Chapter 5

Sites Requiring Cleanup

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Sites Requiring Cleanup

SUMMARY

OTA's assessment of major sources of waste sites and improvements in site selection methods indicates that 10,000 sites might eventually be included on the National Priorities List (NPL), and that even this figure might rise substantially. Sites that now get placed on the NPL do merit cleanup, but many other sites also require cleanup.

At least 5,000 of the 621,000 operating and closed *solid* **waste** facilities in this country, such as sanitary and municipal landfills, may require cleanup. About 20 percent of the current NPL sites were such facilities. More than 1,000 operating hazardous waste land-based facilities may require cleanup under Superfund because of the limitations of the Environmental Protection Agency's (EPA) groundwater protection standards.

An improved site selection process could place some 2,000 more sites on the NPL. Improvements would include attending to environmental threats as well as threats to human health, removing the cutoff score which has no technical basis or merit, and providing national guidance for preliminary assessments and site investigation.

EPA's estimate that about 2,000 sites will eventually be placed on the NPL is likely to significantly underestimate the future needs of Superfund. This chapter will discuss the basis for OTA's higher estimates.

INTRODUCTION

A major uncertainty in the Superfund program is the question of how many-uncontrolled waste sites may require cleanup. OTA has examined three areas in order to assess future needs; they are: 1) solid but not hazardous waste facilities governed by Subtitle D of the Resource Conservation and Recovery Act (RCRA), 2) hazardous waste facilities regulated under Subtitle C of RCRA, and 3) sites in EPA's inventory of uncontrolled sites that under current procedures are not likely to be placed on the NPL but that may warrant cleanup.

To determine whether or not a site merits cleanup under Superfund requires considerable information about the hazards it presents. OTA's analysis estimates in a statistical or probabilistic sense the number of sites not adequately accounted for in EPA's projections of future national needs.

From a policy and planning perspective such an attempt cannot be anything other than semiquantitative. The key point, however, is whether EPA's projection of an NPL of about 2,000 sites might be off by as much as 100 percent or more. Each of the three areas listed above will be examined in detail,

The reader is cautioned, however, about several limitations of these analyses. For example, OTA has not considered nonwaste sites that also qualify for inclusion on the NPL, such as leaking underground storage tanks and areas contaminated by pesticides. Evidence of a threat from such nonwaste sites is likely to increase. Nor has OTA considered sites associated with mining wastes. It may also be argued that OTA's estimates represent a worse-case scenario because companies and States may clean-up sites on their own without the use of

Superfund. But a low estimate may result from the exclusion of some sites from the analysis.

As discussed in chapter 3, underestimating the future size of the NPL could lead to cleanup strategies and allocation of resources that eventually incur higher costs and environmental risks than necessary.

Consider this scenario: a large number of sites go unattended or receive highly impermanent cleanups. These sites get worse over time and lead to large amounts of environmental contamination, particularly of drinking water. At some time, after Superfund resources have been depleted, the costs to cleanup the sites become staggering, perhaps impossible, if permanently effective cleanup technologies or adequate numbers of technical personnel are not available. Overestimating future needs appears to be far less likely, and it presents fewer problems because Congress could adjust the program to account for smaller expenditures.

SOLID WASTE FACILITIES

Our society produces exceptionally large amounts of solid waste from households, commercial establishments, industrial facilities, and virtually every other place where materials are consumed, processed, or examined. The traditional, convenient, and cheap way of disposing of these vast quantities of waste has been to place them in landfills if they were mostly solid or in surface impoundments if they were mostly liquid. Solid waste disposal has been managed both by local governments and private industry. Only recently has it become clear that the land disposal of solid wastes might pose threats to public health and the environment similar to those stemming from the disposal of what are now called hazardous wastes.

There are three reasons why solid waste facilities may become uncontrolled sites that can release hazardous substances into the environment and, therefore, be eligible for the NPL. First, prior to the creation and implementation of the Federal RCRA Subtitle C program, hazardous wastes were generally disposed of along with ordinary solid wastes. Prior to the 1970s few people recognized the dangers of hazardous wastes and the toxic chemicals in them. Thus, hazardous waste produced over many decades simply were placed in land disposal sites, many of which have since been closed. This became particularly significant after World War II, with the widespread production, use, and disposal of synthetic organic chemicals, many of which are toxic and very stable. These closed facilities present unique problems because by now their locations may not be known and there are few, if any, records of what was placed in them. Now they are part of the landscape on which new, often suburban, housing and other buildings have been placed. The technology used to build those facilities and contain the waste was far less sophisticated and safe than today's still-limited containment technologies. Furthermore, because there was little consideration of environmental threats, they were more likely to be placed near sensitive areas such as aquifers that supply drinking water.

Second, even after the regulation of hazardous waste on a broad national level various statutory and regulatory exemptions and exclusions continue to make it possible for some hazardous waste to be disposed of legally in solid waste facilities. A forthcoming report by the Congressional Budget Office estimates that in 1983 over 26 million tons of hazardous wastes were disposed of in sanitary landfills nationwide. It is important to note that relatively small amounts of hazardous waste from individual sources, including households and small businesses, can add up to substantial amounts in a particular solid waste facility. The fact that solid waste facilities may be very large, often hundreds of acres, and that the hazardous waste may be only a small fraction of, and widely dispersed within, the total waste does not preclude major environmental problems. To the contrary, although it might take longer, often decades, for hazardous substances in these sites to reach the environment, eventually large amounts of a broad variety of substances may be released, Moreover, cleaning up such large operations or closed sites presents major engineering problems and is very costly.

Third, even with a well-enforced regulatory program for hazardous wastes on both the Federal and State levels, which is not yet the case, there will be illegal disposal of hazardous waste in solid waste facilities. It is virtually impossible to examine and monitor all incoming waste to detect the broad range of hazardous substances that might be present, perhaps in small amounts and in containers. In many cases it is also possible for midnight dumpers to gain access to a solid waste facility and bypass normal inspections of incoming materials.

Current Recognition and Evidence of the Problem

There are several reasons that explain why the solid waste facility problem for Superfund has received little detailed attention. State and local officials, closest to the problem, comment to OTA that they are aware of the likelihood of release of hazardous substances from solid waste facilities. Because of limited resources, including a nearly total ending of Federal support for solid waste programs, they have tended to focus on hazardous waste facilities and there has been little testing and monitoring of solid waste sites, Where testing has been done, the broad range of hazardous substances of concern to Superfund may not be tested for. Moreover, although some monitoring results have indicated a significant problem of leachate leaving the site, such results generally are not made public. There is considerable concern that once there is public documentation connecting toxic waste problems with *solid waste* facilities there will be public pressures against their operation and the siting of new facilities. How would the vast amounts of solid waste be managed?

Nor is it likely that States could finance cleanups of large numbers of leaking solid waste facilities, either by themselves or even under the current Superfund program. Superfund requires a contribution from the States for cleanups, and for publicly owned and operated facilities that contribution is 50 percent.

At the Federal level, little attention and funding has been given solid waste programs. EPA has only recently recognized that solid waste facilities might be a major source of sites for Superfund. In a congressionally mandated study to evaluate the first period of the Superfund program, EPA states:

> Municipal landfills, both large and small, can cause potentially serious problems, Some facilities have already been closed down, some are still operating. Although such facilities can no longer accept hazardous wastes, many especially in large urban areas and in heavily industrialized areas did in the past accept industrial waste which could include hazardous waste. In addition, people may continue to dump small quantities of paints, solvents, pesticides and other household chemicals which are hazardous. In big landfills, these can potentially add up to big problems. In small towns and rural areas, while the problem may be small, it can be significant to the surrounding community.[1]

Similarly, municipal and private landfills are widely used for sludges from wastewater treatment, generally in very large quantities, The National Research Council recently concluded:

> Landfills have been increasingly used to isolate wastewater sludges containing trace contaminants at levels high enough to be of regulatory concern. The assumption has been that remobilization of such contaminants is minimized by using landfills and that release of contaminants to the environment is unlikely. The panel believes that the data supporting such a conclusion are scant and that remobilization of contaminants in surface and ground waters as well as to the atmosphere is possible.[2]

[1] U.S. Environmental Protection Agency, "Supporting Analysis for CERCLA Section 301(a)(1)(c) Study," draft, July 1984, p. 5.

[2] National Research Council, Disposal *of Industrial and Domestic Wastes* (Washington, DC: National Academy Press, 1984), p. 166.

The above statements, however, consider only one part of the solid waste facility universe, municipal landfills. The following statement contained in EPA's Ground-Water Protection Strategy provides a more comprehensive view of the problem, although only with respect to groundwater contamination rather than the full range of environmental problems that solid waste facilities pose:

> In addition to facilities receiving hazardous wastes, other facilities that may contaminate ground water are of concern. In the mid 1970s, EPA and the States became increasingly concerned that all waste disposal landfills (not just those receiving hazardous wastes under RCRA) may be creating a substantial problem for ground water. There are an estimated 93,000 such landfills in the United States. Of these, 75,000 are classified as on-site/industrial, and we know little about them. Another 18,500 are classified as municipal. Fewer than 10 States require any form of regular monitoring for ground-water quality at these facilities. Landfills are invariably located on land that is , . . susceptible to ground-water contamination problems.
>
> A similar situation obtains at pits, ponds, and lagoons—usually grouped and referred to as surface impoundments—that receive both hazardous and non-hazardous wastes. EPA's recently completed Surface Impoundment Assessment (S IA) surveyed the numbers and locations of surface impoundments, and estimated their potential effects on ground-water quality ., . The SIA identified a total of 181,000 surface impoundments. Most of them are unlined, About 40 percent of municipal and industrial impoundments are located in areas of thin or permeable soils, over aquifers currently used for drinking or that could be used for drinking. About seven percent of all sites appear to be located so as to pose little or no threat to ground water. Because of the lack of generally available knowledge, ground-water protection was rarely, if ever, considered when these facilities were sited . . . facilities handling non-hazardous wastes and hazardous wastes produced by small generators are covered by RCRA Subtitle D criteria (enforceable under citizen suits), but they are not regulated under the Federally enforceable provisions of RCRA. These facilities may be significant sources of ground-water contamination.[3]

Within the context of Superfund, EPA has acknowledged, but only to a limited degree, the contribution to the future size of the NPL by solid waste facilities. These sites, along with several other types of sites "not currently included in the determination of NPL sites, " caused EPA to conclude that as many as 800 more NPL sites might result.[4] This brought the total projected NPL to a maximum of 2,200 sites, but EPA has generally used a figure of 2,000 sites.

Congress recently has acknowledged the significance of the solid waste facility problem for Superfund. However, improvements in regulations and their enforcement would not occur for several years and might significantly affect only new facilities. The Conference Report on the recent reauthorization of RCRA noted:

> Subtitle D facilities are the recipients of unknown quantities of hazardous waste and other dangerous materials resulting from the disposal of household waste, small quantity generator wastes, and illegal dumping. Since construction, siting, and monitoring standards for these facilities are either nonexistent or far less restrictive than those governing hazardous waste disposal facilities, environmental and health problems caused by Subtitle D facilities are becoming increasingly serious and widespread. A high proportion of sites listed on the National Priority List were sanitary landfills. Without the additional environmental protection that the implementation of this provision will provide, even more Subtitle D facilities are destined to become Superfund sites.'

Solid waste facilities continue to attract attention at the State and local levels across the Nation. For example, a New York State legis-

3U.S. Environmental Protection Agency, *A Ground-Water Protection Strategy for the Environmental Protection Agency*, August 1984, pp. 14 and 38.

4Alvin R. Morris, U.S. Environmental Protection Agency, memorandum to Alvin L. Alm and Lee M. Thomas on the results of a Superfund Task Force assessment, Dec. 8, 1983, p, 5.

5U. S. Congress, *Hazardous and Solid Waste Amendments of 1984*, Conference Report 98-1133.

later brought to pub lic attention that a high fraction of solid waste landfills could be contaminating groundwater:

> In late 1983, at least 50 of the state's 538 legal landfills were known to be polluting ground water. Officials at the state's Department of Environmental Conservation estimate that the number could be zoo or more.[6]

Similarly, an official in the Puerto Rican legislature indicated the severe nature of the problem there:

> The major problem is underground water contamination caused by inadequate disposal of hazardous wastes. For more than 10 years, these industries have been disposing of waste in sanitary landfills in a region where the underground is basically permeable to liquids.[7]

For a closed landfill in Southwest Philadelphia for which Superfund cleanup had not yet been obtained the following was reported:

> The state Health Data Center recently released a study that showed the cancer mortality rate in Sharon Hill, Darby Township, and Darby Borough—which are adjacent to the landfill—is 22 percent higher than in the state and the nation. . , . The landfill was ordered closed in 1972 by a court order, but documents and photographs . . . show that the landfill is still operating. . . . EPA officials confirmed the findings of a study that showed a number of carcinogens and other toxic substances were leaking from the landfill into Darby Creek. Although EPA officials said toxic wastes were only found in small quantities, they said it posed a hazard to children who may swim or fish in the creek.[8]

In Maryland an aluminum smelting plant's waste has been interpreted to be an exempted mining waste, but controversy has continued:

> Residents have complained, without much success, about the threat of wastes produced by the plant, particularly contamination of well water with the cyanide they say is leaching out of disposed materials. . . . In *1981,* after receiving no public comment to the contrary, EPA pulled pot liners off its list [of hazardous wastes], pending completion of the study. . . . As a result of that action [the company] terminated an agreement to recycle the pot liners . . . and instead decided to bury them on its 2,000-acre plant site here. The company received a landfill permit from the state last year, but a consultant report released in April found cyanide in groundwater at the plant site. g

In a more systematic way, a study performed for OTA analyzed three data bases on sites already known to be or likely to become uncontrolled sites eligible for Superfund cleanup. The three data bases, which contained sufficient detail to make a judgment as to whether a site could be characterized as a RCRA Subtitle D facility, were: 1) a computerized data base maintained for EPA on about 1,000 mismanaged waste facilities, 2) 550 NPL site descriptions, and 3) a survey of 365 sites where remedial actions have been performed,

Out of 1,389 sites, 245, or nearly 18 percent, were Subtitle D facilities. For the 550 sites proposed or included on the NPL, 108 sites, or nearly 20 percent, were classified as Subtitle D facilities. Examination by OTA of recent proposed additions to the NPL and other data indicate that these percentages are low. The distribution for the 245 solid waste facilities according to EPA Region and State is given in table 5-1,

The greatest number of problem solid waste sites were in EPA Region II, which contained 33 percent of the sites. Regions III, IV, and V also had relatively large numbers of sites. Together these correspond to the Eastern (Atlantic coastal area) and Midwestern portions of the Nation. New York had the greatest fraction with 17.5 percent, followed by New Jersey with 15 percent, Pennsylvania with 7.5 percent, and Tennessee with 5 percent, with these four States containing 45 percent of the sites identified, These statistics should not be interpreted to mean that other regions and States do not have current or potential problems with solid waste facilities; but the older, more densely

[6] John J. Marchi, *The New York Times*, June 16, 1984, Op-ed page.
[7] *The New York Times*, Feb. 21, 1984.
[8] *The Philadelphia Tribune*, June 5, 1984.
[9] *The Washington Post*, Nov. 22, 1984.

Table 5.1 .—Known Problem Subtitle D Sites by EPA Region and State

Location	Number
Region 1:	
Connecticut	5
Maine	2
Massachusetts.	3
New Hampshire	5
Rhode Island	3
Vermont	1
	19
Region II:	
New Jersey.	36
New York	43
Puerto Rico	2
	81
Region Ill:	
Delaware.	8
Maryland	2
Pennsylvania	18
Virginia	6
West Virginia	4
	38
Region IV:	
Alabama	2
Florida.	10
Georgia	1
Kentucky	4
North Carolina	1
Tennessee	13
	31
Region V:	
Illinois	5
Indiana	4
Michigan	12
Minnesota	1
Ohio	11
Wisconsin	5
	38
Region VI:	
Arkansas.	2
Louisiana	2
Oklahoma	5
	9
Region VII:	
Missouri	1
Nebraska.	1
	2
Region VIII:	
Colorado	6
Montana	3
South Dakota	1
Utah	2
	12
Region IX:	
Arizona	4
California	3
Nevada	1
	8
Region IX:	
Guam	1
Idaho	1
Washington	5
	7
Total	245

SOURCE: JRB Associates, "Evaluation of RCRA Subtitle D Facilities," contractor report prepared for the Office of Technology Assessment, June 1984

Table 5-2.—Mismanagement Events at Problem Subtitle D Sites[a]

Event	Documented	Suspected	Total frequency
Erosion	24	11	35
Flood	2	6	8
Fire/explosion	15	6	21
Gaseous emission	20	15	35
Leak	17	23	40
Leachate	129	66	195
Spill	15	9	24
Other	11	3	14

[a]Individual facilities may be classified in several categories Therefore. totals do not add to 245

SOURCE JRB Associates, "Evaluation of RCRA Subtitle D Facilities," contractor report prepared for the Off Ice of Technology Assessment, June t984

populated and more highly industrialized areas may find more environmental problems with larger numbers of solid waste facilities.

Table 5-2 presents the waste mismanagement events identified at the solid waste sites, Mismanagement events are categorized as documerited or suspected based unavailable information. For example, a documented leachate mismanagement event would be one where groundwater monitoring data showed downgradient contamination by leachate. For a suspected event there would be some evidence of leachate movement from the site, such as contamination of surface water, but insufficient hydrogeologic data to establish a causal connection between the site and groundwater conlamination. Leachate migration was the most common problem, occurring at 80 percent of the sites and leading to groundwater contamination; at 65 percent of the sites surface water was affected (see table 5-3).

Table 5-4 gives the data on affected receptors of hazardous releases. Drinking water was the most frequently affected receptor at 49 percent, followed by human health at 23 percent.

Table 5-3.—Affected Media at Problem Subtitle D Sites[a]

Exposed media	Documented	Suspected	Total
Air.	27	23	50
Groundwater	119	77	196
Soil	63	71	134
Surface water	74	85	159

[a]Individual facilities may be classified in several categories Therefore, totals do not add to 245

SOURCE JRB Associates, "Evaluation of RCRA Subtitle D Facilities," contractor report prepared for the Office of Technology Assessment, June 1984

Table 5.4.—Affected Receptors at Problem Subtitle D Sites[a]

Affected receptor	Documented	Suspected	Total frequency
Drinking water	54	67	121
Fauna	8	29	37
Flora.	13	15	28
Human health	8	48	56
Property damage	22	7	29

[a]Individual facilities may be classified in several categories Therefore, totals do not add to 245.

SOURCE JRB Associates, "Evaluation of RCRA Subtitle D Facilities," contractor report prepared for the Off Ice of Technology Assessment, June 1984

Various other information was obtained on the sites. Ownership data showed that nearly half of the sites were owned and probably operated by municipalities. About 80 percent of the facilities were landfills, and nearly 20 percent surface impoundments, Generally the contaminants found at the facilities and their frequency resemble what has been found at all sites evaluated for the NPL. The most common contaminants, found at at least 30 sites, were lead, benzene, phenol, toluene, and trichloroethene.

Data on the size of 92 sites were available; the mean size was 67.4 acres if one 5,000 acre site is excluded. Hazard Ranking System (HRS) scores for placement on the NPL were available for 77 of the solid waste facilities. The median score for the solid waste facilities was 40.8 and for the original 406 sites on the NPL it was 42.2. The range for the solid waste sites was from 19.5 to 75.6. All the information suggests that solid waste sites on the NPL score similarly to NPL sites that dealt solely with hazardous wastes.

Limited information on Superfund expenditures was found. Average Remedial Investigation/Feasibility Study costs for 41 sites averaged $450,000, which is about half of what EPA now estimates to be average RI/FS costs. Estimated remedial cleanup costs (including RI/FS costs and excluding operating and maintenance costs) for six sites averaged $3 million, less than half of the average figure for remedial cleanups now being used by EPA,

Case Studies

As part of the effort to examine the current problem with solid waste facilities two sets of detailed case studies were performed. In the first set, four landfills already on the NPL were examined; in the second set, four landfills believed to be typical of solid waste facilities, but which have not been considered for the NPL, were examined, These eight case studies are summarized below.

The Combe Fill South Landfill, Chester Township, New Jersey, received an HRS score of 45.2. The 60- to 100-acre site was privately owned and operated before the last owner filed for bankruptcy in 1982. The original 30-acre landfill operated from the 1940s and was closed in 1972; a newer, engineered landfill was approved by the State in 1972 for nonhazardous waste disposal and it was closed in 1981. The site is atop a hill in a wooded, rural residential area. Within one-half mile are 90 residential drinking wells; within one-quarter mile are 38 residentially zoned lots; 1 mile away is a State park; and the immediate area is the headwater for several local streams and a brook that receive runoff from the site, In 1981, State agencies sampled surface and groundwater near the site, found contamination and a threat to drinking water supplies, Later, air emissions of volatile organics were found. Even if RCRA Subtitle C regulations for a hazardous waste landfill had been applied to this site, they probably would not have been effective. The site is fundamentally unsuitable for land disposal.

The Laurel Park Landfill, Naugatuck, Connecticut, received an HRS score of 46,8. The facility is a 35-acre, privately owned and operated sanitary landfill, active since 1951, and is atop a hill. About one-half mile downhill are homes; one side of the hill is heavily wooded and abuts a State forest; the area comprises part of the headwaters of two watersheds, Roughly 200 tons per day of municipal and industrial wastes, and septic and sewage sludge are discharged at the site. Since the early 1960s the site has been subject to numerous citizen complaints and regulatory actions. There were fires, spills on roads, noxious fumes, and findings of contaminated leachate affecting surface and groundwaters. Various actions have allowed the facility to remain in operation, including: monitoring groundwater, installing leachate collection and treatment systems, and supplying potable water to some residents. As the site is not particularly well suited for land disposal, even RCRA Subtitle C regulations would not have been totally effective in combating these problems.

The Marshall Landfill, Boulder, Colorado, received an HRS score of 46.5. Marshall Lake is about one-quarter mile east and receives runoff from the site; the town of Superior is 2 miles west; industrial and cattle grazing areas are nearby; and Boulder is 3 miles southeast of the site. Several bodies of water that ultimately receive runoff from the site are used as drinking water supplies. There is an inactive 80-acre portion and an active 80-acre portion of the site. The inactive portion was operated under various owners from 1955 to 1974 and received municipal solid wastes, septic tank wastes, secondary wastewater treatment sludges, and unknown industrial liquid wastes. The active portion accepts sewage sludge, but suspicions have arisen concerning the disposal of radioactive waste and polychlorinated biphenyls (PCBs). There is evidence of contamination of surface and groundwaters, as well as methane generation. If the facility had been regulated under Subtitle C, many of the problems could have been reduced or prevented.

The Syosset Landfill, Syosset, New York, received an HRS score of 54.3. It is located in a residential and light industrial area of Long Island with five public water supply wells within 6,000 feet of the site. The 40-acre landfill was opened in 1936 by the local municipality and closed in 1975, because of suspected groundwater contamination. The water table is only about 30 feet below the bottom of the fill; the landfill is in a recharge zone (where new water enters) of a sole source aquifer. In 1968 the landfill stopped receiving municipal waste. Prior to 1968 and up until 1975 the site received much industrial waste. A study in 1982-83 revealed evidence of migrating contamination, but public water supply wells were not yet contaminated. Compliance with Subtitle C regulations would have mitigated, or at least delayed, the environmental impacts of this facility. Further, the facility probably would not have been located in a recharge zone of a sole source aquifer.

The second set of case studies was performed on four currently operating or recently closed Subtitle D facilities that *are not* on the NPL. (Three of these sites have not been named at the request of the operators.) Sites selected for the case studies had to have groundwater monitoring data, which are not generally available for most solid waste facilities, but not all of the sites made the data available. Two HRS scores were calculated for each site.[10] The methodology, however, was altered because rigid adherence to the current procedure would lead to zero values when certain data were absent; this is a major criticism of the current scoring procedure.

Site A is a closed, county-owned municipal landfill in Maryland that operated from 1962 to 1982. The 161-acre site is hilly and part of the site was originally a ravine. The site is bounded by two streams which discharge to a river that is not a source of drinking water. Groundwater monitoring data obtained by the county over an 8-year period indicate that groundwater leaving the site and discharging into local streams is contaminated with acidic leachate from the landfill, Although probable sources of hazardous substances were being dumped in the unlined site, there is little information about the specifics of the situation, *At this point, although human health problems do not appear imminent, environmental damage is likely and there is a potential for future remedial action at the site.* It is important to note that the site monitoring does *not* monitor for halogenated organic toxic chemicals nor for some toxic metals, Lead, however, has been found downgradient, There are no Federal or State requirements to perform such monitoring. HRS scores calculated for this site were 3.5 and 4.4; these low scores currently preclude placement on the NPL and result because the contaminated water does not affect people downstream,

Site B is a municipally owned and operated landfill in Pennsylvania and was officially permitted by the State in 1983. The 175-acre site is surrounded mostly by cropland. Several houses within 1 mile downgradient have pri-

[10]For the first score, the lowest non-zero rating value was used to score items for which data on waste quantity and toxicity were missing. For the second score, certain assumptions were made; for example, it was conservatively assumed that 0.01 percent of the total amount of waste was hazardous. This approach to the HRS provides an indication of the *possible level* of scores. 'l'his exercise also confirms two other problems with the HRS procedure, a discounting of sites which affect small populations or which affect environmental quality but not human health directly.

vate wells. There is shallow, diffuse, and slow groundwater flow at the site, and surface water discharges into a tributary of a large creek. The facility receives mostly domestic waste, some debris from construction demolition, and some industrial wastes. Before the open dump was turned into a municipal facility, industrial wastes were disposed there, including chemical and fertilizer wastes, dyes used for textiles and printing, sludges from foundries, and shoe factory wastes, Now, surface runoff and leachate are treated and the discharged water appears to meet its National Pollution Discharge Elimination System (NPDES) permit requirements, Groundwater monitoring began in 1983 but it does *not* measure organic pollutants nor most inorganic chemicals of importance in Subtitle C facilities, Monitoring, however, has revealed evidence of contamination, including some toxic metals, attributed to migrating leachate from the unlined site. *There is a significant potential for future remedial action to prevent contamination of drinking water supplies downgradient.* The HRS scores for this site were 14.8 and 18.5, which are below the current NPL cutoff of 28.5 primarily because the affected population is small.

Site C opened in 1972 and is a municipal} owned sanitary landfill in Virginia, operated by a contractor. It is located in a generally rural area, but with some nearby commercial development and light industry, The 57-acre site, with 20 acres still operating, is in marshy area, although the site itself is not marshland. With 50 feet of land buffer, there is a wooded rural residential area to the south and a cattle grazing area to the west. One mile downstream is a small lake used infrequently for irrigation. Surface runoff also enters streams used for recreational fishing.

A shallow aquifer near the site is used by residents to the south and east. A higher quality but deeper aquifer is used by a company to the north. The facility is unlined and has no leachate collection system, Waste received is primarily residential and commercial refuse, with some industrial waste, including chemical-resistant fabric, residues from plastic processing, and residues from glues for paper products. Much emphasis has been placed on not accepting hazardous waste. Groundwater monitoring of the shallow aquifer has occurred for about 2 years, but *not* for toxic organic chemicals. *There is evidence of groundwater contamination by leachate from the site and, hence, future remedial action may be required.* HRS scores calculated for this site were 3.5 and 26, too low for placement on the NPL.

The last site is the Marathon County landfill, Wisconsin, owned and operated by the county. The landfill comprises 27.3 acres and could be expanded greatly. The surrounding area is mostly woodlands and forest. A small number of nearby residences are believed to have private wells and there is a dairy nearby, but both are separated by the 572 acres of the overall site. The site does not drain into locally used surface waters. The site is in a recharge zone for aquifers used for some residences.

A clay liner is used together with leak detection and leachate collection systems; contaminated leachate is treated in a nearby industrial wastewater treatment plant. Just over half the wastes accepted originates from industry, including wastewater treatment sludge, fly ash, alkaline sludge, foundry sand, and papermaking waste, none of which are RCRA hazardous wastes. There is extensive air, surface, and groundwater monitoring by the county, as well as various State-imposed financial responsibility requirements. To date, the containment technology appears to be presenting any migration of leachate offsite. The HRS scores were zero for this site, and *it is unlikely to require remedial actions because of the care applied to its location, design, and operation.* However, the groundwater monitoring program does *not* measure for a number of toxic chemicals, and some hazardous substances are probably in the wastes accepted.

The case studies support the general] proposition that many, if not most, solid waste facilities have and will continue to pose threats associated with the release of hazardous substances into the environment. Subtitle D facilities already identified for Superfund attention resemble hazardous waste sites, Just as important, the solid waste facilities that have been placed on the NPL are basically similar to typical ones, such as the three out of four in the second set of case studies that might qualify someday for the NPL. Moreover, those solid waste facilities, closed or operating, that have not been judged appropriate for the NPL have not been monitored closely for the range of hazardous substances that might qualify them for the NPL, even though considerable evidence often exists for migration of leachate off site. This suggests that the 20 percent of the NPL now accounted for by solid waste facilities could rise substantially. *The concerns of citizens, the media, some State and local officials, and the EPA about the Subtitle D facility problem for Superfund appears well founded.*

Estimate of Possible Future Contribution to the NPL

It appears very likely that many solid waste facilities will become uncontrolled sites requiring cleanup under Superfund. The next question, then, is how will this affect the size of the NPL? OTA first examined the total number of Subtitle D facilities and then estimated what fraction of this total might someday be placed on the NPL.

Data on Operating and Closed Facilities

There is considerable uncertainty about how many Subtitle D facilities there are in the Nation, The uncertainty is greater for closed, older facilities than for operating ones. Table 5-5 presents survey data by EPA Region and State on operating landfills for the years 1981-83, The table also gives the number of open dumps identified by States in their 1983 inventory and projected numbers of dumps that will be upgraded to landfill status (sites not upgraded are usually closed). The numbers of open dumps reported may be low because additional dumps probably exist and remain uninventoried. The data also presents problems because there are varying definitions of landfills. Some States may include industrial landfills, perhaps only offsite ones, while most include only municipal landfills. Definitions may also change from year to year, explaining, for example, the large increase in Texas from 1981 to 1982; 793 sites surely were not built in 1 year in Texas. Considering the transformation from open dumps to landfills and what appears to be a rate of approximately 500 new landfills being permitted annually, the number of operating and presumably chiefly municipal or sanitary landfills in 1984 was probably about 14,000, up from 13,000 in 1983.

The same survey indicates that in 1983 the estimated number of landfills with groundwater, gas, and/or leachate monitoring wells was 1,609, although 14 States did not report this information. An estimated 37 facilities had artificial liners in 1983, with 12 States not reporting this information. In 1983, 30 percent of the facilities were publicly owned, 65 percent privately owned, and 5 percent had some combination of ownership.

There must, in addition, be many closed municipal and sanitary landfills, To estimate their number, OTA obtained data from several States on operating and closed landfills. For six States there was a minimum of 2,784 closed facilities and a total of 895 operating ones. This ratio of about 3:1, applied nationally, yields an estimate of 42,000 closed municipal and sanitary landfills in 1984,

EPA estimates that approximately 75,000 onsite, nonhazardous waste industrial landfills operate nationally, Although this figure has been used in 1984, it is based on an estimate made in 1978 and the advent of the RCRA and Superfund programs may have reduced it significantly. There are no estimates for the number of closed, onsite industrial landfills, but an estimate of twice the above number—l50,000—may be reasonable,

Surface impoundments falling under the Subtitle D classification include wastewater treatment lagoons, potable water treatment lagoons, pits, ponds, basins, mining waste disposal facilities, evaporation ponds, agricultural waste disposal facilities, and others. Often a site may consist of several impoundments, EPA's Surface Impoundment Assessment for 1978-80 gives the best available data. Table 5-6 summa-

Table 5-5.–RCRA Subtitle D Facilities by State

State	Number of all landfills 1981	1982	1983[b]	Number of open dumps[ab]	Open dumps to upgrade[a]
Region 1:					
Connecticut	170	155	151	36	24
Maine	336	328	308	45	NA
Massachusetts	286	273	283	81	NA
New Hampshire	450	250	101	26	0
Rhode Island	35	22	18	4	1
Vermont	73	85	92	4	0
Region 2:					
New Jersey	240	185	185	5	1
New York	641	525	525	56	38
Puerto Rico	68	NA	NA	NA	NA
Region 3:					
Delaware	NA	4	35	4	4
District of Columbia	2	3	NA	NA	NA
Maryland	NA	64	47	0	0
Pennsylvania	1,400	847	925	94	75
Virginia	NA	250	209	50	34
West Virginia	228	127	127	41	36
Region 4:					
Alabama	146	135	135	12	11
Florida	209	214	248	55	17
Georgia	517	299	284	6	4
Kentucky	210	112	128	34	NA
Mississippi	286	120	253	133	10
North Carolina	170	225	167	1	0
South Carolina	128	78	225	0	0
Tennessee	134	160	161	6	2
Region 5:					
Illinois	260	450	329	42	0
Indiana	149	129	348	191	2
Michigan	470	NA	362	150	0
Minnesota	371	105	185	60	0
Ohio	680	235	318	54	NA
Wisconsin	1,050	1,100	1,085	66	10
Region 6:					
Arkansas	490	141	311	78	NA
Louisiana	NA	532	532	532	95
New Mexico	228	231	228	0	0
Oklahoma	215	225	225	66	60
Texas	250	1,043	1,075	11	8
Region 7:					
Iowa	NA	95	94	0	0
Kansas	243	220	224	1	0
Missouri	107	108	128	2	1
Nebraska	277	500	400	2	0
Region 8:					
Colorado	205	206	206	32	26
Montana	221	250	222	16	13
North Dakota	84	97	130	0	0
South Dakota	30	NA	200	140	5
Utah	300	290	296	26	8
Wyoming	NA	86	210	0	0
Region 9:					
Arizona	130	122	116	28	27
California	450	443	542	40	31
Hawaii	24	NA	25	9	4
Nevada	114	120	99	52	10

Table 5-5.—RCRA Subtitle D Facilities by State—Continued

State	Number of all landfills 1981	1982	1983b	Number of open dumps[a,b]	Open dumps to upgrade[a]
Region 10:					
Alaska	80	NA	NA	NA	NA
Idaho	220	130	132	42	20
Oregon	226	249	226	28	3
Washington	NA	136	136	36	18
Guam	3	NA	NA	NA	NA
Total	12,606	11,704	12,991	2,396	598

[a]Data for 1983
[b]There may be some overlap between these column entries
SOURCE Nancy Peterson, 1983 Survey of Land fills,' *Waste Age,* vol 14, No 3, March 1983 "Land Disposal Survey, " *Waste Age,* vol 12, No 1, January 1981

Table 5-6.—Types of Surface Impoundments

	Active sites[a]	Active impoundments	Abandoned sites	Abandoned impoundments
Agricultural	14,677	19,167	173	270
Municipal	19,116	36,179	630	1,006
Industrial	10,819	25,749	941	2,163
Mining	7,100	24,451	264	587
Oil and gas	24,527	64,951	463	537
Other	1,500	5,745	53	168
Total	77,739	176,242	2,524	4,731

Total active and abandoned sites: 80,263
Total active and abandoned impoundments: 180,973

[a]A site may have more than one (impoundment
SOURCE U S Environmental Protection Agency, *Surface Impoundment Assessment National Report,* EPA 570/9-84.002, December 1983

rizes the results of this survey, which found a total of 176,242 active facilities and a minimum of 4,731 closed ones. The latter is a minimum because the survey did not attempt to count closed impoundments and a more realistic figure might be as high as the number of active impoundments.

Table 5-7 gives the data broken down according to purpose of the impoundment. An unknown fraction of the 96,443 storage and treatment facilities may pose environmental problems similar to disposal impoundments and thus may affect future Superfund needs. For example, both during storage, which may be for long periods, and treatment, which may only constitute settling or evaporation, hazardous substances may migrate into the land and water. Evaporation of volatile organic toxic chemicals also presents problems. Only 29,250 of all impoundments had any sort of liner, artificial or natural. Based on limited data, only 1,359 impoundments had any type of monitoring. EPA found that about one-quarter of impoundments potentially would affect groundwater supplies.

Table 5-7.—Purpose of Impoundments (by percent[a] and number)

Category	Storage Percent	Storage Number	Disposal Percent	Disposal Number	Treatment Percent	Treatment Number
Agricultural	55	10,542	26	4,983	19	3,642
Municipal	5	1,809	31	11,215	64	23,155
Industrial	17	4,377	31	7,982	52	13,390
Mining	18	4,401	27	6,602	56	13,693
Oil and gas	29	18,836	67	43,517	4	2,598
Total		39,965		74,299		***56,478***

[a]Percent storage disposal and treatment per category
SOURCE U S Environmental Protect Ion Agency *Surface Impoundment Assessment National Report* EPA 570/9 84002, December 1983

The above data suggest a total of as many as 281,000 landfills, and 340,000 surface impoundments, including both open and closed facilities. These figures are only approximate but are based on the best available, albeit limited and imprecise, data,

Estimates of Future Superfund Needs

The key question is what fraction of the above total of 621,000 Subtitle D facilities might require cleanup under Superfund? There is, of course, no precise means of answering this question. One approach is to consider several possible percentages that appear conservative and reasonable, based on the information from case studies, the lack of current monitoring for hazardous substances, and on the very small numbers of facilities with 1iners and monitoring wells. Information presented earlier on Subtitle D facilities on the current NPL suggest that landfills may pose more serious problems than surface impoundments. This is consistent with the fact that many impoundments may be used for dilute aqueous wastes that pose less serious problems than do the more concentrated hazardous materials often placed in landfills.

Table 5-8 presents two scenarios for sites that might release significant amounts of hazardous substances. The low scenario estimates that 5 percent of landfills and 1 percent of impoundments might require cleanup and leads to a total of 17,4oo cleanups. The high scenario estimates that 10 percent of landfills and 2 percent of impoundments might require cleanup and leads to a total of 34,800 cleanups. If these figures, which OTA believes to be conservative, are even approximate} correct, they suggest that very large sums of money will be needed just to perform studies of Subtitle D facilities, and much more to clean them up. The figure could be hundreds of billions of dollars. Even a fraction, say 5,000 sites or one-third, of the lowest estimate, together with other contributions to be discussed, would quintuple the size of EPA's projected 2,000-site NPL.

Table 5-8.— Estimates of Sites With Potentially Significant Releases into the Environment

	Low scenario		High scenario	
Landfills (281 ,000) ., ...,	5°/0	14,000	1OO/o	28,000
Surface impoundments (340,000)	1 0/0	3,400	2%	6,800
		17,400		34,800

SOURCE Off Ice of Technology Assessment

HAZARDOUS WASTE FACILITIES

The expectation has been that effective protection of public health and the environment from hazardous wastes eventually would be achieved by Superfund's cleaning up past problems and RCRA's preventing future ones. The purpose of this section is to examine the extent to which operating RCRA Subtitle C hazardous waste facilities might become candidates for cleanup under Superfund.

OTA has studied the groundwater protection standards covering land-based facilities regulated by RCRA. Although other types of environmental pollution are possible from hazardous waste facilities, groundwater problems exist at most NPL sites. Moreover, other types of environmental problems are not addressed by the RCRA regulatory program to the same extent as groundwater contamination, For example, there are few regulations covering air emissions of toxic chemicals.

A recent report by EPA's Superfund Task Force[11] indicates that as of December, 1983, groundwater contamination was the number one problem in uncontrolled sites. For example, for the 881 sites rated for the NPL, 526 had observed releases of hazardous substances into groundwater. *Over* 8 *million Americans are potentially exposed to* the groundwater *from these*

[11] 101.1, ismemo.op.cit

sites, and for about 350 *of these sites the contaminated groundwater is the only source of drinking water for the affected population.* Another 6.5 million people are potentially exposed to contaminated surface water at 450 sites. EPA acknowledges that most of the 444 commonly encountered toxic pollutants found at these 881 sites exhibit chronic toxicity and pose health threats at extremely low levels of human exposure. Of the 538 sites on the NPL, 40 percent were originally landfills and 30 percent were surface impoundments.

Furthermore, most of the cleanups being conducted under Superfund involve either leaving the wastes in the ground and attempting to contain them, or removing contaminated materials to land disposal sites, Land disposal sites that have and continue to receive Superfund cleanup wastes may themselves become Superfund sites (although not solely because of the redisposal of wastes), so this issue is particularly important, We are beginning to see examples of this already (e. g., the BKK facility in California). This is to be expected, as EPA estimates that 50 to 60 precent of interim status land disposal facilities are leaking. Over 50 RCRA interim status facilities regulated by EPA are already on the NPL.[12]

EPA's Dependence on Current Groundwater Protection Standards

Current Federal regulatory control of hazardous waste land disposal facilities is *critically dependent* on EPA's groundwater protection standards. Because of the admitted deficiencies and uncertainties of land disposal technology, such as the unproven long-term effectiveness of leachate liners and collection systems, protection of human health and the environment rests ultimately on the protection afforded by the groundwater monitoring requirements. For example, EPA's director of its Office of Solid Waste has said:

> While *no* method of hazardous waste management is failproof, our rules should protect human health and the environment. Even if a containment system fails, groundwater monitoring will identify leakage and the pollutant plume will have to be cleaned up.[13]

However, no mention is made of dealing with the leak itself, nor of stopping the disposal of hazardous materials in the leaking site. Cleaning up the pollutant plume is of limited effectiveness if the leakage continues.

The director for air and waste management in EPA's Region VIII has said:

> In the Agency's view, the cornerstone of our land disposal program rests on the groundwater protection standards. They were devised to provide essential environmental and health controls.[14]

More recently, EPA has formulated a national groundwater protection strategy that recognizes that "cleaning up contaminated groundwater is difficult, expensive, and often unsuccessful, These facts clearly argue for future programs to focus on better protection of the resource while efforts to detect and deal with serious contamination resulting from past actions continue, " EPA's new national groundwater protection strategy guidelines indicate that the RCRA groundwater protection standards will still be used.[15] OTA finds that, because of the inadequacies of the RCRA groundwater protection standards, the goal of protecting the resource rather than cleaning it up after the fact is in jeopardy,

RCRA and Land Disposal

Several aspects of the RCRA regulations have already received considerable analysis. For example, OTA completed a major study of hazardous waste control in March 1983.[16] Another

[12] U.S. Environmental Protection Agency, computer printout from the "Hazardous Waste Data Management System, " provided by Jeffrey Tumarkin, June 19, 1983.

[13] John N. Skinner, U.S. Environmental Protection Agency, letter to Keith H. Gordon, Aug. 12, 1983.

[14] Robert L. Duprey, U.S. Environmental Protection Agency, letter to Leo Younger, Aug. 10, 1983.

[15] *A Ground-Water Protection Strategy for the Environmental Protection Agency, 01).* cit.

[16] U.S. Congress, Office of Technology Assessment, *Technologies and Management Strategies for Hazardous Waste Control,* OTA-M-196 (Washington, DC: U.S. Government Printing Office, March 1983).

major study was done by the National Academ}' of Sciences.17

These works show that even with the best available land disposal technology, hazardous wastes placed in land disposal facilities will likely migrate into the broader environment sooner or later. Moreover, there are commercially available waste reduction and waste treatment alternatives to the land disposal of many hazardous wastes. Finally, RCRA regulations present technical and economic disincentives to industry that limit the use of alternative technologies.

More resources continue to be allocated to the regulation of fundamentally flawed land disposal technology than to the development and demonstration of alternatives to land disposal. EPA frequently has been criticized for not encouraging alternative technological approaches to the land disposal of hazardous waste. EPA's response has been: a) that the technology for recycling and alternative treatment to land disposal may not exist for all or most wastes, b) that the technologies are not "on-the-shelf" but are in some stage of development, and c) that to the extent to which technology does exist, the necessary plant capacity may not be in place. However, EPA's land disposal groundwater protection regulations do not meet these standards either.

To sum up, RCRA regulations do not overcome the fundamental inadequacies of land disposal technology because: 1) experience has shown that regulatory enforcement efforts do not assure compliance with regulations; and 2) as the following analysis shows, even with *compliance with RCRA groundwater protection standards, land disposal will still pose serious risks to health and environment.*

Interim Status

When Congress passed RCRA in 1976, it provided a grandfather clause for existing facilities so that they could continue to operate *as if they had a permit* until EPA issued them a permit .18 This interim status was to allow for a smooth transition to a condition of federal1y permitted hazardous waste facilities,

There remains considerable uncertainty as to the exact number of interim status sites covered by the groundwater protection standards. According to applications for RCRA permits, as of December 1983, 2,000 out of 8,000 interim status sites were required to monitor groundwater.[19] To date only about a dozen of these 2,000 facilities have been issued permits by EPA, thus most continue to operate under interim status. EPA estimates that it will not complete the permitting of the 2,000 facilities for 10 more years,[20] In the following discussions the use of the terms "new" or "permitted" facilities refers to either newly built facilities or interim status ones that have received permits.

EPA's Implementation

In May 1980, EPA issued "interim status standards "[21] as the "minimum requirements" for interim status facilities. These interim status standards (or Part 265 standards) are "in lieu of" the more stringent Part 264 standards[22] that go into effect only after the facility is permitted by EPA. This action cut off any means of bringing an interim status facility into compliance with standards "adequate to protect human health and the environment" short of issuing (or denying) a permit. 's The RCRA re-

[17] National Materials Advisory Board, *Management of Hazardous Industrial Wastes: Research and Development Needs*, NMAB-398 (Washington, DC: National Academy Press, 1983).

[18] RCRA, Section 3005(a).

[19] U.S. Environmental Protection Agency, "Summary Report on RCRA Activities—January 1984" (Washington, DC: Office of Solid Waste, January 1984); As of mid-1984 EPA had status sheets on only 972 facilities, but a number of State officials indicate that more facilities exist in their areas than EPA is aware of. To date EPA has permitted only a few disposal facilities under RCRA.

[20] U.S. General Accounting Office, *Interim Report on Inspection, Enforcement, and Permitting Activities at Hazardous Waste Facilities*, GAO/RCED-83-241 (Gaithersburg, MD: U.S. General Accounting Office, Sept. 21, 1983).

[21] 40 CFR 265

[22] 40 CFR 264.3

[23] There are provisions in both RCRA and CERCLA for EPA to seek an injunction to require action if it can be demonstrated that there may be an imminent and substantial endangerment to health or the environment. These provisions may have been used in a few cases to require corrective action for groundwater pollution at an active interim status site. Their use at an active RCRA regulated site would indicate that there are no pertinent regulations with which the agency can require compliance.

authorization has addressed this issue in part (see below).

Although the interim status groundwater monitoring requirements have only recently gone into effect, as of mid-1984 210 out of 972 facilities were "in assessment" because their groundwater monitoring systems indicate that they are polluting groundwater.[24] Some of these are receiving wastes from Superfund cleanups, Of the 210 facilities, only 72 were found by EPA to have adequate monitoring programs, with 86 not evaluated by a State or EPA office. Of the 586 facilities in the normal detection mode, only 175 were found to have adequate monitoring programs; 85 had no monitoring wells at all, and 173 never were evaluated. Thus, more than the 210 facilities might be required to be in the assessment monitoring mode if they were performing adequate detection monitoring, perhaps as many as 400, A 1983 study by the General Accounting Office of several States with above-average regulatory programs found that only 22 percent of the regulated facilities were complying with the interim status groundwater monitoring requirements.[25]

EPA estimates that 50 to 60 percent of the interim status land disposal facilities are leaking and will require corrective action.[26] There is some evidence that the figure might be closer to 90 percent. A study conducted by EPA in 1975 investigated 50 randomly selected facilities and found that over 90 *percent* of them were leaking into groundwater,[27] Therefore, even before the passage of RCRA, the poor state of these interim status facilities was known.

EPA could have written regulations for financial assurance for corrective action, regulations to monitor and gather necessary environmental data, and regulations to bring facilities promptly into compliance or close them down, Instead, the interim status standards abrogate most of EPA's authority to regulate interim status sites until their application for a permit is acted upon by EPA.

Indicator Parameters

EPA has identified four indicator parameters to determine whether an interim status hazardous waste facility is leaking. The four indicator parameters are: specific conductance, pH, total organic carbon, and total organic halogen. EPA limited the groundwater monitoring requirements for purposes of leak detection to these four parameters,[28] EPA gave the following reason for choosing these parameters:

> Increases in specific conductance indicate the presence of inorganic substances in the groundwater. Likewise, increases or decreases in pH suggest the presence of inorganic contamination, Total organic carbon (TOC) and total organic halogen (TOX) concentrations in groundwater tend to increase as a result of organic contributions from a hazardous waste facility. The methodology to sample and analyze for these indicators is presently available, EPA believes that monitoring these indicators will be sufficient to make the threshold assessment of whether a facility is leaking.[29]

However, the more stringent Part 264 standards for EPA permitted sites[30] give the EPA permit writer the option that the actual waste constituents or their reaction product be monitored rather than the four indicator parameters. EPA's guidance to the permit writers says this about the four indicator parameters:

> In some cases, these parameters may not be the most appropriate, and this use should be carefully reviewed before they are included as indicator parameters in a detection monitoring program. For example, TOC and TOX will be of little value at a facility where no organic wastes are present, and even at facilities handling organic wastes, background levels may reduce the utility of these parameters. The use of pH and specific conductance may also not always be appropriate. There are so

[24] U.S. Environmental Protection Agency, "Interim Status Ground-Water Monitoring Implementation Study," draft, 1984.

[25] GAO/RCED-83-241, op. cit.

[26] *Inside E.P.A.*, Feb. 17, 1984, p. 3.

[27] U.S. Environmental Protection Agency, *The Prevalence of Subsurface Migration of Hazardous Chemical Substances at Selected Industrial Waste Land Disposal Sites*, SW-634 (Washington, DC: Office of Solid Waste, 1977).

[28] 40 CFR 265, W(b).

[29] 45 Federal Register 33194.

[30] 40 CFR 264.98,

> many geochemical controls on pH, such as natural buffering capacity, that it is difficult to predict what changes in pH might occur in a leach ate migrating through the unsaturated and saturated zones. In addition, unless extremely acidic or basic, the addition of large amounts of leachate will likely be required to significantly alter pH. [consequently, pH may be suitable only as an indicator of gross contamination. Detectable changes in specific conductance will similarly require a relatively large increase in ion concentrations. Consequently, it may also be useful as an indicator of gross pollution, and then only at facilities where constituents migrating to ground water are primarily inorganic ions .[31]

Further criticism of the ability of the indicator parameters to detect toxic contaminants at critical concentrations was made at a recent groundwater symposium:.

> . . . there can be highly selective migration of contaminants that are hazardous to human health in drinking waters at concentrations far less than those that would be detected using the ''indicator' parameters .[32]

More recently, EPA has acknowledged that "the indicator parameters are not functioning in either an efficient or effective manner . . . "[33]

Number of Monitoring Wells

The interim status standards require only three wells for detecting groundwater contamination. This is true regardless of the size of the facility, the size of the aquifer, the extent of pollution, or the potential for damage to human health and the environment. In many cases, three wells are far too few to give a reasonable probability of detecting pollution early. In processing RCRA permits, the number of required detection wells is generally 4 to 20 for interim status sites currently operating with 3 wells. On the State level, one interim status site in Illinois was required by the State to install 40 wells and another over 50,[34] and three sites in New Jersey are required to have over 100 wells.[35]

RCRA Reauthorization

Congress has addressed several aspects of the interim status facility issue. The lifetime of interim status has been limited. Existing facilities will lose their interim status 12 months after enactment (November 1985) unless application is made for a final RCRA permit and the site is certified to be complying with the groundwater monitoring and financial responsibility requirements. Existing facilities that become subject to Subtitle C have 6 months to apply for a final permit. Interim status surface impoundments become subject to minimum technological requirements for at least two liners, leachate collection, groundwater monitoring, and early leak detection, unless certain stringent conditions are met and evidence to allow an exemption is submitted within 24 months. Furthermore, upon closure an exempted impoundment (e.g., because of a natural clay liner being present) must remove or decontaminate all waste residues, all contaminated liner material and contaminated soil. If the latter is not removed the operator must comply with post-closure requirements. EPA is also given additional means to seek corrective action at interim status sites by obtaining an administrative order through a civil Federal court action,

Summary

The facilities that are most likely to leak, about 2,000 interim status facilities, have a much less stringent groundwater monitoring standard then the three permitted and presumably far better designed new facilities. According to EPA, these standards are "minimal and are specifically designed not to be burdensome."[36] *There are no corrective action re-*

[31] GeoTrans, Inc., " RCRA Permit Writers Manual, Ground-water Protection, 40 CFR Part 264 Subpart F", Oct. 4, 1983. p. 192.

[32] G Fred Lee and R. Anne Jones, "Water Quality Monitoring at Hazardous Waste Disposal Sites: Is Public Health Protection Possible Through Monitoring Programs?" paper presented at the *Third National Symposium on Aquifer Restoration and Groundwater Monitoring* sponsored by the National Water Well Association, Columbus, OH, May 1983.

[33] U.S. Environmental Protection Agency, " Interim Status Ground-Water Monitoring Implementation Study," op. cit.

[34] Michael Nechvatal, Illinois Environmental Protection Agency, private communication, Mar. 23, 1984.

[35] William Brown, Supervisor with the New Jersey Bureau of Groundwater Discharge Permits, private communication, Mar. 19, 1984.

[36] U.S. Environmental Protection Agency, SW-634, op. cit.

quirements or requirements to stop disposal should groundwater contamination be detected. Sites found to be polluting will be put on a "fast track" for issuing a permit so that corrective action may be required, but so far few Federal permits have been issued to interim status facilities requiring groundwater monitoring. Although the recent legislative changes reduce the risks associated with interim status, a likely effect may be to *hasten the closure of interim status facilities prior to applying for, or obtaining, full permits.* To the extent that a facility operator perceives that a permit is unlikely to be issued, or very high costs would be required, closure could lead to placement on the NPL.

Limitations on Coverage

EPA's strategy, as evidenced in the groundwater protection provisions of Part 264 of RCRA, is to determine when groundwater is becoming polluted enough to threaten public health and then to require the groundwater to be cleaned up, However, groundwater monitoring is not a substitute for techniques such as leak detection systems to analyze the engineering soundness of the waste management facility, e.g., to locate a ruptured liner in a landfill or a leaking storage tank.

Permitted facilities are required to be built to exacting EPA engineering standards whose goal is to "minimize the formation and migration of leachate to the adjacent subsurface soil or groundwater."[37] However, when leachate does appear in groundwater, facility operators are not required to find out what went wrong, "a landfill liner which has been designed not to leak does not violate the design standards if the liner fails at some future time."[38] *RCRA regulations for fully permitted facilities do not require that the leak be fixed or that the waste disposal activities be halted.* When pollution may be coming from one of several sources, there is no requirement to determine which of them it is. In short, *it is not a violation of any RCRA regulation to pollute.* Nor is there currently any evaluation of the implications of a leak for the continued operation of a facility. There is only the requirement that the pollution that has reached groundwater be cleaned up. This, as will be discussed later, is a very limited requirement.

Under RCRA jurisdiction, EPA limits the site owner's responsibility for site maintenance to 30 years after site closure.[39] Since EPA (and many others) have concluded that it is "inevitable" that landfills and disposal lagoons will leak,[40] many of these facilities are likely to eventually fall under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). As firms go out of business, cleanup costs would shift from facility owners and users to the government.

RCRA Reauthorization

Several of the above problems have been addressed legislatively, but it is not yet clear how the new legislative provisions will be implemented. The minimum technological requirements for almost all types of land disposal facilities include the use of early leak detection systems; however, the requirement applies only to *new* units. Another change concerns regulations and permits issued after enactment. Facilities must act to control and clean up all releases of hazardous constituents from all units at the facility, including inactive ones. This requirement may hasten the closure of some facilities in ways that result in their eventual placement on the NPL.

Groundwater Monitoring Wells

The hydrogeology of the site is important in the design of a groundwater monitoring system for interim status and permitted facilities. A good knowledge of the hydrology and geology in the immediate area of a waste disposal site is necessary to know where, how many, and how deep to locate detection monitoring wells. In addition, for compliance monitoring it may also be necessary to create a mathematical model to get some understanding of the

[37] 47 Federal Register 32312.
[38] 47 Federal Register 32330.
[39] 40 CFR 264.117 and 265.117.
[40] 46 Federal Register 11128.

speed and direction of the movement of contaminants,

In determining the location, depth, number, and type of monitoring wells a great many assumptions have to be made about the underground geological structure and the location, depth, quantity, direction, and speed of underground water. Furthermore, the proper location of monitoring wells depends on a knowledge of how all the above parameters may vary with season, rainfall, tidal water, and groundwater usage. These latter factors can cause groundwater flow to greatly increase, decrease, or even change direction over time.

Hydrogeological structures have physically hidden characteristics that must be inferred from limited data, Data are obtained from sources such as core samples, well drilling logs, and historical records of rainfall, The difficulty of doing this was summarized picturesquely in a recent review by the Princeton University Water Resources Program:

> Imagine that we cannot see the sky, we cannot tell the direction or velocity of the wind, and we ask: Is the factory (with its thousands of little chimneys) polluting the air? That is our ground water monitoring problem—at its easiest. It is made more difficult because the geological properties of the soil vary with depth and direction, and this variation is unknown or uncertain. When we look up in the sky, we observe the spatial variation of the pollutants. If we could look up only through a small tube or telescope, then the information we gathered from the one sighting might not be representative of what we would see if we looked everywhere. The small tube into the sky is like our groundwater monitoring well: the data we gather may not tell us too much about what is occurring in other nearby locations.[41]

One of the few studies of operational land disposal sites was an investigation of 50 typical hazardous waste disposal sites conducted in 1976-77 for EPA.[42] This study concluded:

> At sites presently monitored the use of wells as an aid in evaluating groundwater conditions is generally poor, due to inadequacies with respect to one or more of the following parameters: number of wells, distance of wells from potential contamination source, positioning of wells in relation to ground water flow, selection of screened intervals, use of proper well construction materials, sealing against surface water contamination, or inter-aquifer water exchange, completion methods (such as development, maintenance, and protection against vandalism),

Of the 50 sites evaluated, 32 had existing groundwater monitoring systems, usually installed to meet the requirements of State law. Of the 32, the study found seven monitoring systems (or 22 percent) so inadequate that they had to install new wells to conduct the relatively basic monitoring required by the contract.

More recently, EPA has found considerable problems with monitoring wells. Of 148 interim status facilities that had implemented groundwater monitoring programs in response to RCRA interim status regulations, 64 facilities (or 43 percent) had "deficiencies related to the number, depths, and/or locations of monitoring wells."[43] Among the problems encountered were:

- background wells not in the uppermost aquifer,
- background wells affected by the facility,
- downgradient wells not located in the direction of expected contamination movement, and
- downgradient wells not located at depths which would intercept contaminants.

These studies show that the percentage of unsatisfactory monitoring systems was 22 percent in the 1977 study and 43 percent in the 1983 study. These two studies are not comparable, so it is simplistic to conclude that groundwater monitoring had deteriorated in those 6 years.

[41] Princeton University Water Resources Program, *Groundwater Contamination From Hazardous Wastes* (Englewood Cliffs, NJ: Prentice-Hall, 1984).

[42] U.S. Environmental Protection Agency, SW-634, op. cit.

[43] U.S. Environmental Protection Agency, "Resource Conservation and Recovery Act, Ground-water Monitoring Interim Status Regulations—265.90-94, Evaluation of the Requirements, Phase II Report to OMB, Implementation of the Requirements" (Washington, DC: Office of Solid Waste, Mar. 10, 1983).

But there is no basis for believing, in spite of improvements in technology, that the practice has gotten better, There are several possible explanations (not mutually exclusive) for this state of affairs, First, monitoring may be mostly a procedure to reassure the public.

One expert pointed to limitations in the state of the art as a second explanation. He observed, for example, that "contamination migration in fractured rock is complex and generally unpredictable" and that "prediction . . . is generally beyond the state of the art. Pollutant movement is easiest to predict in sand and gravel. Ironically, sand and gravel make the worst base for land disposal because pollutants move very rapidly in these porous soils. Soils that have good containment properties and are hydrogeologically predictable are found in only about 10 to 20 percent of the United States,[44]

There are many other hydrogeological conditions that make the design of groundwater monitoring systems very difficult:

- There can be connections between different aquifers that are difficult to detect.[45]
- Groundwater flow can change direction because of intrusion of tidal water, seasonal recharge patterns, or nearby production wells.
- Leachate does not always flow straight down to an aquifer, but under some geological conditions would flow at an angle and enter an aquifer downstream of the monitoring wells.[46]
- Liquid contaminants in an aquifer do not always flow in the same direction as the groundwater.

A third possible explanation for lack of progress is that a proper groundwater monitoring system takes a great deal of money, time, and expertise. In order to meet governmental regulatory requirements without spending too much, reliance is placed on engineering judgment rather than hard data. This warning appears in the EPA RCRA permit writers guide:

> Experience with the installation of monitoring systems for compliance with the Interim Status Regulations has indicated that most owners/operators who have hired a groundwater consultant to install the groundwater monitoring system have not envisioned spending the time or money to conduct as thorough an investigation as is suggested in this chapter. To retrieve all of the information necessary to design the system in accordance with considerations in this document, test-boring and piezometer installation programs will be necessary, Though some local geologic reports usually exist in the region of most facilities, site specific considerations almost invariably require extensive test borings. Because of the lack of time and funds, in most cases parameters such as the direction of groundwater flow and the nature of subsurface materials have been determined through evaluation of local topography and, to the extent possible, evaluation of existing building foundation borings. Monitor wells are usually located on the basis of this information and completed to just below the water table. Variations in ground-water flow direction and geologic variability have usually not been considered because of lack of information. The primary factors for minimizing the pre-monitor well installation field investigation have been time and cost.[47]

A similar point about cost was made at a congressional hearing in 1982 on EPA's Part 264 groundwater protection standards:

> There are, of course, certain geologic environments in which monitoring becomes extremely expensive and may not be cost-effectively employed, In order to obtain credible information, dozens of wells and hundreds of groundwater samples may be required to develop an adequate analysis of the hydrogeologic system, Although there are probably a large number of existing land disposal sites located in such areas, it is my recommenda-

[44] J. A. Cherry, "Contaminant Migration in Groundwater With Emphasis on Hazardous Waste Disposal," *Workshop on Groundwater Resources and Contamination in the United States*, Mar. 14 and 15, 1983 (Washington, DC: Division of Policy Research and Analysis, National Science Foundation); J. A. Cherry, personal communication, Dec. 7, 1983.

[45] U.S. Environmental Protection Agency, "Permit Writers Training Course on Groundwater Monitoring, RCRA 264, Subpart F" (Washington, DC: Office of Solid Waste, July 1983), pp. 3-7.

[46] Burnell Vincent, U.S. Environmental protection Agency, private communication, Oct. 21, 1983.

[47] GeoTrans, Inc., op. cit., p. 16.

tion that no new land disposal facilities be allowed under these conditions regardless of engineering design. [48]

What is required for a facility operator to detect groundwater pollution? The hazardous waste disposal facility operator must want to detect groundwater pollution and must determine how effective monitoring will be, given the geology of his site. The operator must be willing to hire experts, spend time, and spend money (probably far in excess of EPA's minimum requirements), Finally, sampling and analysis procedures must be designed that optimize the ability to detect contamination, even if they are more stringent than EPA's procedures (see the section in this chapter on statistical procedures). Some facilities operate this way, although they are not required to do so, but they are not required to report to EPA the results of anything over the minimum requirements,

At the other extreme is the facility operator who fulfills only the minimum requirements of the law. Consultants may not be used to optimize the efficiency of the groundwater detection system, Under these circumstances, groundwater detection systems have a low probability of detecting contamination. Many of the sites on the National Priorities List had such groundwater monitoring systems.[49]

The latest EPA Part 264 regulations (July 26, 1982), while an improvement over the Part 265 standards, do not acknowledge the past failure of regulatory groundwater monitoring systems, nor the unsuitability of many geological formations. They continue to rely on regulatory groundwater monitoring in any terrain to detect leaks. But the minimum requirements of the regulations are inadequate to-assure a high probability of detection.

Contaminant Tolerance Levels

The RCRA regulations for EPA permitted land disposal facilities,[50] unlike those for interim status facilities,[51] provide for detection monitoring of the specific contaminants being disposed as an alternative to the use of the four indicator parameters (at the discretion of the EPA permit writer). This would overcome the problem of indicator parameters mentioned in the section on "Interim Status. " Upon close examination, however, this process raises other issues having to do with the tolerance levels of these contaminants.

In regulatory parlance, the tolerance level of a chemical is the concentration that is acceptable to the regulatory agency. The Part 264 RCRA regulations do not have explicit tolerance levels for groundwater contaminants except for the 16 chemicals listed in the EPA primary drinking water standard. However, for the hundreds of toxic constituents listed in the RCRA regulations[52] there is an implicit tolerance level. The regulations specify that the EPA publication "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods"[53] be used to determine whether a sample contains a given toxic constituent.[54]

For most substances, this publication lists more than one analytical method, Some methods are more sensitive than others. In issuing permits, EPA plans to use relatively low-cost scanning techniques, which are the least sensitive methods, explaining:

> The Agency feels that a special hierarchical approach is appropriate for this purpose. These approaches will first use scanning techniques designed to detect broad classes of compounds. If the presence of a particular class of compound is detected, more specific analysis to determine which constituents are actually present can then be initiated. Although some sensitivity may be sacrificed by

[48] David W. Miller, Geraghty & Miller, Inc., testimony before hearing of the House Subcommittee on Natural Resources, Agriculture Research and Environment, Nov. 30, 1982.

[49] U.S. Environmental Protection Agency, Hazardous Waste Site Descriptions: National Priorities List, Final Rule, and Proposed Update (Washington, DC: Office of Solid Waste and Emergency Response, August 1983).

[50] 40 CFR 264.

[51] 40 CFR 265.

[52] 40 CFR 261 appendices VII and VIII.

[53] U.S. Environmental Protection Agency, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, 2d edition (Washington, DC: office of Solid Waste, 1982).

[54] 40 CFR 261 appendix III.

such an approach, the range of detection of certain scanning methods are clearly adequate . . .

Therefore, *the detection limit of the scanning methods, which are the least sensitive of the required test methods, constitutes a de facto tolerance level,* since no further action will be taken if the scan does not detect contamination. Furthermore, there are more sensitive test methods than those chosen, and EPA has demonstrated in the case of dioxin that more sensitive methods can be developed when required. The RCRA regulations do not explain why certain test procedures were chosen and others were not. Finally, tolerance levels are implicit rather than determined for most cases,

Table 5-9 illustrates that these implicit tolerance levels are quite high, when certain EPA health effects projections are considered. The first column shows the minimum concentrations at which 12 selected chemicals can be detected using the RCRA procedures,” The second column shows EPA's estimate of the concentration that EPA projects will cause one cancer per 100,000 people drinking 2 liters a day of the water over a lifetime. These cancer estimates are based on animal studies. There are substantial disagreements about the accuracy of such projections, and the values listed in table 5-9 are not universally accepted. However, they continue to be used by EPA, although they may be changed. Since it is EPA's criteria which determine whether a site should be included in CERCLA, these projections are relevant to this study.

The projected number of cancers per 100,000 is estimated in column three. For example, table 5-9 shows that a hazardous waste disposal site operator, permitted by EPA, may, without violating his permit, pollute groundwater with up to 2,500 nanograms per liter of dieldrin, This is a concentration which EPA projects may cause 3,500 cancers per 100,000 people who drink the water over their lifetime,

EPA is currently seeking to ban the use of pesticides for which the cancer risk is as low as 1 in 100,000.[58] Therefore, it is likely that a facility which is polluting groundwater at a level projected to cause 3,500 cancers per 100,000 would come to the attention of CERCLA.

Next, consider the explicit tolerance levels associated with the 16 contaminants for which there is an EPA drinking water standard. EPA allows that for pollutants for which there is an

[55] U.S. Environmental Protection Agency, SW-846, op. cit.

[56] *Pesticide & Toxic Chemical* News, vol. 12, No. 4, Jan. 11, 1984, p. 15,

Table 5-9.—EPA Detection Limits for Some Carcinogens

Chemical	Highest permitted EPA detection limit (nanograms/liter) (†)	Concentration projected*• to cause one cancer per 100,000 people†† (nanograms/liter)	Projected •• cancers per 100,000 people
aldrin	1,900	0.74	2,600
dieldrin	2,500	0.71	3,500
1,1 ,2,2 -tetrachloroethane	6,900	1,700	4
3,3' -dichlorobenzidine	16,500	103	160
heptachlor	1,900	2.78	680
PCBs	36,000	0.79	46,000
benzo(a)pyrene	2,500	28	90
benzidine	44,000	1.2	37,000
chlordane	14	4.6	3
DDT	4,700	0.24	20,000

“A nanogram is a billionth of a gram One nanogram per liter is approximately one part per trillion.

“ ‘Projections based on the consumption of 2 liters (a little over 2 quarts) a day of the contaminated drinking water over a lifetime Projections are also based on animal studies that include assumptions on the transfer of results from animals to humans, and extrapolate ion from high doses to low doses Despite the uncertainties introduced by these assumptions, these are the projections EPA uses Column 3 has been calculated by OTA by dividing column 1 by column 2 This calculation converts back to high doses Uncertainties Introduced into column 2 by high.to-low dose extrapolations are thus partially corrected for in deriving column 3. Column 3 contains no correction for uncertainties Introduced by applying animal results to humans

†U S Environmental Protection Agency, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, SW-846, 2d ed. (Washington, DC Office of Solid Waste, EPA, 1982)

††Reference 45 FR 79325-79341

existing EPA primary drinking water standard, RCRA permitted facilities may contaminate up to the standard.[57] The primary groundwater pollution standards are shown in table 5-Io. As in table 5-9, this table also projects the cancers per 100,000 for those substances for which data are available from the EPA. In addition, the fourth column indicates the substances known or believed to be carcinogens.

For some of these pollutants, there may be no zero effects level and any amount of the substance is considered a risk to human health. For example, cadmium is carcinogenic[58] and is not considered without risk at any level.[59] Arsenic, lindane, and toxaphene are thought to be carcinogens and, as shown in table **5-10,** are associated with significant cancer risks at the EPA tolerance level.

[57] Toney Baney, RCRA/CERCLA hotline, U.S. Environmental Protection Agency, private communication, Nov. 29, 1983.

[58] U.S. Department of Health and Human Services, *Registry of Toxic Effects of Chemical Substances* (Washington, DC: Public Health Service, Centers for Disease Control, National Institute for Occupational Health and Safety, February 1982].

[59] U.S. Environmental Protection Agency, *Scientific and Technical Assessment Report on Cadmium*, EPA-600-75-003 (Washington, DC: Office of Research and Development, March 1975).

Regarding tolerance levels, not all toxic pollutants that can cause a site to be regulated under CERCLA are monitored under RCRA. A conspicuous example is dioxin contaminated soils. Although sent to RCRA regulated landfills, EPA has not been able to require that the soil be monitored for some dioxins, although they have proposed doing so.[60]

Table 5-11 lists other hazardous substances regulated under CERCLA that are not regulated or monitored under RCRA.[61] A reportable quantity (RQ) is the quantity of a hazardous substance which if spilled must be reported to the National Response Center[62] to determinate if any response under CERCLA is necessary. RQs are based on six criteria: aquatic toxicity, mammalian toxicity, ignitability, reactivity, acute toxicity, and carcinogenicity. They are in five reporting levels: 1, 10, 100, 1,000, and **5,000** pounds, The lower the RQ, the more hazardous the substance.

[60] 48 Federal Register 14514.

[61] 48 Federal Register 23552.

[62] CERCLA, Section 103.

Table 5-10.— Data on RCRA Pollutants With Primary Drinking Water Standards

Pollutants	EPA Primary Drinking Water Standard (µg/l)*	Concentration projected" • to cause one cancer per 100,000 people† (fig/l)	Projected •' cancers per 100,000 people	Comments
arsenic	50	0.022	2,300	a
barium ., ...	1,000	—	—	b
cadmium	10	—	—	a
chromium	50	—	—	—
lead	50	—	—	—
mercury .	2	—	—	—
nitrate (as N)	10,000	—	—	—
selenium	10	—	—	—
silver	50	—	—	—
fluoride ., ...	1,400-2,400	—	—	—
endrin	0.2	—	—	—
lindane	4	0.186	22	b
methoxychlor . . .	100	—	—	—
toxaphene ...	5	0.0071	700	b
2,4-D	100	—	—	—
2,4,5,-T, Silvex	10	—	—	—

a known human carcinogen (††)

b probable human carcinogen based on animal studies (††)

* µg/l microgram Per liter or millionth of a gram per liter 1 µg/l is approximately one part per billion

" Project Ions based on the consumption of 2 liters (a little over 2 quarts) a day of the contaminated drinking water over a lifetime Except for arsenic projections are also based on animal studies that include assumptions on the transfer of results from animals to humans, and extrapolations from high doses to low doses For arsenic projections are extrapolated from the effects of high doses in humans Despite the uncertainties int reduced by these assu m pt Ions these are the projections EPA uses Column 3 has been calculated by OTA by dividing column 1 by column 2 This calculation converts back to high doses Uncertainties Introduced into colu mn 2 by hi gh to low dose ext rapolations are thus part ially corrected for in derivi ng CO l u m n 3 Except for the arsenic number which is based on human data column 3 retains the uncertain ties introduced by applying an [real resu lts to humans

† preference 45 FR 7932579341

†† U S Department of Health and Human Services *Registry of Toxic Effects of Chemical* Substances (Washington DC Public Health Sew Ice Centers for Disease Control, National Institute for Occupational Health and Safety February 1982)

Table 5-11 .—Some Pollutants Regulated Under CERCLA (Reportable Qualities) But Not Under RCRA

Pollutant	Proposed reportable quantity (pounds)†	Oral (mammal) LD50* (mg/kg) (23)
carbofuran. . . .	10	11
chlorpyrifos. . .	1	97
diazinon	10	76
dichlone	1	—
alpha-endosulfan	1	—
beta-endosulfan . .	1	—
endosulfan sulfate. .	1	—
endrin aldehyde . . .	1	—
guthion	1	13
mercaptodimethur . .	10	34
mevinphos	10	3.7
naled	10	250

†48 FR 23552.23595

. LD_{50}—Lethal Dose Fifty—a calculated dose of a substance which is expected to cause the death of 50% of an entire defined experimental animal population It is measured in milligrams of substance Ingested per kilogram of animal body weight For comparison purposes note that the oral toxicity of iodine is 14,000 mg/kg, arsenic acid is 48 mg/kg, and potassium cyanide is 10 mg/kg

Table 5-11 lists those hazardous substances that have proposed RQs in the two most hazardous categories (1 and 10 pounds) and which are *not regulated under RCRA.* The proposed rules do not indicate the basis of the rating for each substance; therefore, it is possible that it is inappropriate to regulate some of these hazardous substances under RCRA, but no discussion of this issue has been found.

The significance of table 5-11 is that these substances could be leaking into groundwater from a RCRA permitted facility without violating the permit, yet would be candidates for regulations under CERCLA. Even more to the point, if these substances are spilled in transportation or manufacturing operations in excess of their RQ, they must, under CERCLA, be cleaned up and disposed in a RCRA regulated facility where RCRA regulations would not require their monitoring.

Table 5-12 addresses those contaminants of concern to CERCLA that are also regulated under RCRA. In many cases, *the groundwater detection levels are higher under RCRA,* as much as 1,000 times higher, This is another example of the puzzle that occurs in comparing RCRA regulations with CERCLA. The cure is considered more protective of public health than the prevention, *Thus a RCRA regulated site may pollute groundwater to a level tolerated by RCRA but come to the attention of CERCLA for the same pollution.*

Table 5-12.—Some Examples of Groundwater Detection Levels of Hazardous Chemicals Which Are Higher Under RCRA than Under CERCLA

Pollutant	CERCLA detection levels (ng/l)†††	RCRA detection levels (rig/l)
dieldrin	5	2,500†
DDT	10	4,700†
DDE	5	5,600†
DDD	10	2,800†
heptachlor	5	1,900†
heptachlor epoxide	5	2,200†
aldrin	5	1,900†
antimony.	20,000	32,000††
arsenic	10,000	53,000††
cadmium	1,000	4,000††
lead	5,000	42,000††
selenium	2,000	75,000††
thallium	10,000	40,000††

†U.S Environmental Protection Agency, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, SW-846, 2d ed (Washington, DC Off Ice of Solid Waste, EPA, 1982)

t tLee M Thomas, Assistant Administrator, U S Environmental Protect Ion Agency, Memorandum to the Admi nistrator Pro Posing additional test methods for reference 17, Oct 17, 1983

†††U S Environmental Protect Ion Agency, "Statement of Work, Organics Analysis, Contract Laboratory Program" (Washington, DC EPA, September 1983) U S Environmental Protect Ion Agency, "Statement of Work, Inorganics Analysis, Contract Laboratory Program" (Washington, DC EPA, May 1982)

The last, and perhaps most important point with regard to tolerance levels, is that for many of the several hundred hazardous constituents for which EPA has published test procedures to monitor groundwater, the level at which these contaminants can be detected has not been published or determined by EPA.[63] Moreover, the test protocols were set more by considerations of analytical chemistry than human health effects; thus some of the detection limits might be too high to protect human health, while others might be lower than necessary. Some of the hazardous constituents for which EPA does not yet know the detection limits are listed in table 5-13. The substances shown were selected because they are alleged carcinogens and preliminary EPA research has given them high hazard ratings, Although research is underway to determine detection levels, RCRA rules permit groundwater contamination by these and other substances to a currently undetermined level.

[63]U.S. Environmental Protection Agency, SW-846, op. cit

Table 5-13.—Some Carcinogenic Chemicals for Which EPA Has Not Yet Determined the Levels at Which They Can Be Detected in Groundwater by the Methods of Reference

aflotoxin
4-aminobiphenyl
aziridine (ethyleneimine)
bis-(chloromethyl)ether
chloromethyl methyl ether
1,2-dibromo-3-chloropropane (DBCP)
diethylnitrosamine (n-nitrosodiethylamine)
diethylstilbesterol[a]
dimethylaminoazobenzine
7,12-dimethylbenz(a)anthracene
dimethylcarbamoyl chloride
1,2-dimethylhydrazine
ethyl methanesulfonate
hydrazine
methyl nitrosourea
nitrosomethylurethane (n-nitroso-n-methylurea)
n-nitosopiperidine
n-nitrosopyrrolidine
streptozotocin[a]
2,3,7,8-tetrachlrodibenzo-p-dioxin (TCDD)
ethylene dibromide (EDB)

[a]Test methods not yet published by EPA as of Jan 19 1984

SOURCE U S Environmental Protect (on Agency *Test Methods* for *Evaluating Solid Waste Physical Chemical Me(hods,* SW 846 2d ed (Washington DC Off Ice of Solid Waste, EPA 19821

In addition, the RCRA test procedures manual indicates that when several chemicals are mixed together, as is usually the case in groundwater monitoring, the ability to detect a specific chemical by a given test procedure is reduced. These analytical interferences raise the detection limits by an undetermined amount.[64] Not being able to detect carcinogens reliably, which can be of concern at very low levels of contamination, is dangerous to human health and increases the likelihood of CERCLA involvement.

The effects of this can be illustrated with the example of ethylene dibromide (EDB). EPA recently has canceled the use of EDB as a fungicide because of its carcinogenicity. In congressional testimony, EPA's pesticide program director said:

> . . . we believe that the risks posed by EDB in drinking water at levels in the low parts per billion are roughly comparable to the risks posed by grain fumigation. In both cases we consider these estimated risk levels to he unacceptable for a lifetime of exposure . . . According to our information, the State of Florida has acted to provide alternative drinking water for approximately 500 wells found to contain EDB at or above 0.1 parts per billion (ppb). This appears to be a responsible and effective way of dealing with these potential risks. In short, the risks of EDB being reported in Florida ground water (typically 1 to 20 ppb) are probably similar to risks posed by grain products .65

EPA does not list a detection level for EDB, but it does list detection levels for 21 other volatile organics. These range from 1.6 to 7.2 parts per billion. Thus, the RCRA tolerance level for EDB might be substantially greater than the 0.1 parts per billion indicated as "responsible" in the EPA testimony quoted above.

In summary, CERCLA is required to address releases of any "hazardous substance, " that is, any substance designated under CERCLA and four other acts administered by EPA, EPA has chosen to have RCRA regulate a narrower universe of substances and many of those are not regulated with the same stringency as in other EPA programs. Therefore, *compliance with a RCRA permit will not necessarily be sufficient to prevent a site from becoming a CERCLA site.* However, proposals being considered by EPA might lower CERCLA requirements rather than increase RCRA ones.

Monitoring in the Vadose Zone

EPA regulations for permitted facilities require that groundwater detection monitoring wells be placed in the uppermost aquifer at the edge of the waste disposal area.[66] Any contaminant detected by the well may first have traveled anywhere from a few feet to several hundred feet under the waste disposal area *before* it reaches the aquifer. Then the contamination may have traveled anywhere from a few feet to several thousand feet in the aquifer before it reached the well, Then, if the leading point

[64] Ibid

[65] Edwin L. Johnson, Director of the Office of Pesticide Programs, U.S. Environmental Protection Agency, testimony before the Senate Committee on Agriculture, Nutrition and Forestry, Jan. 23, 1984.

[66] 40 CFR 264.98(h)

of the plume of contamination is between two monitoring wells, it could travel some distance past the wells before it is detected, Therefore, even if a detection monitoring system works well, considerable environmental damage could occur *before* the contamination is detected.

The vadose zone is the ground above the uppermost aquifer. In humid areas of the United States it is rarely over 100 feet deep and is usually much less. In arid western areas, however, the vadose zone can be several hundred feet deep. Water and associated contaminants from a land disposal facility will travel through the vadose zone to an aquifer at a rate determined by the soil characteristics, the depth of the vadose zone, the amount of fluids in the waste, and the amount of water. It can take anywhere from a few months to many decades.

By the time contamination is discovered in a groundwater monitoring well, the vadose zone could have stored significant amounts of contamination. Thus toxic materials could continue to pollute the groundwater for many decades even if disposal is halted and the groundwater is cleaned. Furthermore, the trend is to require land disposal facilities to be located in areas with low-porosity clay soils, with great depth to groundwater, This may postpone the time it takes contamination to reach groundwater, but also increase the amount of contamination stored in the vadose zone,

Not all contamination that reaches the aquifer is carried away by the groundwater. Some contaminants may be adsorbed on solid surfaces or otherwise contained in the aquifer and gradually released or desorbed in small amounts to pollute the groundwater, One important example is the class of halogenated immiscible hydrocarbons such as paint thinners, pesticides, and PCBs. Thus, by the time this type of contamination is detected in groundwater the vadose zone may be significantly contaminated. Thus it would be useful to detect leachate contamination in the vadose zone beneath a hazardous waste disposal site before it reaches groundwater. It might help avoid the costs of groundwater and contaminated soil cleanup and human health and the environment would be better protected. EPA does require vadose zone monitoring for land treatment of hazardous wastes[67] in the standards for EPA permitted facilities of July 26, 1982. The preamble to the regulations states that "EPA believes that adequate technology and expertise is available to develop effective and reliable systems."[68] Yet in the same regulations vadose zone monitoring is *not* required for landfills, surface impoundments, and waste piles where the need and the benefits would appear to be far greater.

The technology for which there is the most experience in waste disposal monitoring in the vadose zone is the suction lysimeter, a porous ceramic cup placed in the vadose zone to collect a sample of the fluids. In the interim status standards for existing land disposal facilities, EPA rejected the use of lysimeters with this explanation:

> Available leachate monitoring technology generally involves the placement of probes (lysimeters) beneath the disposal facility. Since each probe is not generally capable of monitoring a large area, many of them would have to be placed under a facility in order to detect a localized flaw in the landfill design. It may not be possible to place such devices below an existing landfill or surface impoundment without completely removing the waste and redesigning the facility. Moreover, once such a system is in place, the probes tend to fail over time due to deterioration or plugging. It is difficult to determine when such a failure occurs and, if discovered, the damage is generally irreparable. Under these circumstances EPA does not believe that leach ate monitoring should be a general requirement for landfills and surface impoundments during interim status.[69]

Other commentors have pointed out that lysimeters do not work well in subfreezing or conditions of low soil moisture[70] or very hot and

[67] This method is used for less than 1 percent of wastes that are land disposed; it is also known as land spreading or land farming of wastes.

[68] 47 Federal Register *32329*.

[69] 45 Federal *Register 33191*, May 19, 1980.

[70] Law Engineering Testing Co., "Lysimeter Evaluation Study" (Washington, DC: American Petroleum Institute, 1983).

dry conditions.[71] Are these arguments valid? The first point, that the "probe is not generally capable of monitoring a large area" is contradicted by field experience. Some data indicate that a suction lysimeter located 10 feet below an impoundment could measure a distance of 10 to 30 feet laterally .72 Second, placing suction lysimeters under existing land disposal sites can and has been done by the technique of drilling at a slant. Third, the plugging problem can be largely overcome by packing the sampler with silica flour,[73] a standard technique which appears in EPA manuals.[74] Fourth, the statement that the "damage is generally irreparable" is unclear since what has been placed ought to be replaceable.

As for the other comments, it is not very relevant that lysimeters do not work well in conditions of freezing or low soil moisture since these are not conditions in which there would be much leachate. And as for hot and dry conditions, vadose zone monitoring is currently being conducted in Beatty, Nevada. In any event, it is not necessary that lysimeters work perfectly (no technology does) or that they be convenient to use. The important question is whether they are cost effective in reducing groundwater cleanup costs through early detection of contamination.

Lysimeters have been used for many years for monitoring land disposal sites. At least one State, Texas, uses them for regulatory monitoring. Wisconsin has been requiring vadose zone monitoring since the mid-1970s and there are 19 solid waste sites there with either suction lysimeters or collection lysimeters.[75] California has proposed regulations that would require vadose zone monitoring in new installations.

The U.S. Geological Survey (USGS) has installed suction lysimeters (albeit, not without difficulty) at two existing low-level nuclear waste landfills. This research projected was started by USGS in 1981.76

A 2-year study of three sanitary landfills by the Illinois State Geological Survey placed lysimeters under the existing landfills; all three had contamination in the vadose zone that had not been detected by groundwater monitoring wells.[77] In one site the lysimeters showed that a clay liner had ruptured and in another site lysimeter monitoring showed that contamination detected by a monitoring well was coming from a different site. The researchers did not experience the difficulties reported by EPA,

There is also field experience with geophysical vadose zone monitoring techniques. A commercial hazardous waste disposal facility in Oregon uses a vadose zone monitoring system that "integrates lysimeters, dual purpose tensiometers/lysimeter units, and geophysical arrays to provide an early warning leak detection and sampling system."[78] A firm in Las Vegas has installed three resistivity grids since 1980 at hazardous waste lagoons, and they are all reported to be working well.[79]

Many techniques available for monitoring in the vadose zone for both new and existing land disposal facilities have been evaluated. In 1980, the University of Arizona Water Resources Research Center reviewed a number of techniques for vadose zone monitoring below waste disposal sites for EPA.[80] Many of these are

[71] 'I'f'r r\ 1,. Thoem, Conoco Inc., letter to U.S. Environmental Protection Agency docket for regulations of July 26, 1982 (47 FR 32274), docket No. PLDF II 090.

[72] Robert D. Morrison, Kenneth A. Lepic, and John A. Baker. "Vadose Zone Monitoring at a Hazardous Waste Disposal Facility," paper presented at the conference *Characterization and Monitoring in the Vadose Zone* sponsored by the National Water Well Association, Las Vegas, NV, Dec. 8-10, 1983.

[73] Dr. L. G. Everett, Kamen 'Tempo, private communication, Mar 23, 1984.

[74] L. G. Everett, L. G. Wilson, and E. W. Hoylman, "Vadose Zone Monitoring for Hazardous Waste Sites," performed under contract No. 68-03-3090 for the U.S. Environmental Protection Agency (Santa Barbara, CA: Kamen Tempo), pp. 5-63.

[75] Peter h met, Wisconsin Department of Natural Resources, private communication, Mar. 20, 1984.

[76] Dr. John B. Robertson, U.S. Geological Survey, private communication, Mar. 23, 1984.

77 Thomas M. Johnson and Keros Cartwright, *Monitoring Of Leachate Migration in the Unsaturated Zone in the Vicinity of Sanitary Landfills*. Circular 514 (Urbana, IL: State Geological Survey Division, Illinois Institute of Natural Resources, 1980).

[78] Morrison, et al., op. cit.

[79] Dr. Robert Kaufmann, Converse Consultants, Las Vegas, NV, private communication, Mar. 20, 1984.

[80] L. G. Wilson, *Monitoring in the Vadose Zone: A Review of Technical Elements and Methods s*, EPA-600/7-80-134 (Las Vegas, NV: U.S. Environmental Protection Agency, June 1980),

commercially available and are in common use. Another survey for EPA evaluated state-of-the-art techniques and techniques under research or development that are capable of localizing liner leaks.[81]

EPA, in rejecting the use of vadose zone monitoring in 1982, referred to the University of Arizona work but discussed only one of the 26 techniques evaluated, the suction lysimeter.[82] This technique was rejected largely because of cost, although no analysis was made of the trade-off of avoiding the cost of cleaning the contaminated groundwater. The many applications of vadose zone monitoring were not reviewed. The extent to which the requirements in the reauthorized RCRA for leak detection systems might lead EPA to require vadose zone monitoring is not clear.

Vadose zone monitoring techniques are not generally easy to use nor are they inexpensive. No one technique is universally applicable and to get a reasonable assurance of detecting leachate, several may have to be used at any given site. However, the techniques for groundwater monitoring are also difficult, fallible, and expensive. The cost of cleaning groundwater can be tens of millions of dollars, depending on the amount of contamination. Thus, even if the technology for vadose zone monitoring is more difficult and less reliable than groundwater monitoring there can be substantial benefits from detecting pollution early.

Delays in Starting Corrective Action

Under the Part 264 EPA standards for EPA permitted facilities in a detection monitoring mode,[83] if hazardous constituents are detected by the groundwater monitoring system a "compliance monitoring" program must be instituted. This program consists of two parts, First, the EPA permit writer will establish a "groundwater protection standard" for the unit, which will be specified in the permit for the facility. Second, a new groundwater monitoring program will be instituted to determine whether the unit is in compliance with its groundwater protection standard. This new program will consist of monitoring at the compliance point, i.e., the edge of the disposal area, to detect any statistically significant increase in the concentration levels of hazardous constituents.

The groundwater protection standard includes the hazardous constituents to be monitored or removed if necessary, the concentration limits for each hazardous constituent that trigger corrective action, the "point of compliance" for measuring concentration limits, and the compliance period,

The regulations require that the concentration limits be set at the background level of the constituent in the groundwater or the maximum concentration limits for drinking water established for any of the 16 hazardous constituents covered by the National Interim Primary Drinking Water Regulations, The facility owner may ask for a variance to establish an alternate concentration limit (ACL) if he can demonstrate that the constituent will not pose a substantial present or potential hazard to human health or the environment.

If the groundwater protection standard is exceeded, then another step, the corrective action program, is instituted. This program attempts to bring the facility into compliance with the groundwater protection standard by removing the hazardous waste constituents from the groundwater or treating them in the aquifer. The regulations require that corrective measures be taken to clean up the plume of contamination that has migrated beyond the compliance point but not beyond the property boundary.

Earlier it was shown that even in a well designed and properly functioning groundwater detection monitoring system, a long time (even, in some cases, decades) could elapse before contamination from a leak from a hazardous waste disposal site reached a detection monitoring well. However, because of the structure

[81] M. J. Waller and J. L. Davis "Assessment of Techniques to Detect Landfill Liner Failings, " *Land Disposal of Hazardous Waste*, EPA-600 /9-82-002 (Cincinnati, OH: Municipal Environmental Researc h Laboratory, March 1982), p. 239.

[82] U.S. Environmental Protection Agency, "Summary and Analysis of Comments (40 CFR Part 264, Subparts F, K, L, M and N)" (Washington, DC: Office of Solid Waste, July 9, 1982), p. 72.

[83] 40 CFR Part 264, Subpart F.

of the EPA regulations, a long time could also elapse between the time the contamination reaches a monitoring well and the time anything is done about it. Table 5-14 shows a scenario where this elapsed time is over 2 years. This example does not present a "worst case" scenario, but simply illustrates times required

Table 5-14.—Scenario for Instituting Corrective Action at a RCRA Permitted Site in Detection Monitoring

Jan. 1, 1984. —Contamination reaches groundwater detection monitoring well.

Apr. 1, 1984. —Sample is drawn from monitoring well. Well must be sampled semi-annually (40 C.F.R. 264.98(a)). Assume average time to detect contamination is 3 months,

May 1, 1984. —Determination is made that there is a statistically significant increase over background. This determination must be made "within a reasonable time period" (264,98(g)(2)). Assume 1 month, however, discussion in next section will show this is optimistic.

Aug. 1, 1984, —Submit request to EPA for permit modification to establish compliance monitoring program. This must be done within 90 days (264.98(h)(4). Include notice of intent to seek a variance for alternate concentration limits under part 264.98(b) (264.98 (h)(4) (iv)).

Nov. 1 1984.—Submit data to justify variance under part 264.94(b) for every hazardous constituent identified under part 264.98(h)(2), This must be done within 180 days of the time that a determination is made that there is a statistically significant increase over background (264.98(h)(5)(ii)(B)).

Mar, 7, 7985. —EPA rejects request for variance and issues draft revised permit for compliance monitoring. No time limit specified in the regulations. Assume it takes 4 months for EPA to review the data and prepare a draft permit. Notice is given for public comment.

Apr. 15, 1985.—End public comment period. Regulations require 45 days (124.10(b)).

May 15, 1985. —EPA issues revised draft. No time limit specified in regulations. Assume it takes EPA 1 month to review public comments and revise permit accordingly. Compliance monitoring begins.

Aug. 15, 1985.—Submit request to EPA for permit modification to establish corrective action program. This must be done within 90 days (264.99(i)(2) and 270.14(c)).

Sept. 1, 1985. —Submit engineering feasibility plan for corrective action program. This must be done within 180 days of the time that the request for variance is rejected, i.e., Mar. 1, 1985 (264,98(h)(5)(ii)).

Dec. 1, 1985. —EPA issues draft revised permit for corrective action. No time limit specified i n the regulations. Assume it takes 4 months for EPA to review the data and prepare a draft permit. Notice is given for public comment.

Jan. 15, 1986. —End public comment period, Regulations require 45 days (124.10(b)).

Feb. 15, 1986. —EPA issues revised permit. No time specified in the regulations. Assume it takes EPA 1 month to review public comments and revise the permit, Corrective action begins,

Total **elapsed time: 2** years 1½ months not including delays from statistical analysis.

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to work through the many steps prescribed by the regulations.

The action required is that the plume of groundwater contamination be cleaned up from the edge of the disposal area to the property line. *There is no requirement to find the source of the leak and to repair it; and there is no requirement t to stop disposal operations.*

Statistical Analysis

Contamination in a well must be shown to be a statistically significant increase over background levels, But doing this within 1 month (see table 5-14) is very unlikely,

In sampling groundwater, there is considerable variability due to factors other than the introduction of waste-related contamination. These include seasonal fluctuations, geochemical processes, perturbations introduced by the monitoring well, contamination or other changes introduced by the sampling technique, natural and nonwaste contamination, variability in chemical analysis, and a great many others. It is necessary to distinguish changes in groundwater due to contamination from those due to random or periodic effects. The EPA regulations for both Part 264 and Part 265 state that when a sample of the groundwater is taken from a monitoring well and analyzed for the required contaminants, the results should be compared with the previously determined background levels to see if there is any "statistically significant" increase in contamination .84 Statistical significance is determined by one of several mathematical formulas approved by EPA.

There are four possible outcomes from such a calculation:

1. The test could indicate that groundwater is contaminated when in fact it is not (false positive),
2. The test could indicate that groundwater is contaminated when in fact it is (true positive).
3. The test could indicate that groundwater is not contaminated when in fact it is (false negative).

[84] 40 C.F.R 264.97(h) and 265.93(b).

4. The test could indicate that groundwater is not containinated when in fact it is not (true negative).

A test for statistical significance attempts to minimize the false positives and the false negatives. This can be done by increasing the sample size, i.e., by increasing the number of monitoring wells, the frequency of sampling, and the number of samples taken. But for a given sample size, any test of statistical significance that reduces the probability of false negatives also increases the probability of false positives and vice versa.

There are two ways to design a test for statistical significance. One is to decide in advance the probability of detecting groundwater contamination one wishes to achieve (the probability of detection being one minus the probability of a false negative). In this case the probability of a false positive will be a function of the sample size and the variability of the data. Another way is to determine in advance the probability of a false positive and allow those same factors to determine the probability of detection. In the former case the probability of a false positive will not be known in advance and in the latter case the probability of detecting contamination will not be known in advance, EPA has chosen the latter approach.

The cost of a false positive could be several thousand dollars; e.g., the cost of additional sampling and testing to establish that there is actually no contamination. The cost of a false negative, groundwater contamination that goes undetected, could be large additional cleanup costs and increased threats to human health and the environment. And if the owner cannot afford the necessary corrective action, the site might become a candidate for CERCLA action. Minimizing the occurrence of false positives reduces the short-range costs of disposal site operators but OTA found no mention in any EPA document of why this approach was chosen over the other.

EPA proposed standards for monitoring interim status sites on December 18, 1978,[85] which included a statistical test with a probability of false positives (the level of significance] of 5 percent. In the final regulations adopted in 1980, EPA decreased the probability to 1 percent, But this *increased* the probability of false negatives. In the preamble of the regulations,[86] it is implied that the change was made because of industry concerns over the cost of a false positive. There does not seem to have been an attempt to balance this against the cost of false negatives borne by industry and the public.

In the 1982 regulations for EPA permitted sites, EPA raised the probability of false positives to 5 percent once again, explaining:

> EPA is fixing the level of significance for the Student's t-test at 0.05 for each parameter at each well. When the Agency proposed this significance level for interim status ground-Water monitoring, it received some criticism that this would produce too many notifications of contamination where none had actually occurred.
>
> EPA recognizes that this could be a problem, particularly when there are many comparisons being made for different parameters and for different wells. However, EPA is concerned that a lower significance level would unduly compromise the ability to detect contamination when it did, in fact, occur.[87]

EPA did not, however, raise the probability of false positives from 1 to 5 percent at the interim status sites. No explanation was given for not including interim status facilities in this decision,

OTA has tried to find an estimate by EPA of the probability of detecting groundwater contamination by this statistical procedure. While EPA documents contain many discussions and calculations of false positives, OTA could not find an estimate of the probability of a false negative. The only related material is a study for EPA that was to "estimate the false positive and false negative probabilities for various statistical procedures."[88] However, the study esti-

[85] 43 Federal Register 58982.

[86] 45 Federal Register 33195.

[87] 47 Federal Register 32303.

[88] RB Associates, "Evaluation of Statistical Procedures for Groundwater Monitoring" in U.S. Environmental Protection Agency, *Ground-water Monitoring Guidance for Owners and Operators of Interim Status Facilities*, SW-963 (Washington, DC: Office of Solid Waste and Emergency Response, March 1983).

mated the probabilities of false negatives for only one statistical procedure, and that one is not the one that EPA uses.

More recently, EPA has acknowledged that:

> . . . the t-test, as it is currently being applied, is ill equipped to deal with the very small data sets being generated . . . nor can it effectively handle the wide and largely unknown variabilities due to spatial, temporal, sampling, and analytic problems.[89]

The conference report for the recently reauthorized RCRA that deals with surface impoundments notes that in addition to a statistically significant increase over background concentrations "other evidence of leaking, such as visible leaks or sudden drops in liquid level of the impoundment, also would be sufficient,"[90] It is not clear, however, to what extent EPA might act on this use of adjuncts to statistical analysis.

Compliance Monitoring

Compliance monitoring at permitted facilities measures the degree and extent of the ground water contamination. Results are especially important in designing and evaluating corrective actions. Such monitoring is difficult and expensive:

> In a typical case . . . determining the extent and severity of a plume emanating from one single source in a shallow aquifer requires dozens of monitoring wells and hundreds of samples. It also takes a great deal of time and several hundred thousand dollars. If the geology is more complex or several potential contamination sources exist, the cost will be on the order of half a million dollars. In a case where the aquifer is deep or surface features cannot help in determining the hydrogeology, costs could soar to $2 or $3 million.[91]

Here again, as with the placement of the monitoring wells, the science of hydrogeology enters, but with the additional requirement to model and predict underground *contaminant flow*. Such modeling is not a routinely available technique like well drilling or chemical analysis; it is state-of-the-art scientific research generally carried out by universities and a few companies. Where modeling groundwater flow is possible, predicting contaminant flow may still be very difficult if possible at all (see the section on the vadose zone in this chapter]. As pointed out in **1982**:

> It is not presently possible to determine how thousands of individual chemicals will react in the groundwater environment or to confidently predict the aggregate effects of numerous processes such as attenuation, dispersion, and diffusion. A vast amount of field data would be required to develop a reliable basis for such predictions.
>
> It is frequently suggested that modeling could serve as an adequate predictive tool for this purpose. However, even detailed investigations which might cost on the order of $250,000 to $500,000 per site may not provide enough data to develop a model to be used in this capacity. Furthermore, a relatively successful model based on adequate data can only be expected to yield results within an order of magnitude of the actual situation. This level of accuracy may not be acceptable when public health is at risk and critical concentrations are measured in parts per billion.
>
> The process of obtaining the data for predicting ground water conditions, interpreting the information and making accurate decisions to implement compliance monitoring is a scientific endeavor. It can only be carried out in a confident manner by well trained groundwater technicians. There is presently a severe shortage of trained groundwater scientists in the public and private sector, and it is doubtful that there is sufficient talent available to work on more than a relatively small percentage of the existing sites that would fall under the compliance monitoring aspects of the new hazardous waste regulations.[92]

[89] U.S. Environmental Protection Agency, "Interim Status Ground-Water Monitoring Implementation Study," op. cit.

[90] U.S. Congress, Report 98-1133, p. 99.

[91] Swep T. Davis, Associate Assistant Administrator for Water and Waste Management, U.S. Environmental Protection Agency, statement before the joint hearing of the Subcommittee on Health and the Environment and the Subcommittee on Transportation and Commerce, Aug. 22, 1980.

[92] David W. Miller, Geraghty & Miller, In testimony before hearing of the House Subcommittee on Natural Resources, Agriculture Research and Environment, Nov. 30, 1982.

EPA seems to understand these shortcomings for modeling and predicting contaminant flow. The preamble to the regulations states:

> The way to meet this objective [of protection] is to avoid regulatory schemes that principally rely on complicated predictions about the long term fate, transport, and effect of hazardous constituents in the environment. Such predictions are often subject to scientific uncertainties about the behavior of particular constituents in the hydrogeologic environment and about the effects of those constituents on receptor populations.[93]

However, the RCRA permit writers' manual in its instructions for evaluating the design of a corrective action program takes a somewhat different view of the capability of hydrogeology in predicting contaminant flow:

> Predictions of groundwater flow patterns throughout the contaminated areas, including the drawdowns and hydraulic gradients, that will be established by the recovery system should be provided. On the basis of predicted withdrawal rates, estimates should be provided for the time required to exchange an amount of groundwater equivalent to that originally contaminated,
>
> The applicant will need to use either analytical solutions or numerical (computer) models to provide these predictions of the response of groundwater on site to the proposed recovery system.

To summarize, the *requirement that compliance monitoring predict plume movement is a regulatory requirement t that depends on a technology which does not really exist. Thus, EPA is putting more reliance on state-of-the-art technology to clean up pollution than it does to prevent pollution.*

Corrective Action

Corrective action regulations for permitted facilities require that contaminated groundwater be cleaned to background levels. Background contaminant levels can be, and frequently are, extremely low if they are known at all. The regulations require technology which is capable of removing contaminants to below the level of detection. But again, the corrective action requirements ask for technology that does not really exist. This is acknowledged by EPA in the preamble to the regulations which states:

> . . . the technology of performing corrective action is new. The Agency's and the regulated community's experience in conducting remediation activities (beyond the feasibility study stage) is fairly limited to date.[94] The standards are based on the hope that technology will become available in the future as stated in the preamble. The national experience with groundwater cleanup . . . is relatively limited at this time. EPA expects that over time, the state of knowledge about groundwater cleanup measures will improve.[95]

The most comprehensive study of attempts to clean up sites where groundwater had been polluted was made by EPA in 1980.[96] This was a study of 169 hazardous waste sites requiring remedial action. Groundwater was polluted at 110 sites. In most cases the groundwater supply was abandoned and replaced by a pipeline to another source. In very few cases, because of the high costs, was there any attempt to clean up the groundwater, and none were cleaned to background levels.

Although experts have little experience in restoring polluted groundwater to below detection levels, some attempts have been made to restore groundwater to some degree. It is difficult, very expensive, and the results have been mixed. Typically, treatment of a plume is considered adequate when levels of volatile organics are at or below 100 µg/l. Operating costs for a single site can run over a million dollars a year for 20 or 30 years. One expert summed up the situation:

> Substantial efforts are now being made to reclaim polluted groundwater. In the southwestern U. S., where highly prolific alluvial aquifers are common, a number of problems

93 47 Federal Register 32283

94 47 Federal Register 32313.

95 47 Federal Register 32286.

96 N. Neely, D. Gillespie, F. Schauf, and J. Walsh, U.S. Environmental Protection Agency, *Remedial Actions at Hazardous Waste Sites: Survey and Case Studies*, EPA 430/9-81-05, SW-91O (Washington, DC: Oil and Special Materials Control Division, January 1981).

can be encountered when attempting to reclaim polluted groundwater. First, many of the zones of polluted water are large—often in the range of thousands or tens of thousands of acre-feet. This results in the need to pump substantial amounts of water, which must then be treated and/or disposed. Decades will be required to remove polluted water in many situations. Second, pumpage of groundwater for reclamation often has legal constraints. Third, land ownership often presents a formidable problem, because polluted zones frequently extend beyond property controlled by the responsible entity. Fourth, relatively deep water levels usually allow substantial amounts of pollutants to be in the vadose zone, where pumping is not effective. Fifth, pumping schemes are inherently inefficient in heterogeneous, non-isotropic alluvial aquifers, due to inflow of unpolluted water during pumping. Because of the many limitations of reclamation, groundwater quality management should focus on aquifer protection.[97]

The regulations permit two basic corrective approaches. The first is to pump out the contaminated groundwater. This is not always simple:

> in very arid portions of the country, groundwaters are generally located well below the ground surface. Therefore, it may be extremely difficult, if not impossible, to pump such underground waters. In complex geologic environments, contaminants may perch on clay layers, In such circumstances, even if pumping of surrounding waters were possible, such pumping would not succeed in bringing contaminants to the surface. In addition, in these circumstances, the depth of the contaminant layer may prohibit trenching to reach the contaminants . . . Shallow aquifers may not have sufficient waters to permit effective pumping. In addition, certain tight clay formations may prohibit effecting pumping from shallow aquifers. In these circumstances, if excavation is not possible, it is impossible to remove all contaminants.[98]

The EPA RCRA permit writers' guide recognizes these difficulties and gives technological approaches for handling them. Where there is insufficient groundwater for efficient pumping, then fresh water must be injected into the aquifer by injection wells to flush out the plume of contamination. But the plume itself is the lesser problem:

> . . . the removal of additional amounts of water, frequently many times in excess of that originally contaminated, will be required to reduce contaminant concentrations to acceptable levels . . . Many of the hazardous constituents present in any plume of contamination migrating from a hazardous waste management facility will likely be subject to some amount of adsorption to the geologic materials on site . . . as contaminated groundwater is removed from the subsurface and replaced by water of lower contaminant concentrations, contaminants will desorb from subsurface solids and establish new equilibrium concentrations of contaminants in the groundwater. Thus, the process of restoring groundwater quality will become a process, in most cases, of not only removing contaminants originally present in groundwater but also of removing contaminants adsorbed to subsurface solids.

The expensive process of pumping huge amounts of water for decades does not guarantee that cleanup standards will be met. The issue of whether EPA will insist on full compliance with its standards when faced with such costs becomes important. In addressing such public concerns, an EPA official wrote: "It may be costly and take decades, but it can be done and under the regulations the owner is required to undertake it."[99] However, EPA's instructions to their permit writers are less optimistic:

> . . . the permit writer should also consider the relative costs of these measures when determining the adequacy of flushing rates predicted for proposed recovery systems. In-

[97]Kenneth D. Schmidt, "Limitations in Implementing Aquifer Reclamation Schemes," paper presented at *Third National Symposium on Aquifer Restoration and Groundwater Monitoring* sponsored by the National Water Well Association, Columbus, OH, 1983.

[98]"Comments on Interim Final Hazardous Waste Regulations Promulgated by the United States Environmental Protection Agency Pursuant to Sections 3004 and 3005 of the Resource Conservation and Recovery Act, Docket 3004, Permitting Standards for Land Disposal Facilities" (Washington, DC: The American Petroleum Institute, Nov. 23, 1983].

[99]Lee M. Thomas, Assistant Administrator, U.S. Environmental Protection Agency, letter to Senator Robert C. Byrd, Dec. 30, 1983.

creasing flushing by increasing pumping rates and the number of wells, well points, and/or drains will certainly increase the costs associated with the recovery system. Similarly, requiring the use of injection wells and/or increasing their number and rates of injection will increase cost. In some cases, particularly as flushing rates become higher, the cost of increasing flushing rates by requiring these design changes will become disproportionally high relative to the additional flushing achieved and the advantages gained.

Thus, the permit writer will need to balance a number of factors when reviewing the adequacy of flushing rates expected from a proposed recovery system.

The EPA permit writers' guide also points out many problems that may be encountered in attempting corrective action and it does not have solutions to all of them. For example, the problem of cleaning up immiscible fluids is poorly understood.

Once contaminated water is pumped out of the ground, something must be done with it. One solution is to remove the contaminants and return the cleaned water to the aquifer. This has been tried at some CERCLA sites. Table 5-15 shows some examples of the kind of levels of cleanup that can be practically (albeit at great cost) achieved using the most common techniques. Although impressive, these results are far from background levels, and are higher than generally accepted safe levels.

A second technology that the RCRA groundwater protection standards allow for corrective action is "in situ" treatment. This is the introduction of chemical or biological agents into the aquifer to react with and destroy the hazardous constituents. If anything, even less is known about these technologies than those discussed above, as the permit writers' guide points out:

> ... to date in situ treatment has been applied in only limited circumstances, and little experience is available that can be related directly to the cleanup activities required in Part 264 corrective actions programs. In most cases, use of' these techniques will assume the character of a field experiment.

Table 5.15.—Removal of Selected Specific Organics From Groundwater

Organic compound	Process effluent concentration range[a]		
	Adsorption	Stripping	Biological
phenol	**<10**	—	10-50
toluene	<100	<10	10-50
benzene	<50	<10	1o-1oo
ethyl acetate	—	—	10-20
formaldehyde	—	—	50-100
aceton	—	—	10-20
methyl ethyl ketone	—	25,000	10-20
aniline	<10		10-50
nitroaniline	50-100	-	10-50
methanol	—	15,000	10-50
isopropanol	—	10,000	10-50
isobutanol	—	40,000	10-50
methylene chloride	<100	200	<50
trichloroethylene	<10	5-1o	<10
1,1 ,1-trichloroethane	<10	50	10-50
1,1,2-trichloroethane	<10	50	10-50
tetrachlorethylene	5-1o	5-1o	10-200
nitrobenzene	<10	—	100-1,000

[a]Note: All values in µg/l or ppb.

SOURCE: J. R. Absalon and M. R. Hockenbury, "Treatment Alternatives Evaluation for Aquifer Restoration" (paper presented at the Third National Symposium on Aquifer Restoration and Groundwater Monitoring sponsored by the National Water Well Association, Columbus, OH, May 19s3).

The purpose of this discussion is not to condemn available technologies for cleaning up contaminated aquifers. However, it is possible to see the predicament facing a facility operator with a need to take corrective action. To abandon his facility, thus making it a Superfund site, may seem an attractive option.

Estimating Future Needs

Data to Illustrate the Scope of the Problem

About 2,000 hazardous waste land disposal facilities required to conduct groundwater monitoring have filed for interim status. Many more may require regulation, particularly surface impoundments. (Note that injection wells are regulated under another statute and not by the RCRA groundwater protection standards although they are used for hazardous waste disposal.) Various EPA data provide some indication of the number of hazardous waste management facilities that might threaten groundwater: surface impoundments, 770; landfills, ZOO; injection wells, 700; land treatment, 70; waste piles, 170; and storage and treatment tanks, 2,040.

OTA has analyzed the data from EPA's 1981 study of waste management to examine the extent 'to which land disposal facilities receive toxic hazardous wastes. Toxic wastes present long-term chronic health risks and are to be contrasted with wastes that are hazardous only on the basis of characteristics such as reactivity, ignitability, and corrosivity. The *data indicate that a significant t fraction—perhaps a majority—of the wastes being placed in land disposal facilities nation wide are toxic chemicals that would pose long-term health problems if released into the environment.* For surface impoundments and landfills almost all the wastes may be toxic, while for injection wells about one-third of the wastes ma}' be toxic.

Number of Future NPL Sites

Planning needs to take into account the possibility that currently operating RCRA hazardous waste facilities will become future NPL sites. The reasons are:

- Hazardous waste land disposal facilities have a poor record of performance. They continue to be used for toxic materials posing long-term problems. Even with the many changes in the recent RCRA reauthorization, including the *eventual* limits on some land disposal, low' -cost land disposal will remain widely used for some time.
- The current groundwater protection standards are so inadequate that, even with perfect compliance, the} would not *prevent* the release of hazardous substances from many of the facilities they cover. Releases are unlikely to be detected early enough in all cases to limit contamination to levels that would or could be effectively cleaned up by RCRA facility operators.
- One important consequence of the reauthorized RCRA may be to hasten the closing of the worst hazardous waste facilities. Man\ owners and operators may escape near-term and possibly long-term responsibility for cleaning up sites that have serious enough problems to eventually place them on the NFL.

As indicated earlier, it is possible only to estimate the number of facilities that might become future NPL sites. On the basis of the analysis in this chapter, OTA believes that a reasonable estimate is that at least half of the approximately 2,000 operating hazardous waste facilities that are or should be subject to RCRA groundwater protection standards will become NPL sites. Many more sites may require cleanup, but they might be cleaned *up* by their *owners* or users.

THE SITE SELECTION PROCESS

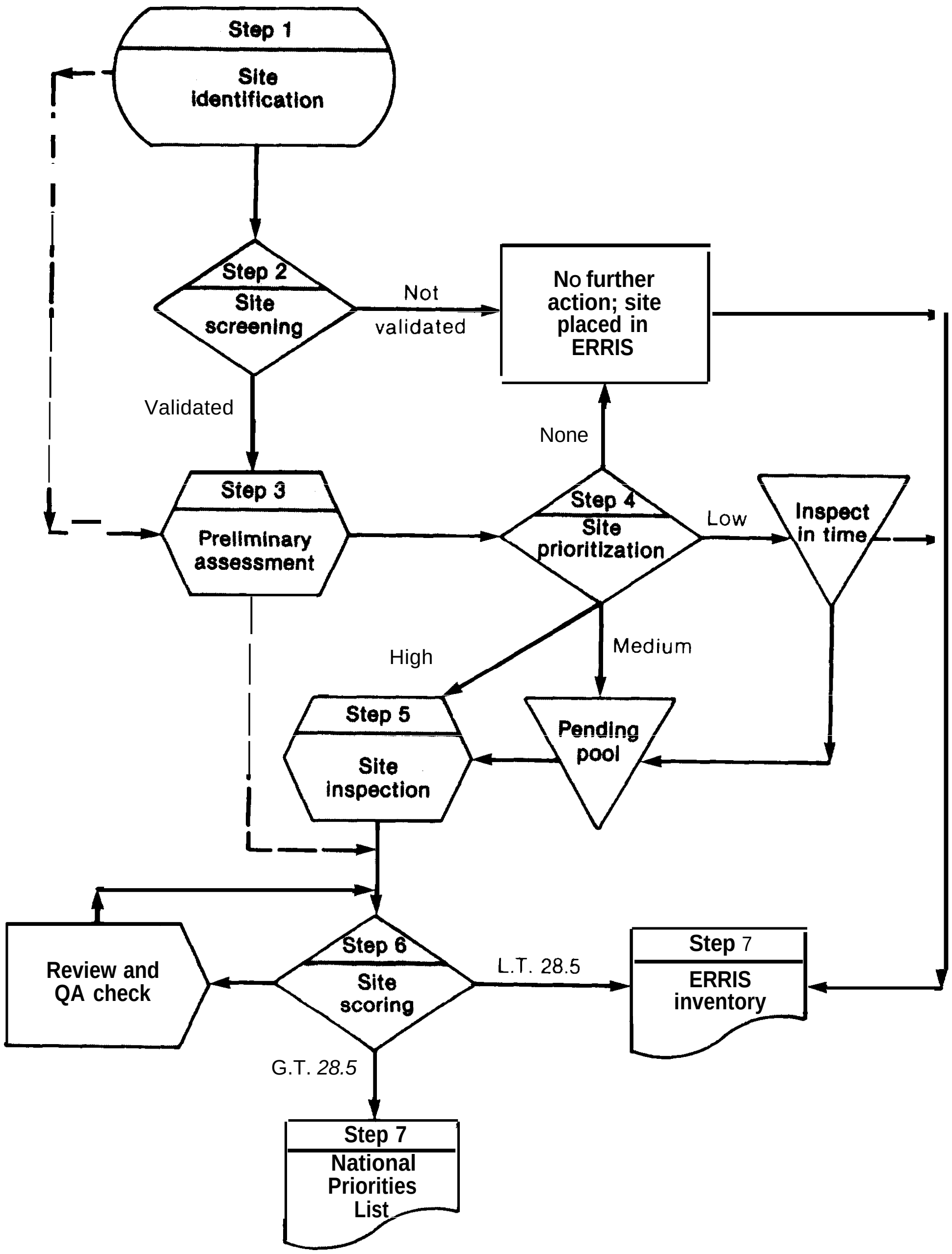
This section describes EPA's current process for selecting sites for the NPL (figure 5-I]. This process was analyzed to ascertain the likelihood that sites that merit cleanup will not be placed on the NPL.

Site Identification

There is a large backlog of about 12,000 sites, that have not y& been evaluated. Efforts to discover sites have slowed. For the most part, States do not have the resources for site identification, and Federal resources are not being supplied. EPA policy is to place highest priority on evaluating already identified sites. Only a few States, including New York, Michigan, and California, have developed programs to identify additional sites, However, even without emphasis on discovering new sites, the national inventory has been growing steadily, to about 19,000 by late 1984.

The argument has been made that the vast majority of the worst sites have been identified. But there are likely to be older, abandoned sites

Figure 5.1 .—Summary Site Scoring Flowchart



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and sites that pose indirect environmental hazards that have not been identified.

Setting Priorities for Sites

As a result of the "desk-top" preliminary assessment (PA) based on known information, priorities for subsequent actions at the site are established. Each site is given a high, medium, low, or no priority ranking. Without priority, a site is retained in EPA's basic site inventory, ERRIS (Emergency and Remedial Response Information System), High-priority sites are immediately inspected; the others wait their turn, Sites with low priority are unlikely to get attention. (Although some States may request inspection of low-priority sites, this does not yet appear to be happening.) Documentation is required only if a low or no priority status is assigned, There are no national EPA guidelines or criteria for setting priorities, The process is subjective, rests on professional judgment, and provides little assurance of consistency among EPA Regions or States. No national data are available on the numbers of sites in the various priority categories. On most occasions, little attempt is made to verify the completeness or accuracy of the information upon which the priority judgment is made.

Although States usually conduct PAs, regional EPA offices, EPA contractors, and Field Investigation Teams (FIT), also conduct them. The States are supposed to perform this task to a greater extent in the future. For fiscal year 1985, EPA has budgeted $1,800 per PA for State work. An example of the type of guidance provided by some Regions is given in figure 5-2 for EPA Region 5. The guidance is minimal. In addition, as a practical matter, sites that do not affect a large population are less likely to receive a high priority, even though they may present serious hazards,

Figure 5-2.— Region 5 Prioritization Criteria

High priority for inspection	**1. Known hazardous waste onsite.** **and** **2. Known contamination of surface, water, groundwater, or air,** **or** **Potential to affect large population**
Medium priority for inspection	1. Known or suspected hazardous waste onsite. and 2. Potential to contaminate surface water, groundwater or air, or Potential to affect any population.
Low priority for inspection (pending)	1. Known or suspected hazardous waste onsite, and No potential to contaminate surface water, groundwater, or air, and No potential to affect any population. 2. Site has been or is being evaluated and State is taking action. 3. No known hazardous waste onsite, but the potential exists.
No further action	1. No hazardous waste onsite. 2. Site has been cleaned up. or 3. Hazardous material onsite, but handled correctly. Complete documentation needed to justify

SOURCE Office of Technology Assessment

Site Inspections

Most site inspections (SIs) are conducted by EPA FIT contractors with the purpose of obtaining data to evaluate and score the site to determine its eligibility for placement on the NPL. SIs involve considerable field work, often with limited sampling and analysis. For fiscal year 1985, EPA has budgeted $16,800 per SI for State work. The order in which sites are inspected does not necessarily reflect the priorities assigned in the earlier step. Instead, inspection schedules take into account geographic distribution and other logistical factors. Within the same region, the completeness of the information entered into the S1 form varies considerably according to who conducted the inspection, prior known facts about the site, suspected hazards, and other factors. The lack of detailed guidance can lead to data voids or inaccuracies that can have an important effect on site scoring.

Site Scoring

Sites are scored by an established procedure called the Hazard Ranking System (HIM), which can be regarded as a crude hazard or risk assessment. An initial scoring is conducted by the State, the region, or the FIT. There are reviews at the EPA regional and headquarters levels, with EPA headquarters assigning the final score. All the facts provided in the file are assumed correct. The cutoff score of' 28.5 was chosen to provide an original NPL of 400 sites, the minimum required by statute. *EPA has retained this cutoff for administrative convenience and consistency over time, even though there is no technical justification for believing that sites with lower scores do not merit cleanup.* Sites designated by States as their highest priority site are examptcd from the cutoff. As of September 1984, only seven sites with scores less than 28.5 were on the NPL.

The H KS methodology has been critized elsewhere, and the major problems will be summarized only briefly here.[100] The final score is a composite of' three migration route scores for groundwater, surface water, and air. Some of the major problems with the HRS are:

- There is a very strong bias toward human health effects, with little chance of a site getting a high score if there are primarily environmental hazards or threats.
- For human health effects, there is a strong bias in faker of high affected populations.
- For the air route there must be documentation (e.g., laboratory data) of' a release, but there is no such requirement for the water routes.
- Scoring for toxicity/persistence may be based on a site contaminant, which is not necessarily one with a known or potential release.
- A site with a very high score for one migration route but zero or very low scores for the other two routes can get a relatively low total score, while a site with moderate scores for all three routes might get a higher score; in other words, averaging the route scores creates a bias against a site with one particularly important hazard.
- Only the quantity and not the distribution of waste is considered, even though similar quantities over markedly different areas pose different threats.

Variability Among EPA Regions

Table 5-16 presents data, arranged by EPA Region, on a number of aspects of the site selection process. No matter what statistic is examined, there is considerable variability among the Regions. Some examples are:

- The percent of ERRIS sites that have become NPL sites varies from 1.1 percent (Region 7) to 5.3 percent (Region 2],
- The percent of the national ERRIS inventory by Region varies from 3 percent (Region 8) to 20 percent (Region 5).
- The percent of the national NPL by Region varies from 3 percent (Regions 7 and 8) to 26 percent (Region 5).
- Several Regions have a high fraction of' NPL sites compared to ERRIS sites (Regions 1, 2, 3, and 5). Two Regions have much smaller fractions of the NPL sites compared to ERRIS sites (Regions 6 and 7).
- For fiscal year 1985, plans to perform PAs as a fraction of the Regional ERRIS number varies from 4 percent (Region 6) to 38 percent (Region 8).
- For fiscal year 1985, plans to perform SIs as a fraction of the Regional ERRIS number varies from 1 percent (Regions 5 and 7) to **7** percent (Region 10).

[100] See *Workshop on Selection of Hazardous Waste Sites for Superfund*, U.S. Senate Committee on Appropriations, March 1982.

Table 5-16.—Site Selection Variability Among EPA Regions

	ERR IS		% of national total		FY 85 Preliminary Assessments (PAs)			FY 85 Site Investigations (SIs)			FY 85 PA/SI Total	
Region	Number	% NPL	ERR IS	NPL	Number	(%, ERRIS)	$(000)	Number	(% ERRIS)	$(000)	$(000)	% Total
1 . .	937	4.8	5	8	240	(26)	432	55	(6)	921	1,353	7
2 .	2,313	5.3	12	23	NA	NA	NA	NA	NA	NA	1,775	10
3 .	1,741	3.4	9	11	NA		NA	NA	NA	NA	1,820	10
4	3,423	19	18	12	1,135	(33)	2,043	190	(6)	3,183	5,226	28
5	3,689	38	20	26	1,295	(35)	2,331	25	(1)	419	2,750	15
6	2,289	1.3	12	5	100	(4)	100	100	(4)	4	1.869	10
7	1.318	11	7	3	290	(22)	522	10	(1)	168	690	4
8	576	31	3	3	220	(38)	396	15	(3)	251	647	3
9	1,388	19	7	5	NA	NA	NA	NA	NA	NA	805	4
10 :	878	2.4	5	4	260	(30)	468	65	(7)	1,088	1.556	8

SOURCE Office of Technology Assessment using data from various EPA documents

- Regions 4 and 10 appear to have planned for a large PA/S I effort for fiscal year 1985 as compared to their fraction of the national ERRIS sites. Conversely, Regions 5, 7, and 9 have relatively small efforts compared to their fraction of the national ERRIS sites.

Data on variations in total and component H KS data for EPA Regions and the Nation are given in table ,5-17. While the variation among total scores for the regions is not great, there are considerable variations for the component scores. This suggests problems in the Hazard Ranking System.

In particular, for most regions the air route scores are very low, with the notable exceptions of Regions 1 and 6 which have relatively high scores with high correlations of those scores with the total scores. To ascertain the extent and significance of the national variability in air scores, a more detailed analysis was done; the results are given in table 5-18.

In examining the number of' sites with a nonzero air score, it is seen that Regions 4, 5, and 9 have relatively low fractions. For all 1-legions, 20 percent of the N PI. sites received nonzero air scores, but without Regions 4, 5. and 9 that fraction increases to 29 percent. Of more importance is the number of sites with an air score for which placement on the NPL is crucial]y dependent on that air score (those sites that would have a total H KS score below 28.5 without their air scores). Consider the fraction of crucial sites relative to the number of N]}], sites. Without Regions 4, 5, and 9, nine percent of' NPL sites depend on their air scores for NP 1, status, compared to 6 percent for a 11 Regions.

Table 5-17. —Summary Statistics on Hazard Ranking Scores

EPA Region	Number NPL sites	Mean total	Mean GW	R GW-total	Mean SW	R SW-total	Mean A	R A-total
1	45	466	67,3	0.557	207	0.433	169	0.570
2	122	449	627	0.468	203	0443	139	0390
3 . . .	59	403	492	0.525	195	0475	207	0299
4	66	42,9	68,5	0.777	16.0	0173	228	0012
5	137	425	68,6	0.710	129	0272	379	0232
6	29	435	59,0	0557	190	0.120	249	0539
7 . . .	14	385	52.7	0748	193	0,431	118	0179
8	18	459	61 1	0722	390	0652	8.78	0270
9 . .	28	392	515	0.578	202	0.368	642	0007
10	21	409	525	0.443	137	0.282	19.3	0335
All	539	425	593	0712	201	0.435	129	0.055

Total total score
GW groundwater score
SW surface water score
A air score
R correlation coefficient between route score and total score

SOURCE Office of Technology Assessment

Table 5-18.—Analysis of NPL Sites With Air Route HRS Scores

		Sites with-air scores		
Region	Number of NPL sites	Number/percent of NPL sites	N-umber/percent crucial for listing[a]	Crucial sites, percent of NPL sites
1	45	'1 2/27	3/25	7
2	122	30/25	9/30	7
3	59	22/37	9/41	15
4	67	3/5	0/0	0
5	141	11/8	2/18	1
6	30	13/43	2/15	7
7	14	4/29	1/25	7
8	18	3/17	0/0	0
9	29	3/10	2/67	7
10	21	7/33	3/43	14
Total	546	108/20	31/29	6
Without regions 4,5,9	309	91/29	27/30	9

[a]A site has a crucial air score if its total HRS score without the air score would be below 28.5 the cutoff for Placement on the NPL

SOURCE US Environmental Protection Agency, NPL dated September 1983

If the 9 percent is applied to the NPL sites of Regions 4, 5, and 9 (and accounting for the four crucial sites), then there is an indication that 17 sites may have been missed due to the procedures followed in these three Regions. This discrepancy could increase if more attention is given to Subtitle D landfills, which often pose problems of methane generation.

Although the groundwater route clearly has the highest scores and the highest correlation with total scores in table 5-I7, here too there is considerable variation among the regions.

Most of the variations are difficult to explain other than through administrative, procedural, or policy variations among the Regions and States. The one exception is probably for Regions 1, 2, 3, and 5 (and to a lesser extent for Region 4), for which an argument could be made that these locations have a substantially greater number of uncontrolled sites resulting from earlier periods and higher densities of industrial activities as compared to the rest of the Nation.

Estimate of Future NPL

Many sites may not be making it through the site selection system, Available statistical data support this view.

Table 5-19 gives the results of a 1983 survey of States conducted by the Association of State and Territorial Solid Waste Management Officials (ASTSWMO), States were asked to identify the number of sites that might require cleanup and the number of sites needing a cleanup response. This table also gives the number of sites in EPA's ERRIS inventory and on the NPL (as of August 1984), These data reveal marked differences between the estimates made by States and EPA data for the total population of uncontrolled sites, even though the totals appear similar, about 18,000 for each. It appears that some States believe there are many more sites than EPA estimates, and in other cases the reverse appears the case. Only a few States have estimates within about 10 percent of the ERRIS data. If the highest figures are used for each State, then the universe of uncontrolled sites appears to be about 24,000.

The responding States estimate about 8,000 sites will require cleanup. That is, the States foresee the need for a large NPL. According to the States, about 40 percent of all uncontrolled sites will need cleanup. But less than 5 percent of current ERRIS sites have been placed on the NPL, and EPA's projection of about 2,000 NPL sites out of a total ERRIS of 20,000 amounts to a 10 percent placement for the NPL. The problem of estimating the future size of the NPL is further shown by the considerable variation among the State estimates. Seventeen States believe that 50 percent or more of sites will need cleanup and 13 States believe that 10 percent or less will require cleanup.

Table 5-19.—ERRIS/NPL v. State Officials Views on Site Cleanup Requirements

	ASTSWMO data			ERRIS/NPL data		
	Total sites	Response needed	Percent	Total ERRIS	Total NPL	Percent
Region I:						
Maine	—	—	—	78	5	6
Vermont	12	6	50	22	2	9
New Hampshire	95	50	52	74	10	14
Massachusetts	350	53	15	455	16	4
Connecticut	200	200	100	230	6	3
Rhode Island	—	—	—	78	6	8
Subtotal	657	309	47	937	45	5
Region II:						
New York	750	200	27	1,132	29	3
New Jersey	1,500	800	53	1,041	85	8
Puerto Rico	—	—	—	139	8	6
Virgin Islands	1	0	0	1	0	0
Subtotal	2,251	1,000	44	2,313	122	5
Region III						
Pennsylvania	1,200	600	50	1,008	39	4
Maryland	100	11	11	166	3	2
Delaware	80	8	10	69	9	13
Virginia	275	15	6	280	4	1
West Virginia	200	—	—	213	4	2
District of Columbia	3	0	0	5	0	0
Subtotal	1,858	634	34	1741	59	3
Region IV:						
North Carolina	—	—	—	646	3	<1
South Carolina	30	30	100	203	9	4
Georgia	300	150	50	589	5	1
Florida	237	90	38	373	28	8
Alabama	400	100	25	402	7	2
Mississippi	250	25	10	272	1	<1
Tennessee	650	500	77	622	6	1
Kentucky	150	75	50	316	7	2
Subtotal	2,017	'970	48	3.423	66	2
Region V:						
Ohio	40	40	100	855	22	3
Indiana	200	200	100	696	17	2
Michigan	1,200	700	58	779	48	6
Illinois	550	100	18	896	11	1
Wisconsin	750	500	67	241	20	8
Minnesota	125	90	72	222	23	10
Subtotal	2,865	1,630	57	3,689	141	4
Region VI:						
Arkansas	300	20	7	248	6	2
Louisiana	—	—	—	319	5	2
Oklahoma	50	15	30	449	4	1
Texas	1,300	150	12	1,109	10	1
New Mexico	200	100	50	164	4	2
Subtotal	1,850	285	15	2,289	29	1
Region VII:						
Iowa	—	—	—	280	3	1
Missouri	100	65	65	604	7	1
Kansas	150	100	67	260	4	2
Nebraska	150	15	10	174	0	0
Subtotal	400	180	45	1,318	14	1
Region VIII:						
North Dakota	15	0	0	31	1	3
South Dakota	50	2	4	38	1	3
Wyoming	—	—		74	1	1

Table 5-19.—ERRIS/NPL v. State Officials Views on Site Cleanup Requirements—Continued

	ASTSWMO data			ERRIS/NPL data		
	Total sites	Response needed	Percent	Total ERRIS	Total NPL	Percent
Montana	79	20	25	81	5	6
Colorado	20	8	40	242	9	4
Utah	—	—	—	110	1	1
Subtotal	164	30	18	576	18	3
Region IX:						
Arizona	200	50	25	225	6	3
Nevada	150	15	10	118	0	0
California	4,750	2,000	42	955	19	2
Hawaii	50	5	10	77	0	0
Guam	—	—	—	13	1	8
Subtotal	5,150	2,070	40	1,388	26	2
Region X:						
Idaho	—	8	—	114	4	4
Oregon	45	8	18	167	3	2
Washington	500	—	0	501	14	3
Alaska	10	2	20	96	0	0
Subtotal	555	18	3	878	21	2
Totals	17,767	7,126	40	18,552	541	3

SOURCE Office of Technology Assessment

It is not possible for OTA to calculate exactly how much the current site selection process might underestimate future NPL sites. But an estimate can be made. First, it should be noted that the results of the ASTSWMO survey and the ERRIS data do not include most Subtitle D solid waste facilities nor Subtitle Chazardous waste facilities examined in the two previous sections of this chapter. Thus, the Following estimates do not include those categories.

Three main parameters can be examined to make an estimate. First, the size of the ERRIS inventory can vary. As shown in table 5-20, OTA has considered a low and high case, with the low case representing EPA's current estimate of 22,000 sites, and the high case assuming an inventory of 32,000 sites. The high case assumes that the steady increase in ERRIS over the past 2 years, amounting to several thousand sites, will continue. If site discovery and identification is given renewed emphasis, an inventory of 32,000 appears possible within 5 to 10 years,

The fraction of sites that receive a site investigation after the preliminary assessment has been 28 percent. The fraction of sites that have received a site investigation and have been scored, and which then have been placed on the NPL, has also been 28 percent. If it is assumed that the inconsistencies discussed above were corrected, including removal of the arbitrary 28.5 cutoff score and that environmental problems were recognized, then both of these fractions could increase significantly. OTA has, therefore, used two additional fractions of 35 and 45 percent for each of these step-downs. Note that in 1982 and 1983 the fractions of sites investigated that were placed on the NPL were 42 and 38 percent, respectively, Also, in a study of 11 civilian agencies with uncontrolled sites (excluding the Department of Defense) it was found that 39 percent of sites which had received preliminary assessments had completed site investigations, with more SIs possible.[101] These higher fractions also recognize that if the site selection system were improved, the sites that have been eliminated from the NPL could be reevaluated and contribute to the NPL,

The range of step-down fractions for the two levels of ERRIS in table 5-20 yield a wide range

[101] U.S. General Accounting Office, *Status of Civilian Federal Agencies' Efforts To Address Hazardous Waste Problems On Their Lands*, RCED-84-188 (Gaithersburg, MD: U.S. General Accounting Office, Sept. 28, 1984).

Table 5.20.– Range of Estimates for Future Size of the NPL

Estimated future ERRIS sites -	PAs completed =	PAs to complete -	Site investigations to complete		- Additional sites for NPL		+ Current NPL =	Estimated future NPL
22,000 (low)	6,859	15,141	4,239	*(280/o)*	1,187	(28%)	538	1,725
					1,484	(35%)	538	2,022
					1,908	(45%)	538	2,446
			5,299	*(35%)*	1,484	(28%)	538	2,022
					1,855	(35%)	538	2,393
					2,385	(45%)	538	2,923
			6.813	(45%)	1,908	(28%)	538	2,446
					2,385	(35%)	538	2,923
					3,066	(45%)	538	3,604
32,000 (high)	*6,859*	25,141	7,039	*(280/o)*	1,971	(28%)	538	2,509
					2,464	(35%)	538	3,002
					3,168	(45%)	538	3,706
			8,799	(35%)	2,464	(28%)	538	3,002
					3,080	(35%)	538	3,618
					3,960	(45%)	538	4,498
			11,313	(45%)	3,168	(28%)	538	3,706
					3,960	(35%)	538	4,498
					5,091	(45%)	538	5.629

NOTE: PA Preliminary assessment

SOURCE Off Ice of Technology Assessment

for a future NPL based on an improved site selection process. In comparison to EPA's prejection of about 2,000 sites on the NPL, OTA projects an additional 1,000 to 3,000 sites. OTA believes that with an improved site selection process an additional 2,000 sites might be recognized as requiring cleanup.

SUMMARY ESTIMATION

On the basis of the information in this chapter, OTA concludes that the number of uncontrolled waste sites that may merit cleanup and placement on the NPL will be markedly greater than EPA's current estimates. There are some basic benefits to be derived from a site selection system that maximizes *early* identification. With early identification, better decisions can be made about priorities and the allocation of resources for cleanups. There will be less chance that the worst sites will be neglected.

As discussed in chapter 3, setting national priorities requires as complete a picture as possible of total cleanup needs facing the Superfund program. It is not now possible to understand whether it makes sense, environmentally and economically, to let 50 percent of the NPL sites go unattended, while at the same time some 30 percent are receiving remedial cleanup, and another 20 percent receive attention of some sort. Placement on the NPL establishes eligibility for cleanup, and there is some indication that a site's score establishes priority for determining whether it receives an initial response, a remedial cleanup, or studies to select a cleanup option.

OTA finds that the contribution from solid waste facilities to an expanded NPL could easily be 5,000 sites, and perhaps more, The contribution from operating hazardous waste facilities could to be 1,000 sites. Improving the site selection process could add another 2,000 sites. Therefore, together with the 2,000 sites, which would result from current *procedures* and policies and which OTA agrees merit cleanup, the *total NPL could reach 10,000 sites.*

The largest uncertainty is for the contribution from solid waste facilities, both open and closed. Assuming that only 5,000 sites from this category might require cleanup is conservative; it could be two to three times greater.

The 10,000 figure is consistent with the results of the survey of State officials; they estimated a need for about 8,000 cleanups. But it is unlikely that the estimates of State officials included many solid waste facilities.[102] It should also be noted that State officials also concluded that the more than 10,000 sites that were not put into the highest priority category still had "the potential to threaten public health and the environment. "

Finally, consider EPA's recent analysis of future Superfund needs.[103] It concluded that "the current inventory of sites and anticipated new additions will produce an NPL of 1,500 to 2,500 sites over the next several years. " Although EPA discussed a number of potential sources of additional NPL sites, including some that OTA did not, the major factors that lead to their lower projection include:

- EPA did not consider surface impoundments, even though: a) according to their data such sites are the single largest source of NPL sites, about one-third, and b) the surface impoundment problem is acknowledged in EPA's Ground-water Protection **Strategy.** In OTA's analysis, 340,000 such facilities were considered.
- EPA did not consider closed as well as open industrial landfills. OTA estimated that there were twice as many closed as open ones (150,000 sites).
- No basis was provided for concluding that there were only twice as many closed municipal landfills as open ones. OTA used data for several States to develop an estimate of three times as many closed as open facilities (42,000 such sites).
- EPA did not account for the more stringent 1984 amendments to RCRA for hazardous waste facilities that could lead to more failures of companies. Nor was there any reference to EPA's problems with groundwater protection standards, which could lead to the creation of uncontrolled sites. EPA's Interim Status Ground-Water Monitoring Implementation Study substantiates this problem. OTA estimated that 1,000 hazardous waste facilites could become NPL sites; EPA's estimate was about half this figure.
- EPA gave limited consideration to the site selection process and changes in it that could result in more ERRIS sites, with more of them becoming NPL sites. Nevertheless, there is some indication that EPA believes that an improved site selection process (without further site identification) could add an additional 1,670 to 2,170 sites to the NPL. OTA's estimate from further site identification and improved site selection was 2,000 additional sites.

EPA has said that a full examination of the problem of future sites could lead to a situation where the funding needed "would overwhelm" the Superfund program. But OTA's point is that by acknowledging the full extent of future needs, rather than underestimating them, effective planning can prevent a crisis.

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[102] This view is supported by the basic similarity in the States' estimates of total number of uncontrolled sites to the number in ERRIS, and their dissimilarity from the numbers of solid waste facilities. (ERRIS does contain some solid waste facilities, something over 2,000 sites according to EPA; but this is a small fraction of the total universe of Subtitle D facilities.)

[103] U. S. Environment] Protection Agency, "Extent of the Hazardous Release Problem and Future Funding Needs, CERCLA Section 301(a)(l)(C) Study" (Washington, DC: Office of Solid Waste and Emergency Response, December 1984),