

190. *See, e.g.*, H.R. 791, 100th Cong., 2d Sess. (1988), The Ground Water Research, Management, and Education Act of 1988; S. 1419, 100th Cong., 1st Sess. (1987), The Ground Water Safety Act of 1987.

and prevent contamination must be tailored to the full range of conditions found at any site, including sources, contaminants, and users."[191] Thus, the future will probably reveal more groundwater protection activity at the state and local level than at the national level. State legislation focusing exclusively on groundwater quality is already in place in several states including Arizona,[192] California,[193] Florida,[194] Wisconsin,[195] and Nebraska.[196] Some of these efforts will have an enormous impact on the development of environmental law, as well as the day-to-day lifestyle of the public. However, as society recognizes that there is no safe harbor for hazardous pollutants, not even underground harbors, and that eliminating hazardous substances from groundwater is neither simple nor inexpensive, governmental efforts to protect the integrity of our groundwater supply will continue to escalate.

D. Renewed Federalism: The Shift from Big Brother to Little Brother

As noted above, much of the regulatory activity in both the waste reduction and groundwater protection areas has shifted to the states. A trend toward a less-centralized approach to hazardous pollution regulation can be seen in other areas as well. For example, in the 1987 amendments to the Clean Water Act, Congress for the first time authorized federal regulation of non-point source pollution,[197] one of the major unregulated sources of hazardous water pollution. However, rather than impose a federally-crafted regulatory scheme, Congress called upon the states to formulate non-point source management plans.[198] A similar system was set up for devising the means to combat toxic "hot-spots"—waters expected to remain contaminated by toxic pollutants even after federal standards are met.[199] While such shared responsibility has been used in major federal environmental statutes regulating *non-hazardous* pollutants for years,[200] Con-

191. PROTECTING THE NATION'S GROUNDWATER, *supra* note 173, at 11.
192. ARIZ. REV. STAT. ANN. §§ 49-201 to 49-381 (1988 & Supp. 1989).
193. CAL. WATER CODE §§ 2100-2102 (Deering 1977).
194. FLA. STAT. ANN. §§ 403.063, 403.1659 (West 1986).
195. WIS. STAT. ANN. §§ 160.001 to 160.50 (West 1989).
196. NEB. REV. STAT. § 81-1505 (1987).
197. 33 U.S.C. § 1329 (1982).
198. *Id.*
199. The Water Quality Act of 1987, Pub. L. No. 100-4, §308, 101 Stat. 7, 38 (1987).
200. The prime example of shared responsibility is the use of state implementation

gress has in the past generally vested the national government with primary regulatory authority over *hazardous* pollutants.[201] Thus, a shift from federal to state and local regulation in the hazardous pollution area is relatively new in the modern environmental era.

This trend is likely to continue, however, for two main reasons. First, it is becoming increasingly clear that a complete solution to the hazardous pollution problem will not be achieved solely by regulating the activities of a few large industrial polluters. The day-to-day activities of the ordinary individual must be changed if hazardous pollution is to be adequately controlled because many hazardous substances are released into the environment via our homes. Albuquerque, New Mexico's Environmental Health and Energy Department estimated that the 96,320 households in Albuquerque generated 1.6 million pounds of hazardous waste per year, or 16.5 pounds per household. Over one million pounds of the total was used motor oil, with substantial percentages of antifreeze and paint.[202] Similarly, the National Academy of Sciences estimates that home lawns may average ten pounds of pesticide application per acre, while farm use rarely exceeds two.[203]

Accordingly, if effective control of all hazardous pollution is the true goal, the general public must sooner or later change their day-to-day lifestyles. Regulations which affect such matters are generally more politically palatable when implemented at the state and local level because people feel they have a more meaningful voice in the decision-making process at those levels. As Justice Powell observed in a different context, "the most effective democracy occurs at local levels of government, where people with first hand knowledge of local problems have more ready access to public officials responsible for dealing with them."[204] Although there is some debate about the practical ve-

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plans to achieve national ambient air quality standards for non-hazardous air pollutants under the Clean Air Act. 42 U.S.C. § 7410 (1982).

201. For example, although states are given discretion in determining how they will achieve the national ambient air quality standards for non-hazardous air pollutants, see *supra* note 200, the federal EPA is empowered to set national emission standards for both new and existing sources of hazardous air pollutants. 42 U.S.C. § 7412 (1982).

202. Brown, *Household Hazardous Waste: The Unresolved Water Quality Dilemma*, 14 CURRENT MUN. PROBS. 364, 367 (1987-88).

203. 17 Envtl. L. Rep. (Envtl. L. Inst.) 1081 (1987) (citing National Academy of Sciences, Urban Pest Management (1980)).

204. Garcia v. San Antonio Metro. Transit Auth., 469 U.S. 528, 575, n.18 (Powell, J.,

racity of this observation,[205] the common perception that it is true makes local regulation of day-to-day activities more politically acceptable than national regulation.

Second, the trend toward decentralized regulation will be bolstered by heightened awareness of the scientific and economic uncertainties involved in the regulation of hazardous pollutants. The recognition that there is no magic, clear-cut solution to the problem of hazardous pollution will increase public understanding that a risk-free world is unachieveable and that even government regulators with the increased expertise that sometimes is available at the federal level cannot solve the problem. In many situations, the best option may be to empower the local population to obtain information concerning the risks and costs involved and directly determine which risks are worth assuming and which are not. The balance struck in making such decisions may vary from community to community. Residents of Tacoma, Washington may conclude that the economic and other benefits provided by the ASARCO copper smelter outweigh the uncertain, but in many instances, very real health risks posed by arsenic emissions from the plant,[206] while residents of Institute, West Virginia may elect to close Union Carbide's methyl isocyanate production plant rather than risk a Bhopal-type disaster,[207] or vice-versa.

Recent federal legislation, such as the Emergency Planning and Community Right to Know Act (EPCRTKA),[208] is premised on the assumption that the federal government's role in hazardous pollution regulation should sometimes be limited to ensuring that local populations have the opportunity to become better informed about hazardous pollutants in their communities. It is then up to the local population, rather than the federal government, to decide whether a plant should be closed down to prevent the risks. A similar emphasis is found in the SARA provisions providing for increased public participation in all phases of the cleanup decision-making process. The amendments provide for public meetings at or near the facility to discuss proposed

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dissenting).

205. *See, e.g.*, La Pierre, *Political Accountability in the National Political Process—the Alternative to Judicial Review of Federalism Issues*, 80 Nw. U.L. Rev. 577, 630-31 & nn.308-09 (1985).

206. Rucklehaus, *supra* note 140, at 10,192-93.

207. Wall St. J., March 27, 1985, at 8, col. 1.

208. 42 U.S.C. §§ 11,001-11,050 (Supp. V 1987).

and final remedial plans,[209] funding to assist local groups in obtaining the necessary technical assistance to interpret information regarding the nature of the hazards and proposed remedies,[210] and a right for the public to comment on proposed consent decrees before they are judicially approved.[211] As the public begins to recognize the level of scientific, economic, and political uncertainties which surround the hazardous pollution problem and comprehend the pervasive nature of the sources of that problem, an increased emphasis will likely be placed on allowing local populations to decide for themselves, within limits,[212] how hazardous substances will be regulated. State and local governments will thus play an increasingly larger role in the hazardous pollution arena in the future.

V. Conclusion

Hazardous pollution regulation was not the most pressing environmental issue when the modern era of environmental law began twenty years ago, but it rapidly ascended the priority ladder to its present lofty position. The ascent failed to produce a fully effective regulatory scheme, but it has revealed some of the previously unappreciated difficulties in regulating hazardous pollutants. As society becomes increasingly aware of these difficulties and responds by altering the course of hazardous pollution regulation, new barriers will likely be discovered. However, by dealing with the problems already discovered, society's ability to regulate the hazardous pollution it has created will improve.

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209. 42 U.S.C. § 9617(a) & (b) (1982).

210. 42 U.S.C. § 117(e) (1982).

211. 42 U.S.C. § 9622(d)(2) (1982).

212. The federal government will, and should, continue to ensure that minimum standards are met.