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Report to Congress

DISPOSAL OF HAZARDOUS WASTES

REPORT TO CONGRESS

DISPOSAL OF HAZARDOUS WASTES

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FOREWORD

Section 212 of the Solid Waste Disposal Act (P.L. 89-272) as amended required that the U.S. Environmental Protection Agency (EPA) undertake a comprehensive investigation of the storage and disposal of hazardous wastes. This document represents EPA's Report to the President and the Congress summarizing the Agency's investigations and recommendations in response to the congressional mandate. The findings are based on a number of contractual efforts and analyses by Agency staff carried out since the passage of the Resource Recovery Act of 1970.

The report is organized into a summary, five major sections, and appendixes. The first section discusses the congressional mandate and the Agency's response to it. Next, the public health, technological, and economic aspects of the problem of disposing of hazardous wastes are reviewed. A section detailing the case for hazardous waste regulation follows. The report concludes with a discussion of implementation issues and a presentation of findings and recommendations.

Although there have been minor editorial revisions, this publication is essentially the same as that delivered on June 30, 1973, to Congress, except that the references have been reverified and revised accordingly. Also, the report has been typeset in a conventional style to improve its readability.

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Deputy Assistant Administrator
for Solid Waste Management

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SUMMARY AND CONCLUSIONS

The management of the Nation's hazardous residues—toxic chemical, biological, radioactive, flammable, and explosive wastes—is generally inadequate; numerous case studies demonstrate that public health and welfare are unnecessarily threatened by the uncontrolled discharge of such waste materials into the environment.

From surveys conducted during this program, it is estimated that the generation of nonradioactive hazardous wastes is taking place at the rate of approximately 10 million tons yearly.[1] About 40 percent of these wastes by weight is inorganic material and about 60 percent is organic; about 90 percent occurs in liquid or semiliquid form.

Hazardous waste generation is growing at a rate of 5 to 10 percent annually as a result of a number of factors: increasing production and consumption rates, bans and cancellations of toxic substances, and energy requirements (which lead to radioactive waste generation at higher rates).

Hazardous waste disposal to the land is increasing as a result of air and water pollution controls (which capture hazardous wastes from other media and transfer them to land) and denial of heretofore accepted methods of disposal such as ocean dumping.[2]

Current expenditures by generators for treatment and disposal of such wastes are low relative to what is required for adequate treatment and disposal. Ocean dumping and simple land disposal costs are on the order of $3 per ton whereas environmentally adequate management could require as much as $60 per ton if all costs are internalized.[3]

Federal, State, and local legislation and regulations dealing with the treatment and disposal of nonradioactive hazardous waste are generally spotty or nonexistent. At the Federal level, the Clean Air Act; the Federal Water Pollution Control Act; and the Marine Protection, Research, and Sanctuaries Act provide control authority over the incineration, and water and ocean disposal of certain hazardous wastes but not over the land disposal of residues. Fourteen other Federal laws deal in a peripheral manner with the management of hazardous wastes. Approximately 25 States have limited hazardous waste regulatory authority.

Given this permissive legislative climate, generators of waste are under little or no pressure to expend resources for the adequate management of their hazardous wastes. There is little economic incentive (e.g., the high costs of adequate management compared with costs of current practice) for generators to dispose of wastes in adequate ways.

Technology is available to treat most hazardous waste streams by physical, chemical, thermal, and biological methods, and for disposal of residues. Use of such treatment and disposal processes is costly, ranging from a low of $1.40 per ton for carbon sorption, $10 per ton for neutralization/precipitation, and $13.60 per ton for chemical oxidation to $95 per ton for incineration.[4] Several unit processes are usually required for complete treatment and disposal of a given waste stream. Transfer and adaptation of existing technology to hazardous waste management may be necessary in some cases. Development of new treatment and disposal methods for some wastes (e.g., arsenic trioxide and arsenites and arsenates of lead, sodium, zinc, and potassium) is required.[5] In the absence of treatment processes, interim storage of wastes on land is possible using methods that minimize hazard to the public and the environment (e.g., secure storage and membrane landfills).

A small private hazardous waste management industry has emerged in the last decade, offering treatment and disposal services to generators. The industry currently has capital investments of approximately $25 million and a capacity to handle about 2.5 million tons of hazardous materials yearly, or 25 percent of capacity required nationally. However, the industry's current throughput of hazardous waste is about 24 percent of installed capacity, or 6 percent of the national total. The low level of utilization of this industry's services results from the absence of regulatory and economic incentives for generators to manage their hazardous wastes in an environmentally sound manner. This industry could respond over time to provide needed capacity if a national program for hazardous waste management, with strong enforcement capabilities, was created. This industry would, of course, be subject to regulation also.

The chief programmatic requirement to bring about adequate management of hazardous wastes is the creation of demand and adequate capacity for treatment and disposal of hazardous wastes. A national policy on hazardous waste management should take into consideration environmental protection, equitable cost distribution among generators, and recovery of waste materials.

A regulatory approach is best for the achievement of hazardous waste management objectives. Such an approach ensures adequate protection of public health and the environment. It will likely result in the creation of treatment and disposal capacity by the private sector without public funding. It will result in the mandatory use of such facilities. Costs of management will be borne by those who generate the hazardous wastes and their customers rather than the public at large; thus, cost distribution will be equitable. Private sector management of the wastes in a competitive situation can lead to an appropriate mix of source reduction, treatment, resource recovery, and land disposal.

A regulatory program will not directly create a prescribed system of national disposal sites because of uncertainties inherent in the private sector response. EPA believes that the private sector will respond to a regulatory program. However, full assurance cannot be given that treatment and disposal facilities will be available in a timely manner for all regions of the Nation nor that facility use charges will be reasonable in relation to cost of services. Also, private enterprise does not appear well suited institutionally to long-term security and surveillance of hazardous waste storage and disposal sites.

Given analyses performed to date, EPA believes that no Government actions to limit the uncertainties in private sector response are appropriate at this time. However, if private capital flow was very slow and adverse environmental effects were resulting from the investment rate, indirect financial assistance in forms such as loans, loan guarantees, or investment credits could be used to accelerate investment. If facility location or user charge problems arose, the Government could impose a franchise system with territorial limits and user charge rate controls. Long-term care of hazardous waste storage and disposal facilities could be assured by mandating use of Federal or State land for such facilities.

EPA studies indicate that treatment and disposal of hazardous wastes at central processing facilities are preferable to management at each point of generation, in most cases, because of economies of scale, decreased environmental risk, and increased opportunities for resource recovery. However, other forces may deter creation of the "regional processing facility" type of system. For example, the pending effluent limitation guidelines now being developed under authority of the Federal Water Pollution Control Act may force each generator to install water treatment facilities for both hazardous and nonhazardous aqueous waste streams. Consequently, the absolute volume of hazardous wastes requiring further treatment at central facilities may be reduced and the potential for economies of scale at such facilities may not be as strong as it is currently.

Given these uncertainties, several projections of future events can be made. Processing capacity required nationally was estimated assuming complete regulation, treatment, and disposal of *all* hazardous wastes at the earliest practicable time period. Estimates were based on a postulated scenario in which approximately 20 regional treatment and disposal facilities are constructed across the Nation. Of these, 5 would be very large facilities serving major industrial areas, each treating 1.3 million tons annually, and 15 would be medium-size facilities, each treating 160,000 tons annually. An estimated 8.5 million tons of hazardous wastes would be treated and disposed of away from the point of generation (off site); 1.5 million tons would be pretreated by generators on site, with 0.5 million tons of residues transported to off-site treatment and disposal facilities for further processing. Each regional processing facility was assumed to provide a complete range of treatment processes capable of handling all types of hazardous wastes; and, therefore, each would be much more costly than existing private facilities.

Capital requirements to create the system described are approximately $940 million. Average annual operating expenditures (including capital recovery and operating costs) of $620 million would be required to sustain the program. These costs are roughly estimated to be equivalent to 1 percent of the value of shipments from industries directly impacted. In addition, administrative expenses of about $20 million annually for Federal and State regulatory programs would be necessary. For the reasons stated earlier, however, capacity and capital requirements for a national hazardous waste management system may be smaller than indicated, and more in line with the capacity and capital availability of the existing hazardous waste management industry.

In summary, the conclusions of the study are that (1) a hazardous waste management problem exists and its magnitude is increasing; (2) the technical means to solve the problem exist for most hazardous waste but are costly in comparison with present practices; (3) the legislative and economic incentives for using available technology are not sufficient to cause environmentally adequate treatment and disposal in most cases; (4) the most effective solution at least direct cost to the public is a program for the regulation of hazardous waste treatment and disposal; (5) a private hazardous waste management service industry exists and is capable of expanding under the stimulus of a regulatory program; (6) because of inherent uncertainties, private sector response cannot be definitely prescribed; (7) several alternatives for Government action are available, but, based on analyses to date, EPA is not convinced that such actions are needed.

EPA has proposed legislation to the Congress that is intended both to fulfill the purposes of Section 212 of the Solid Waste Disposal Act as amended and to carry out the recommendations of this report. The proposed Hazardous Waste Management Act of 1973 would authorize a regulatory program for treatment and disposal of EPA-designated hazardous wastes; the States would implement the program subject to Federal standards in most cases. All studies performed in response to Section 212 will be completed in time to serve as useful input to congressional consideration of our legislative proposal.

DISPOSAL OF HAZARDOUS WASTES

Section 1

THE CONGRESSIONAL MANDATE

In 1970, Congress perceived hazardous waste storage and disposal to be a problem of national concern. Section 212 of the Resource Recovery Act of 1970 (P.L. 91-512—an amendment to P.L. 89-272), enacted on October 26, 1970, required that EPA prepare a comprehensive report to Congress on storage and disposal of hazardous wastes. That section stated the following:

The Secretary [*] shall submit to the Congress no later than two years [†] after the date of enactment of the Resource Recovery Act of 1970 a comprehensive report and plan for the creation of a system of national disposal sites for the storage and disposal of hazardous wastes, including radioactive, toxic chemical, biological, and other wastes which may endanger public health or welfare. Such report shall include: (1) a list of materials which should be subject to disposal at any such site; (2) current methods of disposal of such materials; (3) recommended methods of reduction, neutralization, recovery or disposal of such materials; (4) an inventory of possible sites including existing land or water disposal sites operated or licensed by Federal agencies; (5) an estimate of the cost of developing and maintaining sites including consideration of means for distributing the short- and long-term costs of operating such sites among the users thereof; and (6) such other information as may be appropriate.

THE EPA RESPONSE

This document represents EPA's Report to the President and the Congress summarizing the Agency's investigations and recommendations concerning hazardous wastes in response to the congressional mandate. All information required by the mandate is included in the report and its appendixes. This report provides a definition of current status, issues, and options. It does not purport to provide a complete solution to the hazardous waste management problem.

Section 212 requires an evaluation of a system of national disposal sites (NDS's) for the storage and disposal of hazardous wastes as a solution to the hazardous waste problem. To evaluate the NDS concept properly, it is necessary to view it in the context of the total problem. On probing the problem, EPA determined that several means of accomplishing the NDS objective exist. To provide the Congress with maximum flexibility of action, EPA elected to investigate and evaluate several alternative solutions. A series of interrelated contractor and in-house studies was undertaken for the specific purpose of complying with Section 212 of the Resource Recovery Act of 1970.

First Study

The first study, upon which subsequent efforts were based, quantified the hazardous waste problem.[6] From a thorough literature survey and contacts with various trade and technical associations, Government agencies, and industry, a list of hazardous materials was compiled, and each candidate substance on this list was rated according to the nature and severity of its hazardous properties. In addition, volume and distribution data (both by geography and by industry groups) were gathered, and current hazardous waste handling and disposal practices were surveyed. It was found that the magnitude of the hazardous waste problem was larger than originally anticipated and that current disposal practices are generally inadequate.

Second Study

Next, a more detailed technical study on the properties of these materials and their treatment and disposal methods was conducted.[7] A "profile report" was written on each listed substance summarizing its

*The Secretary of Health, Education, and Welfare. Reorganization Plan Number 3 of 1970 transferred authority to the Administrator, EPA.

†EPA requested and received a time extension for submission of this report until June 30, 1973, because appropriation of funds to implement the Resource Recovery Act of 1970 was delayed for 8 months after enactment.

physical, chemical, and toxicological properties; its industrial uses; and the hazards associated with proper handling and disposal methods. Each profile report incorporated a critical evaluation of currently used and available technology for the handling, storage, transport, neutralization, detoxification, re-use, and disposal of the particular substance. Also, advanced methods of hazardous waste treatment were surveyed, and research and development needs were formulated. The study showed that treatment and disposal technology is available for most hazardous wastes.

Third Study

A favorable public attitude is essential for the successful implementation of any nationwide hazardous waste management program. Therefore, a third study was undertaken to determine citizen awareness and attitudes regarding the hazardous waste problem and reaction to the possibility of having a treatment and disposal facility located in the vicinity.[8] The majority of citizens sampled were found to be in favor of regional processing facilities for hazardous wastes since such facilities would increase environmental protection and stimulate the economy of the region.

Fourth Study

A fourth study analyzed and compared alternative methods of hazardous waste management.[9] It was concluded that there are three basic approaches: (1) process hazardous wastes "on site" (i.e., at the plant where they are generated); (2) process "off site" at some regional facility (either public or private); (3) combine on-site pretreatment with off-site treatment and disposal. These basic alternatives were evaluated with respect to economics, risk, and legal and institutional issues. The study indicated that option (2) is preferable for most hazardous waste streams and option (3) is preferable for dilute aqueous toxic metal wastes.*

Fifth Study

A fifth comprehensive study examined the feasibility of an NDS system for hazardous wastes.[10] Potential locations for regional processing and disposal sites were identified. Conceptual designs of hazardous waste treatment and disposal facilities were developed, based on multicomponent waste streams characteristic of industry. Capital and operational cost estimates were made, and funding and cost distribution mechanisms were examined.

Strategy Analysis

Lastly, a strategy analysis was performed, based on information from the previous studies. It was concluded that a regulatory program is the best approach to the hazardous waste problem. The case for hazardous waste regulation is discussed in Section 3. Issues of implementation are evaluated in Section 4, and findings and recommendations are given in Section 5. A review of the hazardous waste disposal problem precedes these discussions.

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*In this report the term "waste stream" refers to mass flow in the engineering process sense and not necessarily to a liquid stream.

Section 2

IDENTIFICATION AND DISCUSSION OF THE PROBLEM

Inadequate management of hazardous wastes has the potential of causing adverse public health and environmental impacts. These impacts are directly attributable to the acute (short-range or immediate) or chronic (long-range) effects of the associated hazardous compound or combination of compounds, and production quantities and distribution.[11,12] Many cases document the imminent and long-term danger to man or his environment from improper disposal of such hazardous wastes. Three examples follow.

Several people in Minnesota were hospitalized in 1972 after drinking well water contaminated by an arsenic waste buried 30 years ago on nearby agricultural land.

Since 1953, an Iowa company has dumped several thousand cubic yards of arsenic-bearing wastes on a site located above an aquifer supplying a city's water. Arsenic content in nearby monitoring well samples has been measured as high as 175 parts per million; the U.S. Public Health Service drinking water standards recommend an arsenic content less than 0.05 part per million.

In Colorado, a number of farm cattle recently died of cyanide poisoning caused by indiscriminate disposal of cyanide-bearing wastes at a dump site upstream. Additional case studies citing the effects of hazardous waste mismanagement are given in Appendix A.

Discussed in this section are the types, forms, sources, and quantities of hazardous waste; the current status of treatment and disposal technology; and the economic incentives bearing on hazardous waste treatment and disposal.

THE NATURE OF HAZARDOUS WASTES

The term "hazardous waste" means any waste or combination of wastes which pose a substantial present or potential hazard to human health or living organisms because such wastes are lethal, nondegradable, or persistent in nature; may be biologically magnified; or may otherwise cause or tend to cause detrimental cumulative effects.[13] General categories of hazardous waste are toxic chemical, flammable, radioactive, explosive, and biological. These wastes can take the form of solids, sludges, liquids, or gases.

The sources of hazardous wastes are numerous and widely scattered throughout the Nation. Sources consist of industry, the Federal Government [mainly the Atomic Energy Commission (AEC) and the Department of Defense (DOD)], agriculture, and various institutions such as hospitals and laboratories.

During this study, waste streams containing hazardous compounds were identified and quantified by industrial source (Appendix B). These waste streams were selected by utilizing a decision model (Appendix C) that is relatively unsophisticated compared to that required for standard-setting purposes.[14] Therefore, the hazardous compounds and waste streams cited in this report should be considered as illustrative and are not necessarily those that should be regulated. From these data, the total quantity of nonradioactive hazardous waste streams generated by industrial sources in 1970 was estimated to be 10 million tons (9 million metric tons), or approximately 10 percent of the 110 million tons (100 million metric tons) of all wastes generated by industry annually.[15] This quantity includes most industrial wastes generated from contractor-operated Government facilities.

Approximately 70 percent of industrial hazardous wastes are generated in the mid-Atlantic, Great Lakes, and Gulf Coast areas of the United States (Table 1). About 90 percent by weight of industrial hazardous wastes are generated in the form of liquid streams, of which approximately 40 percent are inorganic and 60

TABLE 1

ESTIMATED INDUSTRIAL HAZARDOUS WASTE GENERATION BY REGION* IN TONS PER YEAR (1970)†

Region	Inorganics in aqueous		Organics in aqueous		Organics		Sludges,‡ slurries, solids		Total		Percent of total
	Tons	Metric tons	Tons	Metric tons	Tons	Metric tons	Tons	Metric tons	Tons	Metric tons	
New England	95,000	86,000	170,000	154,000	33,000	30,000	6,000	5,450	304,000	275,450	3.1
Mid Atlantic	1,000,000	907,200	1,100,000	1,000,000	105,000	90,600	55,000	50,000	2,260,000	2,047,800	22.9
East North Central	1,300,000	1,180,000	850,000	770,000	145,000	132,000	90,000	81,600	2,385,000	2,163,600	24.2
West North Central	65,000	59,000	260,000	236,000	49,500	45,000	18,500	16,800	393,000	350,800	4.0
South Atlantic	230,000	208,500	600,000	545,000	75,000	68,000	80,000	72,600	985,000	894,100	10.0
East South Central	90,000	81,700	385,000	350,000	44,000	40,000	9,500	8,600	528,000	480,300	5.4
West South Central	320,000	290,000	1,450,000	1,315,000	180,000	163,000	39,000	35,400	1,989,000	1,803,400	20.2
West (Pacific)	120,000	109,000	550,000	500,000	113,000	103,000	30,500	27,770	813,500	739,770	8.3
Mountain	125,000	113,500	5,000	4,540	50,000	45,400	11,500	10,400	191,500	173,840	1.9
Totals	3,345,000	3,034,900	5,370,000	4,874,540	794,500	717,000	340,000	308,620	9,849,500	8,929,060	100.0

*Refers to Bureau of Census regions, as defined in Appendix B.
†Source: EPA Contract No. 68-01-0762.
‡Predominantly inorganic.

percent are organic materials. Representative hazardous waste substances have been cross indexed by industrial sources (Table 2). It is important to recognize that these hazardous substances are constituents of waste streams, and it is these waste streams which require treatment, storage, and disposal.

Sources of radioactive wastes are nuclear power generation and fuel reprocessing facilities; private sources, such as medical, research and development, and industrial laboratories; and Government sources (AEC and DOD). Quantities of radioactive wastes generated in 1970 from the first two sources were identified (Table 3). Only a limited amount of information is available on source material, special nuclear material, or byproduct materials from Government operations. Such information is related to weapons production and is therefore classified.

Disposal of uranium mill tailings represents a unique problem similar in magnitude to the disposal of all industrial hazardous wastes. Several Federal agencies are working on the problem at present; a satisfactory disposal or recovery method has not yet been defined. Aside from uranium mill tailings, the quantity of radioactive wastes associated with the commercial nuclear electric power industry and other private sources is estimated to be approximately 24,000 tons (22,000 metric tons) per year at present, or less than 1 percent of the total hazardous wastes from all industry.

Toxic Chemical Wastes

Practically all of the estimated 10 million tons (9 million metric tons) of nonradioactive hazardous waste generated annually in the United States falls into the toxic category. In the context of this report toxicity is defined as the ability of a waste to produce injury upon contact with or accumulation in a susceptible site in or on the body of a living organism. Most toxic wastes belong to one or more of four categories: inorganic toxic metals, salts, acids, or bases; synthetic organics; flammables; and explosives. There is considerable overlap within these waste categories. For example, a synthetic organic waste may be flammable and explosive, and it may also contain toxic metals. Flammable and explosive wastes are often categorized as separate hazardous waste entities; however, they are generally toxic and will be discussed here. Many radioactive and some biological wastes are also toxic, but they will be discussed separately.

Toxic Metals. Approximately 25 percent of the metals in common usage today are toxic.[12] The concentration and chemical form of toxic metals determine their potential health and environmental hazards. Some metals are essential to life at low concentrations but are toxic at higher concentrations.[12,16] Also, a pure metal is usually not as dangerous as a metallic compound (salt).[12] The largest quantities of toxic metal waste streams are produced by the mining and metallurgy and the electroplating and metal-finishing industries. For example, arsenic-containing flue dusts collected from the smelting of copper, lead, zinc, and other arsenic-bearing ores amount to 40,000 tons (36,200 metric tons) per year. Approximately 30,000 tons (27,200 metric tons) of chromium-bearing waste is discharged by the metal-finishing industry annually.

TABLE 2

REPRESENTATIVE HAZARDOUS SUBSTANCES WITHIN INDUSTRIAL WASTE STREAM

Industry	Hazardous substances										
	As	Cd	Chlorinated hydrocarbons*	Cr	Cu	Cyanides	Pb	Hg	Miscellaneous organics†	Se	Zn
Mining and metallurgy	√	√		√	√	√	√	√		√	√
Paint and dye		√		√	√	√	√	√	√	√	
Pesticide	√		√			√	√	√	√		√
Electrical and electronic			√		√	√	√	√		√	
Printing and duplicating	√			√	√		√		√	√	
Electroplating and metal finishing		√		√	√	√					√
Chemical manufacturing			√	√	√			√	√		
Explosives	√				√		√	√	√		
Rubber and plastics			√			√		√	√		√
Battery		√					√	√			√
Pharmaceutical	√							√	√		
Textile				√	√				√		
Petroleum and coal	√		√				√				
Pulp and paper								√	√		
Leather				√					√		

*Including polychlorinated biphenyls.

†For example, acrolein, chloropicrin, dimethyl sulfate, dinitrobenzene, dinitrophenol, nitroaniline, and pentachlorophenol.

TABLE 3

ESTIMATE OF RADIOACTIVE WASTE GENERATED IN 1970*

Waste stream source	Form	Total annual curies	Tons per year	Metric tons per year	Major radioactive elements
Mineral extraction† (uranium)	Sludge	9.0×10^3	4,400,000	4,000,000	Ra, Th, Pb, Po
Commercial nuclear electric power	Solid or liquid	4.0×10^7	2,240	2,000	U, Th, Ra, Pu, Ag, Fe, H, Mn, Ni, Co, Ru, Cs, Ce, Sr, Sb, Pm, Eu, Am, Cm
Miscellaneous private sources	Solid or liquid	2.0×10^5	11,000-22,000	10,000-20,000	Co, Sr, Pm, Cs, Pu, Am, Cm
Government sources	Solid or liquid	Not available	Not available	Not available	Pu, Am, Cm
All known sources	Sludges, solids, or liquids	$>4.0 \times 10^7$	>4,413,240	>4,012,000	

*Source: EPA Contract No. 68-01-0762.

†Uranium mill tailings from extraction of uranium ores.

Synthetic Organics. Hazardous synthetic organic compounds include halogenated hydrocarbon pesticides (such as endrin), polychlorinated biphenyls, and phenols. An estimated 5,000 tons (4,540 metric tons) of synthetic organic pesticide wastes were produced in 1970.[17] DOD currently has 850 tons (770 metric tons) of dry pesticides and 15,000 tons (13,600 metric tons) in liquid form requiring disposal. Most of the liquid form consists of agent orange herbicide (a mixture of 2,4-D and 2,4,5-T) banned from use in South Vietnam.[18] These stocks contain significant quantities of a teratogenic dioxin. There are disposal requirements caused by the increasing numbers of waste pesticide containers as well. Over 250 million pesticide containers of all types will be used this year alone.[19]

Flammables. Flammable wastes consist mainly of contaminated organic solvents but may include oils, pesticides, plasticizers, complex organic sludges, and off-specification chemicals. Highly flammable wastes can pose acute handling and chronic disposal hazards. Hazards related to disposal may exceed those of transportation and handling if sufficient waste volumes are involved. The nationwide quantities of flammable wastes have not been assessed as a separate category but are included in the totals given previously.

Explosives. Explosive wastes are mainly obsolete ordnance, manufacturing wastes from the explosives industry, and contaminated industrial gases. The largest amount of explosive waste is generated by DOD. An inventory by the DOD Joint Commanders' Panel on Disposal Ashore indicates that the military has accumulated about 150,000 tons (136,080 metric tons) of obsolete conventional ammunition.[20] The former practice of loading obsolete munitions on ships and sinking them in the ocean has been discontinued. Final disposal is being delayed until a more suitable disposal method is available. A joint Army, Navy, National Aeronautics and Space Administration, and Air Force group is working to resolve this impasse. Most waste materials generated by the commercial explosives industry consist of chemical wastes that are not clearly separable from wastes produced by large industrial chemical firms (e.g., ammonia, nitric acid, sulfuric acid, and some common organic chemicals). These wastes represent a greater problem than military wastes because of uncontrolled disposal practices. Open burning of explosives, which is widely practiced, can result in the emission of harmful nitrogen oxides and other pollutants.

Radioactive Wastes

Most radioactive wastes consist of conventional nonradioactive materials contaminated with radionuclides.[21] The concentration of the latter can range from a few parts per billion to as high as 50 percent of the total waste. Frequently, many radionuclides are involved in any given waste. Radioactive wastes are customarily categorized as low- or high-level wastes, depending upon the concentrations of radionuclides. However, the long-term hazard associated with each waste is not necessarily proportional to the nominal level of radioactivity, but rather to the specific toxicity and decay rate of each radionuclide. The most significant radionuclides, from the standpoint of waste management, decay with half-lives of months to hundreds of thousands of years. For the purposes of this study, the term "high-level wastes" refers to those wastes requiring special provisions for dissipation of heat produced by radioactive decay; "low-level wastes" refers to all others.

The biological hazard from radioactive wastes is primarily due to the effects of penetrating and ionizing radiation rather than to chemical toxicity. On a weight basis, the hazard from certain radionuclides is more acute than the most toxic chemicals by about six orders of magnitude. The hazard from radionuclides cannot be neutralized by chemical reaction or by any currently practicable scheme. Thus, the only currently practical way to "neutralize" a radionuclide is to allow its decay. Storage of wastes containing radionuclides under carefully controlled conditions to assure their containment and isolation is necessary during this decay period. The time period necessary for decay of radionuclides to levels acceptable for release to the environment varies with each waste.

Radionuclides may be present in gaseous, liquid, or solid form. Solid wastes per se are not normally important as potential contaminants in the biosphere until they become airborne (usually as particulates) or waterborne (by leaching). Consequently, environmental effects and existing regulatory limits are based primarily on concentrations in air and water.

Biological Wastes

Biological wastes were divided into two categories for this study: pathological hospital wastes and warfare agents. Pathological wastes from hospitals are usually less infectious than biological warfare agents. Both types of wastes may also be toxic. For example, toxins produced by various strains of micro-organisms may be just as hazardous as the associated infectivity of the organism.

Pathological Hospital Wastes. Approximately 170,000 tons (154,000 metric tons) of pathologic wastes are generated by hospitals annually, which is approximately 4 percent of the total 4.2 million tons (3.7 million metric tons) of all hospital wastes generated per year.[22,23] These wastes include malignant or benign tissues taken during autopsies, biopsies, or surgical procedures; animal carcasses and wastes; hypodermic needles; off-specification or outdated drugs; microbiological wastes; and bandaging materials.

Biological Warfare Agents. Biological warfare agents are selected primarily because of their abilities to penetrate outer epithelial tissues of plants or animals and to spread rapidly. Antipersonnel agents like *Bacillus anthrax* are cultured to affect a specific animal; anticrop agents like *Puccinia graminis* (Lx) (rice blast) are used to inhibit growth of specific plants. DOD representatives have advised EPA that all stockpiles of biological warfare agents, including antipersonnel and anticrop agents, have been destroyed.[24] Because of the Administration's policy of restricting production of biological warfare agents, the total quantity to be disposed of should be small in the future.

Chemical Warfare Agents. Production of chemical warfare agents such as HD (mustard), GB, and VX has been discontinued, but significant stockpiles of these agents must be treated and disposed of in an environmentally acceptable manner. The Department of the Army is in the process of demilitarizing HD (mustard) at Rocky Mountain Arsenal in Colorado and is presently studying the feasibility of demilitarizing GB and VX by means of incineration. The exact quantity of chemical agents to be incinerated is classified, but it has been estimated that after the treatment process there will be approximately 70,000 tons (63,600 metric tons) of residual salts that will require proper disposal.

FACTORS INFLUENCING THE GROWTH OF HAZARDOUS WASTES

A number of factors will increase the quantities of hazardous wastes generated in the future and will affect their disposal requirements. Some of these factors are production and consumption rates, legislative and regulatory actions, energy requirements, and recycling incentives.

National production and consumption rates are increasing 4 to 6 percent each year, while resource recovery from wastes is declining. During the period 1948 to 1968, U.S. consumption of selected toxic metals increased 43 percent.[25] Since 1954, production of synthetic organic chemicals has increased at an average rate of 10.5 percent per year.[26] Included in the latter category are such materials as dyes, pigments, and pesticides. Some of these products contain heavy metals in addition to organic constituents. Similar data indicating production growth can be cited for most industries that generate hazardous waste. There is a correlation between the amount of production and waste generated. Therefore, it can be concluded that hazardous waste generation rates will generally parallel industrial production rates.

Changing product material content also has an impact. For example, increasing polyvinyl chloride plastics usage results in more mercury-bearing wastes from the chlorine production industry; in the computer industry, changeover from vacuum tube technology to integrated circuit board technology has resulted in increased generation of acid etchant wastes containing heavy metals.

The Nation's projected energy requirements are driving utilities toward construction of nuclear-powered facilities. As of September 1972, there were 28 nuclear power plants in operation; 52 were being built, and 70 more were being planned. Operation of the additional 122 nuclear power plants will definitely increase the quantities of radioactive wastes.[27] Shortages of clean-burning high-grade coal have initiated a trend to utilize lower grades of coal, which contain larger amounts of arsenic and mercury; therefore, aqueous wastes from the scrubbers and ashes from coal-burning furnaces will contain increased quantities of toxic wastes.

Enforcement of new consumer and occupational safety legislation could result in product bans, with attendant disposal requirements. More stringent air and water effluent controls, new pesticide controls, and the new restrictions on ocean dumping of wastes will result in larger quantities of hazardous wastes in more concentrated form requiring disposal. As air, water, and ocean disposal options are closed off, there will be increased pressure for improvements in production efficiency, for recovery and recycling of hazardous substances, and for disposal of hazardous wastes on or under the land.

PUBLIC HEALTH AND ENVIRONMENTAL EFFECTS

In order for an organic or inorganic hazardous compound within a waste to affect public health and the environment, it must be present in a certain concentration and form. Public health and environmental effects are directly correlated with the concentration and duration of exposure.[12,28] This has been better documented for acute effects resulting from high concentrations over a short period of time than for chronic effects resulting from low concentrations over a long period of time.[29] Most of the work to establish chronic effects has been done on lower animals, and extrapolating the evidence directly to man becomes difficult because of species variations.[29]

Synergistic or antagonistic interactions between hazardous compounds and other constituents within the waste can enhance or modify the overall effects of the particular hazardous compound. As an example, the effects of mercury salts with trace amounts of copper will be considerably accentuated in a suitable environment.

The form of a hazardous waste is also very critical because it determines if a toxic substance is releasable to the ambient environment. As an example, an insoluble salt of a toxic metal bound up within a sludge mass that is to be disposed of at a landfill does not present the same degree of immediate threat to public health and the environment as a soluble salt of the same metal that is unbound going to the same landfill. The interaction between biological systems and hazardous wastes is unpredictable, and in many cases the end product is more lethal than the original waste. An example is the conversion of inorganic mercury by anaerobic bacteria into methyl mercury. Furthermore, persistent toxic substances can accumulate within tissues of mammals as do certain radioisotopes. Under these circumstances, substances that are persistent in the ambient environment even though in low concentrations will be magnified in the living system. As a result, critical concentrations may accumulate in tissues and cause detectable physiological effects.

Cancers and birth defects are only a few of the recorded physiologic effects that have been correlated with the presence of hazardous compounds in man. Other milder effects have also been recorded, such as headaches, nausea, and indigestion. In the environment, the effects of hazardous wastes are manifested by such things as fishkills, reduced shellfish production, or improper eggshell synthesis.[30]

This evidence points to the fact that hazardous wastes are detrimental to public health and the environment. The real issue, therefore, is to document the fact that present management practices for treating, storing, or disposing of hazardous wastes do not provide the necessary reassurances that man or the environment are being adequately protected.

PRESENT TREATMENT AND DISPOSAL TECHNOLOGY

Treatment processes for hazardous waste streams should perform the following functions: volume reduction where required, component separation, detoxification, and material recovery. No single process can perform all these functions; several different processes linked in series are required for adequate treatment. Residues from these processes, or all hazardous wastes if treatment is bypassed, require ultimate disposal.

Treatment and disposal technology is available to process most hazardous waste streams. A range of treatment and disposal processes was examined during the course of this study and the general applicability of these processes to types and forms of hazardous wastes is indicated (Table 4). Many of these processes have been utilized previously for managing hazardous wastes in industry and Government. Several processes have capabilities for resource recovery. Selection of appropriate methods depends on the type, form, and volume of waste, the type of process required to achieve adequate control, and relative economics of processes.

Several treatment processes perform more than one function or are applicable to more than one type or form of waste. For example, evaporation provides both volume reduction and component separation for inorganic liquids. Carbon sorption and filtration provide component separation for both liquids and gases and are applicable to a wide range of heterogeneous waste streams. Both carbon sorption and evaporation are capable of large throughput rates. Neutralization, reduction, and precipitation are effective for separation of most heavy metals.[31,32]

Certain weaknesses are inherent in some treatment processes. For example, the five biological treatment processes are inefficient when waste streams are highly variable in composition and concentration or when solutions contain more than 1 to 5 percent salts.[33] Furthermore, biological treatment processes require larger land areas for facilities than the other physical or chemical processes. The efficiency of removal of hazardous liquids and gases from waste streams by carbon sorption is strongly dependent on pH. Similarly, the four dissolved solid removal proc-

TABLE 4

CURRENTLY AVAILABLE HAZARDOUS WASTE TREATMENT AND DISPOSAL PROCESSES*

Process	Functions performed†	Types of waste‡	Forms of waste§	Resource recovery capability
Physical treatment:				
Carbon sorption	VR, Se	1, 3, 4, 5	L, G	Yes
Dialysis	VR, Se	1, 2, 3, 4	L	Yes
Electrodialysis	VR, Se	1, 2, 3, 4, 6	L	Yes
Evaporation	VR, Se	1, 2, 5	L	Yes
Filtration	VR, Se	1, 2, 3, 4, 5	L, G	Yes
Flocculation/settling	VR, Se	1, 2, 3, 4, 5	L	Yes
Reverse osmosis	VR, Se	1, 2, 4, 6	L	Yes
Ammonia stripping	VR, Se	1, 2, 3, 4	L	Yes
Chemical treatment:				
Calcination	VR	1, 2, 5	L	
Ion exchange	VR, Se, De	1, 2, 3, 4, 5	L	Yes
Neutralization	De	1, 2, 3, 4	L	Yes
Oxidation	De	1, 2, 3, 4	L	
Precipitation	VR, Se	1, 2, 3, 4, 5	L	Yes
Reduction	De	1, 2	L	
Thermal treatment:				
Pyrolysis	VR, De	3, 4, 6	S, L, G	Yes
Incineration	De, Di	3, 5, 6, 7, 8	S, L, G	Yes
Biological treatment:				
Activated sludges	De	3	L	No
Aerated lagoons	De	3	L	No
Waste stabilization ponds	De	3	L	No
Trickling filters	De	3	L	No
Disposal/storage:				
Deep-well injection	Di	1, 2, 3, 4, 6, 7	L	No
Detonation	Di	6, 8	S, L, G	No
Engineered storage	St	1, 2, 3, 4, 5, 6, 7, 8	S, L, G	No
Land burial	Di	1, 2, 3, 4, 5, 6, 7, 8	S, L	No
Ocean dumping	Di	1, 2, 3, 4, 7, 8	S, L, G	No

*Sources: EPA Contract Nos. 68-03-0089, 68-01-0762, and 68-01-0556.

†Functions: VR, volume reduction; Se, separation; De, detoxification; Di, disposal; and St, storage.

‡Waste types: 1, inorganic chemical without heavy metals; 2, inorganic chemical with heavy metals; 3, organic chemical without heavy metals; 4, organic chemical with heavy metals; 5, radiological; 6, biological; 7, flammable; and 8, explosive.

§Waste forms: S, solid; L, liquid; and G, gas.

esses (ion exchange, reverse osmosis, dialysis, and electrodialysis) are all subject to operational problems when utilized for treating heterogeneous brines.[33]

Radioactive emissions and effluents from production or reprocessing facilities are routinely controlled by a variety of treatment methods. High efficiency filters are used to remove radioactive particulates from gaseous effluents; caustic scrubbers of charcoal absorbers are used to remove radioactive gases. Liquid effluents containing small quantities of soluble or insoluble radioactive constituents are usually treated with conventional water treatment techniques such as ion exchange, settling, precipitation, filtration, and evaporation.[34]

Commonly used disposal processes for hazardous wastes include land burial, deep-well injection, and ocean dumping. Detonation and open burning are sometimes used for disposal of explosives. Incineration is used for disposal of some organic chemicals, biologicals, and flammables.

All disposal processes have potential for adverse public health and environmental effects if used unwisely or without appropriate controls. Land disposal sometimes consists of indiscriminate dumping on the land, with attendant public health problems from animal vectors; water pollution from surface water runoff and leaching to groundwaters; and air pollution from open burning, windblown particulates, and gas venting. Sanitary landfills are much preferable to dumps in that daily earth cover minimizes vector problems and open burning and particulate transport. Unless specially designed, however, sanitary landfills still have potential for surface and groundwater pollution and air pollution from gas venting. Deep-well injection of liquid and semiliquid wastes can pollute groundwaters unless great care is taken in site selection and construction and operation of such wells. EPA policy opposes deep-well injection unless all other alternatives have been found to be less satisfactory in terms of environmental protection and unless extensive hydraulic and geologic studies are made to ensure that groundwater pollution will be minimized. Environmental problems associated with ocean dumping have long been recognized. The Congress recently passed legislation to control ocean dumping of wastes (Section 3). Incineration, open burning, and detonation all can result in air pollution unless adequate controls are employed. The residues from incineration, and from associated pollution control devices, may require special care in disposal.

Selection of appropriate treatment and disposal methods for a given waste is a complex process. It is simplistic to assume that a treatment and disposal process is applicable to all wastes of a given category. For example, available treatment and disposal processes for three types of heavy metal hazardous

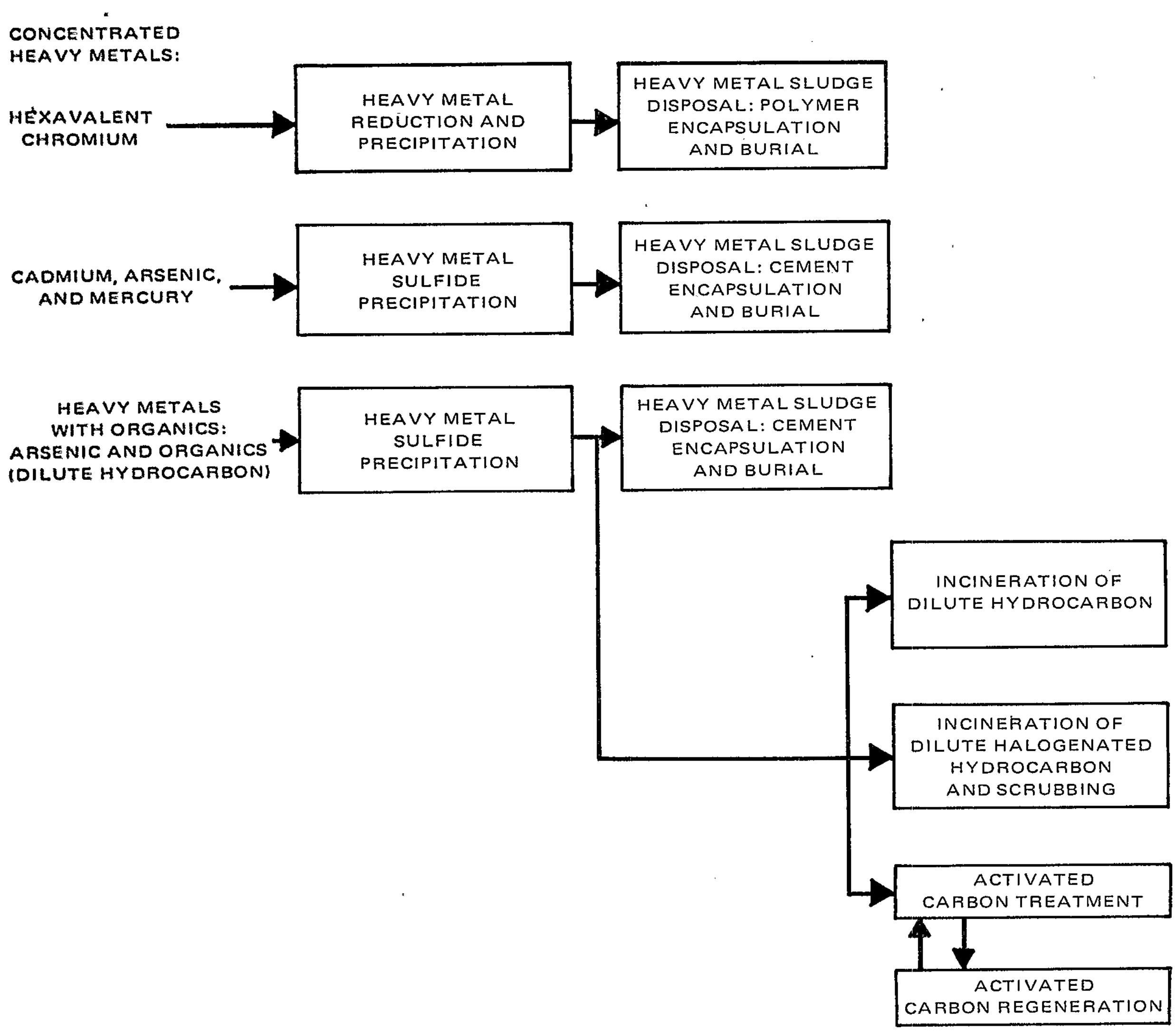

Figure 1. Examples of interrelationships between hazardous wastes and treatment and disposal processes. (Source: EPA Contract No. 68-01-0556.)

wastes—hexavalent chromium; cadmium, arsenic, and mercury; and arsenic and organics (dilute hydrocarbon)—exhibit significant differences (Figure 1).

Transfer and adaptation of existing technology to hazardous waste management may be necessary in some cases. Some hazardous waste streams (e.g., those containing arsenites and arsenates of lead, sodium, zinc, and potassium, and arsenic trioxide) cannot be treated or disposed of adequately with existing technology.[35] Secured storage is available until the appropriate treatment and disposal technology is developed. Synopses of treatment and disposal processes are given in Appendix D.

Public Use of Existing Technology

AEC and DOD presently utilize almost all the processes identified (Table 4) for management of hazardous wastes. High-level radioactive treatment and storage sites operated by AEC are located at Hanford, Washington; Savannah River, South Carolina; and the National Reactor Testing Station in Idaho. Similar DOD-operated nonradioactive hazardous waste treatment, storage, and disposal sites are located at a great number of arsenals, depots, and ammunition plants throughout the country.

Private Use of Existing Technology

Some large manufacturers, notably in the chemical industry, have established in-house hazardous waste processing facilities which utilize some of the treatment and disposal processes identified (Table 4). EPA-held data on such in-house operations are sparse. From available ocean and land disposal data, it is estimated, however, that only a small percentage of the hazardous wastes generated by industry receive treatment and are disposed of at in-house facilities.

The Hazardous Waste Processing Industry

In recognition of this situation, several private companies have built facilities to treat, dispose of, and recycle many hazardous wastes. These companies sell waste processing services to industries in their areas, generally within a 500-mile (805-kilometer) radius. However, largely because of lack of demand for services, these regional waste processing plants still are few in number (about 10 nationwide) and operate at about 25 percent of available capacity.

The total processing capacity of all facilities is approximately 2.5 million tons (2.3 million metric

TABLE 5
SUMMARY OF INFORMATION ON PRIVATELY OWNED REGIONAL HAZARDOUS WASTE PROCESSING PLANTS*

Item	Amount
Number of regional plants	Approximately 10
Estimated available capacity	2,500,000 tons per year (2,272,000 metric tons per year)
Estimated utilization of available capacity	25 percent
Available capacity as percent of required nationwide capacity	25 percent
Regional distribution	Mostly in North Central, Mid Atlantic, and Gulf Coast Regions
Total capital investment	$25 million
Resource recovery	Limited at present mostly to solvents and metallic salts

*This table does not consider very small firms with limited facilities (e.g., those plants that consist solely of an incinerator).

tons) per year (Table 5). Operating at full capacity, these private processing firms presently could handle about 25 percent of the total nationwide nonradioactive hazardous wastes. None of these facilities provide a complete range of treatment and disposal processes capable of handling all types of hazardous wastes (Table 5).

As stated earlier, nuclear weapons production facilities, commercial nuclear power reactors, and private sources generate a substantial quantity of high- and low-level radioactive wastes. High-level wastes are controlled by AEC. Management of low-level wastes by private companies at AEC or cooperative State sites is a highly specialized business with limited markets. As a result, there are only two companies engaged in handling and disposing of low-level radioactive wastes. The quantities of radioactive wastes are expected to increase exponentially starting around 1980, and, as a result, the number of nuclear waste disposal companies should also increase.

ECONOMIC INCENTIVES

The costs associated with proper hazardous waste treatment and disposal are fixed capital intensive and vary widely, depending on the particular treatment process that is required. Examination of typical capital and operating costs for a number of selected processes that are applicable to medium-size regional industrial waste treatment and disposal facilities illustrates that environmentally adequate technology is expensive (Table 6). Moreover, to arrive at the actual costs associated with proper treatment of hazardous wastes, a combination of several treatment processes is usually required.

The comparative economics of proper hazardous waste management versus presently used environmentally inadequate practices, such as disposal in dumps or in the ocean, indicate that adequate treatment and disposal of hazardous wastes cost 10 to 40 times more than the environmentally offensive alternatives (Figure 2). With these kinds of economic differentials, and in the general absence of pressures to do otherwise, one realizes why the more environmentally acceptable methods are seldom utilized. Available technology cannot compete economically with the cheaper disposal alternatives. Clearly, there are substantial economic incentives for industry not to use adequate hazardous waste treatment and disposal methods.

Should a generator elect to process his hazardous wastes in an environmentally acceptable manner, a basic decision must be made whether the particular waste stream should be processed on site or off site at some regional treatment facility, such as existing commercial waste processing plants. The cost analysis of this problem, as it applies to a number of commonly occurring industrial waste streams, was conducted by means of a mathematical model that produced "economic decision maps."[36] Typical examples are attached in Appendix E. An analysis of the decision maps indicates that cost factors generally favor off-site treatment and disposal of industrial hazardous wastes with the exception of dilute aqueous toxic metal streams. Other factors, such as the impact of pending water effluent standards and transportation problems, may alter this judgment.

SUMMARY

EPA's findings relative to the current handling of hazardous wastes can be summed up as follows:

(1) Current treatment and disposal practices are inadequate and cause unnecessary hazards to all life forms.

(2) Techniques for safe and environmentally sound treatment and disposal of most hazardous wastes have been developed. Adaptation and transfer of existing technology and development of new methods are required in some cases. It is possible to retain hazardous wastes for which treatment and disposal methods are unavailable in long-term storage until their chemical conversion to harmless compounds or their reuse in industrial practice becomes feasible.

TABLE 6

COSTS OF REPRESENTATIVE HAZARDOUS WASTE TREATMENT PROCESSES*,†

Process	Capacity		Capital costs‡ ($1,000)	Operating costs§	
	1,000 gal/day	1,000 liters/day		$/1,000 gal	$/1,000 liters
Chemical oxidation of cyanide wastes	25	94.8	400	68	18
Chemical reduction of chromium wastes	42	159	340	29	7.65
Neutralization/precipitation	120	452	3,000	50	13.20
Liquid-solid separation	120	452	9,000	40	10.60
Carbon sorption	120	452	910	7	1.85
Evaporation	120	452	510	10	2.64
Incineration	¶74	**67	4,900	††95	‡‡105

*Source: EPA Contract No. 68-01-0762.

†Data correspond to a typical medium-size treatment and disposal facility capable of processing approximately 150,000 tons (136,000 metric tons) per year or 600 tons (545 metric tons) per day.

‡Capital costs include land, buildings, and complete processing and auxiliary facilities.

§Operating costs include neutralization chemicals, labor, utilities, maintenance, amortization charges (7 percent interest), insurance, taxes, and administrative expenses.

¶Tons per day.

**Metric tons per day.

††Dollars per ton.

‡‡Dollars per metric ton.

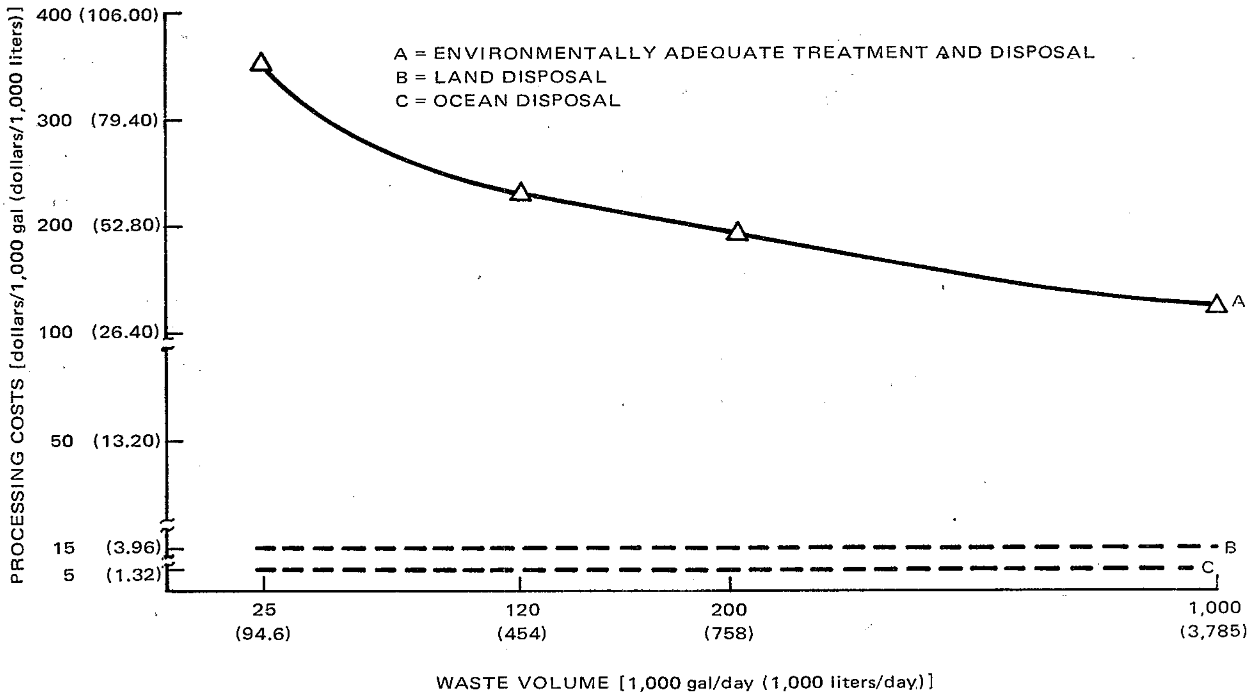

Figure 2. Cost comparison of proper versus improper hazardous waste management practices for aqueous wastes. Data include capital writeoff but not transportation costs from the generator to the nearest treatment or disposal facility. Note the economies of scale attainable by using large waste processing facilities. (Source: EPA Contract Nos. 68-01-0762 and 68-03-0089; based on cost data from typical treatment and disposal facilities capable of handling aqueous toxic wastes.)

(3) There are substantial economic incentives for industry not to use environmentally adequate treatment and disposal methods. Such methods are substantially more expensive than current inadequate practices, and in a climate of permissive legislation or total absence of legislation, competitive economic forces result in least-cost disposal regardless of the environmental consequences.

(4) A small industry has emerged to treat and dispose of hazardous and other industrial wastes. This industry is not currently operating at capacity because its services are being utilized only by a few clients who are concerned about the environment, have no cheaper disposal alternatives, or sometimes find themselves forced to use such services because of environmental regulations. This industry, however, has the capability to expand to meet demands engendered by future Federal or State actions.

It is evident that a need exists for bringing about environmentally acceptable and safe treatment and disposal of hazardous wastes. A discussion of the need for a regulatory program to achieve this goal follows in Section 3.

Section 3

THE CASE FOR HAZARDOUS WASTE REGULATIONS

The potential for public health and environmental damages from mismanagement of hazardous wastes and the lack of economic incentives for proper management has been described in Section 2. There is a strong precedent for Federal regulation when health damage is at issue. Regulation is used because the other conceptual alternative, massive economic incentives, does not ensure compliance. Some forms of regulation, however, may embody certain types of economic incentives. Federal and State statutes have attempted to regulate and control various parts of the problem, but there has never been an attempt to regulate hazardous waste management in a comprehensive manner.

The following discusses legislative precedents that relate to hazardous wastes and illustrates a legislative gap in the regulation of land disposal of hazardous wastes.

EXISTING AUTHORITIES FOR HAZARDOUS WASTE MANAGEMENT

A large body of Federal and State law exists today which exerts a significant but peripheral impact on the land disposal of hazardous wastes. The following discussion reviews existing laws and assesses their impact on the treatment, storage, transportation, handling, and disposal of hazardous wastes.

Federal Control Statutes

Thirteen Federal statutes have varying degrees of direct impact on the management of hazardous wastes. Four additional Federal statutes are either indirectly or potentially applicable to hazardous wastes. The Clean Air Act, as amended, and the new Federal Water Pollution Control Act (FWPCA) are discussed in some detail later in this section. The other statutes and their impact on the treatment, storage, transportation, and handling of hazardous wastes are summarized in the following.

Section 212 of the *Resource Recovery Act of 1970* directs the Administrator of EPA to study the feasibility of a system of national disposal sites for hazardous wastes.[37] The act authorizes no regulatory activities, however.

The *Atomic Energy Act of 1954, as amended,* authorizes AEC to manage radioactive wastes generated in fission reactions by both AEC and private industry.[38] High-level radioactive wastes from weapons and reactor programs are controlled directly by AEC at its facilities; commercially generated low-level radioactive wastes are generally disposed of at facilities licensed and controlled by the States. Naturally occurring materials, such as uranium mill tailings and radium, and radioisotopes produced by cyclotrons are not subject to regulation under the act. There is room for improvement at the radioactive waste storage and disposal facilities, but compared with the management of other hazardous wastes, high-level radioactive waste management is well regulated.

The Department of Transportation (DOT) is responsible for administering five statutes which affect the transport of hazardous wastes. The oldest of these, the *Transportation of Explosives Act*, prohibits the knowing unregulated transport of explosives, radioactive materials, etiologic (disease-causing) agents, and other dangerous articles in interstate commerce unless the public interest requires expedited movement or such transport involves "no appreciable danger to persons or property."[39] Supplementing this law is the *Hazardous Materials Transportation Act of 1970,* a nonregulatory statute which authorizes the Secretary of DOT to evaluate hazards associated with hazardous materials transport, establish a central accident reporting system, and recommend improved hazardous material transport controls.[40] The *Safety Regulation of Civil Aeronautics*

Act authorizes the Federal Aviation Administration to establish air transportation standards "necessary to provide adequately for national security and safety in air commerce."[41] The *Hazardous Cargo Act* places regulatory controls on the water transport of explosives or dangerous substances, authorizing the U.S. Coast Guard to publish regulations on packing, marking, labeling, containerization, and certification of such substances.[42] The *Federal Hazardous Substances Labeling Act* authorizes the Secretary of DOT to identify hazardous substances and prohibits the transport of such substances if their containers have been misbranded or the labels have been removed.[43] The act authorizes the seizure of misbranded hazardous substances and requires the courts to direct the ultimate disposition of such seized substances.

The *Federal Environmental Pesticide Control Act of 1972* requires the Administrator of EPA to establish procedures and regulations for the disposal or storage of packages, containers, and excess amounts of pesticides.[44] EPA is also required to "accept at convenient locations for safe disposal" those pesticides whose registration is suspended to prevent an imminent hazard and later canceled if the pesticide owner so requests.[44]

The *Marine Protection, Research, and Sanctuaries Act of 1972* prohibits the transport from the United States for the purpose of ocean dumping any radiological, chemical, or biological warfare agents, high-level radioactive wastes, or (except as authorized by Federal permit) any other material.[45] In granting permits for ocean dumping, the EPA Administrator must consider "appropriate locations and methods of disposal or recycling, including land-based alternatives, and the probable impact of [such use] upon considerations affecting the public interest."[46]

The *Clean Air Act* and the *Federal Water Pollution Control Act*, examined in detail later in this section, provide extensive control authority over the incineration and water disposal of certain hazardous wastes.[47,48]

The *Poison Prevention Packaging Act* authorizes the Secretary of Health, Education, and Welfare to establish special packaging standards for hazardous household substances whenever it can be shown that serious personal injury or illness to children can result from handling, using, or ingesting such substances.[49] Hazardous household substances already identified in regulations include oven cleaners, cigarette and charcoal lighter fluids, liquids containing turpentine and methyl alcohol, and economic poisons (pesticides).

The *Food, Drug and Cosmetic Act* prohibits the adulteration and misbranding of certain consumer items and requires the disposal by destruction or sale of any items seized under the act.[50]

The first of the Federal statutes that has a general, nonregulatory impact on the management of hazardous wastes is the *National Environmental Policy Act of 1969* (NEPA).[51] Section 101(b) of NEPA requires the Federal Government to "use all practicable means" to attain the widest range of beneficial uses without degrading the environment or risking health or safety. In order to ensure that the environmental policies expressed in Section 101 are effectively carried out, Section 102(2)(C) requires all agencies of the Federal Government to prepare detailed environmental impact statements for all "major Federal actions significantly affecting the quality of the human environment." All Federal hazardous waste management activities thus clearly fall within NEPA's ambit.

The *Armed Forces Appropriation Authorization Acts of 1969 and 1970* prohibit the use of Federal funds for the transportation, open-air testing, or disposal of any lethal chemical or biological warfare agent in the United States except under certain conditions requiring prior determination of the effect on national security, hazards to public health and safety, and practicability of detoxification prior to disposal.[52,53]

The *Coastal Zone Management Act of 1972*, in declaring it a national policy to preserve and protect the resources of the Nation's coastal zone, recognizes waste disposal as a "competing demand" on coastal zone lands which has caused "serious environmental losses."[54] Because applicants for Federal coastal zone managment grants must define "permissible land and water uses within the coastal zone," an applicant's failure to regulate hazardous waste disposal within such area so that it qualifies as a "permissible use" can serve as a basis for denying program funds under the act.

The *Occupational Safety and Health Act of 1970* (OSHA) authorizes the Secretary of Labor to set mandatory standards to protect the occupational safety and health of all employers and employees of businesses engaged in interstate commerce.[55] Section 6(b)(5) deals specifically with toxic materials and other harmful agents, requiring the Secretary to "set the standard which most adequately assures . . . that no employee will suffer material impairment of health or financial capacity" from regular exposure to such hazards. Employees of hazardous waste generators and treatment and disposal facilities engaged in interstate commerce thus are clearly entitled to the act's protection. It should be noted that standards issued under the act can directly impact some phases of hazardous waste management. For example, the OSHA-enforced asbestos regulation requires that certain wastes be packaged for disposal.

State Control Statutes

At least 25 jurisdictions have enacted legislation or published regulations which control hazardous waste management activities to some degree. The most effective of these regulatory controls are currently placed on low-level radioactive wastes, AEC having contracted with a growing number of States for low-level radioactive waste disposal. Nonradioactive hazardous wastes, however, are essentially unregulated in practice, for none of the 25 jurisdictions has fully implemented its control legislation. The major reason for this failure is the negative approach—broadly worded blanket prohibitions—utilized by virtually all of these States.

Legislative strategies which rely on blanket prohibitions rather than comprehensive management controls are difficult or impossible to administer in any meaningful, systematic fashion. In addition, many of these States enact control statutes without providing for acceptable treatment or disposal facilities. A recent survey of 16 of the 25 "control" States reveals, for example, that less than half of them have treatment and disposal facilities located within their boundaries (Table 7).[56] By failing to specify acceptable alternatives to prohibited activities, such States encourage hazardous waste generators to ignore the law altogether or to select and employ divergent disposal alternatives unknown to the State control authorities that may be more environmentally harmful than the prohibited activity.

Summary

With the exception of radioactive waste disposal, which appears to be the subject of adequate Federal and State regulation, land-based hazardous waste treatment, storage, and disposal activities are essentially unregulated by Federal and State laws. Because this legislative gap allows uncontrolled use of the land for hazardous waste disposal, there has been little incentive for the use of proper hazardous waste treatment and disposal technology to date. Until nationwide controls are established, the pressure on the land as a receptor for hazardous wastes can be expected to increase as the major hazardous waste disposal controls of the Clean Air Act, the FWPCA, and the new Federal ocean dumping statute are tightened. The latter statute's mandate to the EPA Administrator to consider land-based disposal alternatives when granting ocean dumping permits seems certain to provide opponents of the practice of dumping toxic wastes into the ocean with a new and powerful legal tool. Depending on the courts' interpretation of this statute, the Marine Protection, Research, and Sanctuaries Act of 1972 could add significantly to the pressure on land as the last disposal medium for hazardous wastes.

PRECEDENTS FOR HAZARDOUS WASTE REGULATION

Both the Clean Air Act and the FWPCA include provisions that address the problem of hazardous waste management directly.[47,48] The former statute authorizes the control of hazardous air pollutants, and the latter controls the discharge of hazardous pollutants into the Nation's waters.

The Clean Air Act best exemplifies a control strategy designed to protect the public health and welfare by placing the burden of standards compliance on the air polluter. As with most environmental control statutes, the costs of compliance are internalized by the polluter and ultimately passed on to the consumer, indirectly in the form of tax benefits to the polluting industries, or directly in the form of higher prices for goods and services.[57] In the past, Clean Air Act standards have been based almost exclusively on health effects. As a result of adverse court decisions on ambient air quality standards, however, EPA has expanded its efforts to consider, in

TABLE 7

SUMMARY OF STATE LEGISLATION SURVEY*

State	Solid waste		Radioactive material				Pesticides			
	Disposal regulations	Licensing of disposal sites	Regulations on: Disposal	Transportation	Processing	Storage	Regulations on: Disposal	Transportation	Processing	Storage
Alabama	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
California	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Colorado	Yes	Yes	Yes	No	No	No	No	No	No	No
Illinois	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kansas	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Maine	No	No	Yes	Yes	Yes	Yes	Yes	No	No	No
Michigan	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Nevada	No	No	Yes	Yes	Yes	Yes	Yes	No	No	Yes
New Jersey	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
New York	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Oregon	Yes	Yes	Yes	No	No	No	Yes	Yes	No	Yes
South Carolina	Yes	Yes	Yes	No	No	Yes	No	No	No	No
Texas	Yes	Yes	Yes	Yes	Yes	Yes	No	–	Yes	Yes
Vermont	No	No	Yes	Yes	Yes	Yes	Yes	No	No	No
Virginia	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No	No
Washington	Yes	Yes	Yes	No	No	No	Yes	No	No	No

State	Explosives				Transportation		Industrial safety regulations for handling hazardous materials	Presence of existing facilities	
	Disposal	Regulations on: Transportation	Processing	Storage	DOT regulations	Other†		Radioactive	Hazardous‡
Alabama	–	–	–	–	Yes	–	Yes	Yes	No
California	No	Yes	No	Yes	Yes	Yes	Yes	–	Yes
Colorado	No	No	No	No	Yes	No	No	No	No
Illinois	–	Yes	–	–	Yes	Yes	–	Yes	No
Kansas	Yes	Yes	Yes	Yes	Yes	Yes	–	Yes	--
Maine	Yes	Yes	–	–	Yes	–	Yes	No	No
Michigan	Yes	Yes	–	–	No	Yes	Yes	No	Yes
Nevada	Yes	No	No	Yes	Yes	No	No	No	No
New Jersey	Yes	Yes	Yes	Yes	Yes	–	No	Yes	Yes
New York	Yes	Yes	Yes	Yes	Yes	–	Yes	Yes	Yes
Oregon	Yes	Yes	No	Yes	Yes	No	No	No	No
South Carolina	No	Yes	No	No	Yes	Yes	–	Yes	No
Texas	–	–	–	–	Yes	Yes	–	Yes	Yes
Vermont	Yes	Yes	Yes	Yes	Yes	–	No	No	No
Virginia	Yes	Yes	Yes	Yes	Yes	–	No	No	No
Washington	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes

*Source: EPA Contract No. 68-01-0762.
†Includes hauling permits, vehicle registrations, material registrations, bills of lading, placard attachment, and vehicle standards.
‡Includes pesticides, toxic substances, and other chemicals.

addition to health and welfare factors, (1) beneficial and adverse environmental effects; (2) social, economic, and other pertinent factors; (3) the rationale for selecting the standard from the available options.[58-60]

The FWPCA Amendments of 1972 generally exemplify a control strategy based on factors in addition to human health and welfare. Typical of the FWPCA's new regulatory provisions are those keyed to "best practicable" control technology and "best available technology economically achievable," determinations which are to be made by EPA from studies of the age, size, and unit processes of the point sources involved and the cost of applying effluent controls.

The Clean Air Act

Section 112 of the Clean Air Act authorizes the Administrator of EPA to set standards for hazardous air pollutants at any level "which in his judgment provides an ample margin of safety to protect the public health."[61] Hazardous air pollutants are defined as those which "may cause, or contribute to an increase in mortality or an increase in serious irreversible or incapacitating reversible, illness" [Section 112(a)(1)]. Asbestos, beryllium, and mercury are three hazardous pollutants for which emission limits under Section 112 have been promulgated.

The Federal Water Pollution Control Act

The FWPCA contains a number of provisions with direct impact on hazardous pollutant-bearing wastes.

Section 502(13) defines "toxic pollutant" as "those pollutants . . . which . . . after discharge and upon exposure, ingestion, inhalation or assimilation into any organism . . . will cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions . . . or physical deformations on such organisms or their offspring." Section 115 directs EPA to locate and contract for "the removal and appropriate disposal of [in-place toxic pollutant] materials from critical port and harbor areas." The potential for increased pressure for land disposal of such toxic pollutants is evident.

Title III of the FWPCA contains four provisions authorizing control over toxic pollutants discharged into water from point sources. The importance of the FWPCA's distinction between point and nonpoint sources cannot be overemphasized from a hazardous waste management viewpoint, for discharges from point sources *only* are subject to the act's regulatory controls.* Because the act defines "point source" as "any discernible, confined and discrete conveyance," and offers as examples such things as pipes, ditches, and tunnels, Congress seems *not* to have intended that land disposal facilities are to be included within the point source definition.[62] In fact, the opposite appears to be true, for Section 304(e) of the act requires EPA to publish nonregulatory "processes, procedures, and methods to control pollution resulting from . . . *the disposal of pollutants in wells or in subsurface excavations*" [emphasis supplied].[63]

Since the types of pollutant discharges normally associated with improperly managed hazardous waste disposal facilities are runoff into navigable waters and migration into groundwater supplies, it seems safe to conclude that, unless a disposal facility discharges toxic pollutants into a waterway through a "discernible, discrete conveyance," such as an outfall pipe, it will be exempt from the act's proscriptions.

Hazardous waste treatment facilities, however, should not escape the act's reach. Any toxic wastes produced by such facilities and not treated on site must be stored and/or eventually transported in some manner, and any container or confined means of conveyance for such waste, by definition in Section 502(13) of the act, qualifies as a potential point source of water pollution discharge.

The first of Title III's proscriptions against toxic pollutant discharges may be found in Section 301(f), which prohibits the "discharge of any radiological, chemical, or biological warfare agent, or high level radioactive waste into the navigable waters." The other statutory authorities which impact on the disposal of these wastes were discussed previously.

Section 306 is the second reference to hazardous wastes. It requires EPA to publish national standards of performance for new point source categories reflecting "the greatest degree of effluent reduction achievable . . . , including where practicable, a standard permitting no discharge of pollutants."[64] The act singles out such new source categories as the organic and inorganic chemicals industries, well-known generators of toxic wastes. These standards, which must take into account the cost of standards' achievement and "any non-water quality environmental impact and energy requirements,"* must be published not later than January 1974. Hazardous waste generators and treatment facilities which otherwise qualify as "new" clearly are comprehended in Section 306(a)(3), which defines new sources as "any building, structure, facility, or installation from which there is or may be the discharge of pollutants." This adds to the general qualification of such facilities as point sources.

The third FWPCA provision affecting toxic pollutants is Section 307, which requires EPA to identify and publish effluent standards for a list of toxic pollutants or combinations of such pollutants. Standards are to be set "at that level which the Administrator determines provides an ample margin of safety," and are to take effect not later than 1 year after promulgation.[65] Even though Congress' standard-setting process mandate to EPA under this section

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*Section 301(a) established FWPCA's broad prohibitions against the "discharge of any pollutant." Section 502(12) defines "discharge of pollutants" as "any addition of any pollutant to navigable waters *from any point source*" [emphasis supplied].

*Section 306(b)(1)(B). The FWPCA's legislative history, however, makes it clear that individual new sources, rather than EPA, will determine which technologies will be used to achieve Section 306(b)'s performance standards. Conference Report No. 92-1465, FWPCA Amendments of 1972, 92d Congress, 2d Sess. (Sept. 28, 1972, p.128.)

was limited to consideration of toxicity data alone,* other factors, as previously discussed, likely will be considered to produce judicially enforceable standards, given recent air-pollution-related court decisions.[58-60,†]

Section 311 is designed to protect the navigable waters and adjoining shorelines of the United States and the waters of the contiguous zone from "hazardous substance" discharges. EPA must designate as hazardous substances those elements and compounds "which, when discharged in any quantity, . . . present an imminent and substantial danger to the public health and substantial danger to the public welfare, including but not limited to fish, shellfish, wildlife, shorelines, and beaches."[66] Designed primarily to control spills from vessels and onshore or offshore facilities, Section 311 requires violators to pay a fixed cost for each hazardous substance unit unlawfully discharged,‡ with the President alone authorized to permit certain of these discharges when he has determined them "not to be harmful."[67] Coastal zone area hazardous waste generation and treatment facilities thus would clearly be subject to Section 311 controls and penalties.

CLOSING THE CIRCLE ON HAZARDOUS WASTES

The foregoing discusses the many Federal and State statutes that have impact on hazardous waste management activities. The more detailed analyses of the Clean Air Act and the FWPCA illustrate that, whereas the toxic effluents of hazardous waste generation and treatment facilities will probably come under control, land-based facilities for open storage or disposal of such hazardous wastes remain essentially unregulated. As standards and regulations published under recent environmental legislation begin to close off water as a disposal medium, and as enforcement of air pollution standards takes shape, hazardous waste generators can be expected to turn increasingly to land disposal as a means of solving their hazardous waste problems. The need for regulations for land disposal will become more acute.

The concluding part of this section discusses the persons and activities that would be subject to control under a comprehensive hazardous waste regulatory program, reviews in some detail the type of hazardous waste standards considered to be appropriate under such a program, and identifies and evaluates the strengths and weaknesses of three alternative regulatory program enforcement strategies.

Persons and Activities Subject to Regulatory Controls

In order to forestall the type of environmental degradation likely to occur from the uncontrolled use of the land as an ultimate sink for the Nation's ever-increasing supply of hazardous wastes, the focus of any hazardous waste regulatory program must first be on land disposal activities and those who provide and utilize land disposal services. Persons subject to disposal controls should include all generators of hazardous waste who opt for on-site disposal, as well as those persons who receive wastes off site for disposal. Long-term sealed storage should be considered disposal for the enforcement purposes of such regulation. The location of disposal sites should be permanently recorded in the appropriate office of legal jurisdiction.

The next priority activity for regulation is treatment since utilization of the appropriate hazardous waste treatment processes can often detoxify such wastes and render them safe for unregulated disposal in sanitary landfill facilities or at a minimum reduce the need for long-term "perpetual care" and environmental risks inherent therein. EPA has proposed a regulatory program for hazardous waste streams

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*Section 307(a)(2) requires the Administrator of EPA to publish proposed toxic effluent standards (or prohibitions) which "shall take into account (1) the toxicity of the pollutant, (2) its persistence, (3) degradability, (4) the usual or potential presence of the affected organism in any waters, (5) the importance of the affected organisms, (6) the nature and extent of the effect of the toxic pollutant on such organisms . . . ." No other considerations are mentioned in Section 307 or its legislative history.

†See *Kennecott Copper* v. *EPA*, U.S. App. D.C., _F. 2d _, 3 ERC 1682 (Feb. 18, 1972) (EPA must explain in detail the basis for sulfur oxide standards promulgated under informal rulemaking); *Anaconda Company* v. *Ruckelshaus*, D.C. Colorado, _F. Suppl. _, 4 ERC 1817 (Dec. 19, 1972) [EPA must hold adjudicatory (formal rulemaking) hearing before promulgating State sulfur oxide emission standard that applies to a single company]; *International Harvester Co.* v. *Ruckelshaus*, U.S. App. D.C., _F. 2d _, 4 ERC 2041 (Feb. 10, 1973) (failure to support auto emission standard with "reasoned presentation" requires EPA to reconsider automakers' showing that technology is not available to achieve 1975 standards).

‡Section 311(b)(2)(B)(IV) requires EPA to establish units of measurement based on usual trade practices, with penalties for each unlawful unit discharged ranging from $100 to $1,000 per unit.

which incorporates treatment in order to lessen the demand on land disposal alternatives. All persons who treat the same hazardous wastes, either on site (generators) or off site (contract service organizations), should be subject to the same treatment standards. Processes for recovery of recyclable constituents from hazardous wastes should be controlled adequately by treatment regulations, for the technologies employed are often the same.

Other hazardous waste management activities that should be subjected to improved controls are hazardous waste transport and handling. As indicated earlier, DOT administers a number of Federal statutes designed to control the transportation of hazardous materials in interstate commerce. These statutes should be amended by DOT where necessary to ensure that hazardous wastes are properly marked, containerized, and transported (to authorized disposal sites). The packaging and labeling provisions of all other Federal statutes that have a potential impact on hazardous wastes should be reviewed by EPA and amended where necessary to ensure their applicability to such wastes.

It should be noted that control of toxic materials before they become toxic wastes could greatly reduce the size of the overall hazardous waste management problem. The proposed Toxic Substances Control Act, now pending before Congress, would provide for regulatory controls over toxic substances before they become wastes. The proposed legislation authorizes testing of chemical substances to determine their effects on health or the environment and restrictions on use or distribution of such chemicals when warranted. Such restrictions may include labeling of toxic substances as to appropriate use, distribution, handling, or disposal, and limitations on particular uses, including a total ban. This "front-end" approach to toxic substances problems should dovetail neatly with a hazardous waste regulatory program.

Types of Hazardous Waste Standards

The foundation of any regulatory program, of course, is the body of standards the program establishes and enforces. The Clean Air Act and FWPCA regulatory programs progressed from ambient air and water quality standards to specific pollutant emission and discharge standards as practical experience with each statute's enforcement revealed the necessity for such an evolution.[68]

Because of the nature of the discharges associated with improperly managed hazardous waste, two types of standards are likely to be necessary in order to satisfactorily regulate hazardous waste treatment and disposal: (1) The "performance" standard would set restrictions on the quantity and quality of waste discharged from the treatment process and on the performance of the disposal site (e.g., the amount and quality of leachate allowed); (2) the "process" standard would specify treatment procedures or process conditions to be followed (e.g., incineration of certain wastes) and minimum disposal site design and operating conditions (e.g., hydraulic connections are not allowed).

The performance standards, which correspond directly to the emission and discharge standards of the Clean Air Act and the FWPCA, would be designed to prevent hazardous pollutant discharges from treatment and disposal facilities from reaching air and surface waters in excess of acceptable air and water limits. A major advantage of this type of standard is the ability to use health and environmental effects data and criteria already developed by EPA's Office of Air and Water Programs and Office of Research and Development.

Process standards would be designed to ensure that certain treatment technologies and minimum design and operating conditions are employed. These standards assume double importance because of the uncertainty surrounding the FWPCA's standard-setting authority regarding discharges into ambient groundwaters,* and the act's clear lack of authority to regulate diffuse discharges from nonpoint sources such as land disposal sites. Process (design and operating) standards, therefore, which are intended to establish controls at the hazardous waste sources, would be an important part of any regulatory program.

Strategies for Hazardous Waste Regulation

Hazardous wastes can be regulated by three distinct control strategies: (1) Federal only, (2) State

*Although the broad definition given to "navigable waters" in Section 502(7) of the FWPCA arguably includes groundwaters, the restriction of the act's regulatory provisions to discharges of pollutants from point sources virtually eliminates the most common source of groundwater pollution; i.e., runoff or leachate from nonpoint sources. (See earlier discussion of point sources.)

only, (3) Federal/State partnership. Each of these alternatives is examined.

Federal Only. The Federal-only type of control strategy requires the exclusive jurisdiction of the Federal Government (Federal preemption) over all management activities for hazardous waste. The most obvious advantages include national uniformity of standards, elimination of State pollution havens for industries controlling a significant portion of such a State's economy, and uniform administration and enforcement. The major disadvantages of this control strategy are the difficulty in proving conclusively that the hazards of human health and the environment justify total Federal involvement, the prohibitive costs and administrative burdens involved in maintaining a nationwide Federal monitoring and enforcement program, and the total disincentive for State involvement in what is essentially a State problem. The only comparable Federal program is that involving the exclusive disposal of high-level radioactive wastes by AEC.

State Only. Under the State-only control strategy, the Federal Government would establish "recommended guidelines" for hazardous waste treatment and disposal which the States could adopt as a minimum, modify in either direction (more or less stringent) in response to local needs and pressure groups, or ignore altogether. These Federal guidelines could be used to recommend what would otherwise be process and performance standards under a Federal regulatory program, as well as the minimum efforts the Federal Government believes are necessary to administer and enforce an effective State control program. States could finance activities themselves; alternatively, the Federal Government could offer technical and financial support to assist States in program development and enforcement. The major advantage of this approach is in its low level of Federal involvement and correspondingly low Federal budget requirements. Another advantage includes enhanced ability to tailor solutions to particular problems that may be essentially local in character. The disadvantages of the State-only approach to hazardous waste control include its total dependence on the States for the adoption and enforcement of voluntary guidelines, the nonavailability of Federal backup enforcement authority, the potential for extreme nonuniformity between the individual States adopting control programs, and the much greater period of time needed to enact and fully implement such a control system nationwide.

Federal/State Partnership. The Federal/State partnership is the control strategy that had been adopted by the Nation's major environmental pollution control statutes. The Federal Government would establish minimum Federal hazardous waste treatment and disposal standards; all States would be required to adopt these as minimum State standards within a specified time period. The States would bear the responsibility for establishing and administering EPA-approved State control programs. Functions could include operating a statewide hazardous waste facility permit program, maintaining an inspection and monitoring force, enforcing statutory sanctions against violators, and filing program progress reports with EPA. As in the Federal air and water pollution control programs, States with approved implementation programs would be eligible for Federal financial assistance. For those States that fail to submit approved programs, or that do not enforce the Federal/State standards, backup Federal enforcement powers could be exercised to ensure uniform compliance or Federal program grant funds could be withheld. Provision could also be made for a federally administered control and enforcement program for certain hazardous wastes determined to pose extremely severe hazards, an approach already utilized by AEC for high-level radioactive wastes. The major advantage of this control strategy stems from the well-established legislative precedents discussed earlier; land pollution control regulations employing this strategy would be capable of being fully integrated with existing controls over air and water pollution. Other advantages include utilizing the Federal Government's superior resources to set standards and design programs, while retaining the concept of State responsibility for what are traditionally recognized as State problems; minimal Federal involvement once the States' implementation programs are fully underway; uniform minimum national hazardous waste standards, with States retaining the power to set more stringent standards if local conditions so dictate; and reasonable assurance that the standards will be enforced ultimately by some-one. The disadvantages of the combined Federal/State hazardous waste control strategy involve its potential for delay in final implementation, since States can be expected to demonstrate varying degrees of readiness and interest in gearing up State machinery to run their respective control programs. The major drawback to this approach, however, involves its potential for large expenditures of Federal manpower and funds should the States choose to sit back and "let the Feds do it"; even worse is the possibility that Federal standards for hazardous waste control will be completely unenforced in laggard States simply because of the lack of adequate funds to exercise the reserve powers. This problem seems capable of resolution, however, if adequate incentives for State action are made available (Federal grants or technical assistance) and if significant disincentives are applied (such as withholding air and water program grant funds or characterizing the State as "irresponsible").

SUMMARY

The earlier parts of this section describe the gap in Federal and State hazardous waste management legislation, a gap which if not filled soon by Congress' adoption of a comprehensive hazardous waste control strategy could well result in irreparable damage to the health and environment of the Nation's citizens. The most viable hazardous waste control strategy would consist of a Federal/State regulatory partnership in which the Federal Government would bear the responsibility for setting process and performance standards applicable to all hazardous waste treatment and disposal activities while qualified State governments would be responsible for administering federally approved control programs and enforcing the Federal standards.

Section 4

ISSUES OF IMPLEMENTATION

The previous section spells out the need for a regulatory program. A hazardous waste regulatory program does not directly create an NDS system as envisioned in Section 212 of the Resource Recovery Act of 1970. However, such a system would be ineffective unless its use is mandated through regulations. Even with total governmental subsidy of its construction and operation, such a system would not be assured of receiving all hazardous wastes. Therefore, a regulatory program is needed in any case.

EPA believes that private industry will respond to a regulatory program, but there are a number of questions relating to that response. Furthermore, several options are available to the Government to modify a purely private sector system to circumvent these questions if need be.

In this section, estimates are developed of a hazardous waste management system required to implement a hazardous waste regulatory program, the cost of such a system, and possible variations of the system. Issues related to cost distribution, private sector response, and the role of Government are discussed thereafter.

HAZARDOUS WASTE MANAGEMENT SYSTEM

A hazardous waste management program should result in creation of a system with certain characteristics: adequate treatment and disposal capacity nationwide, lowest cost to society consistent with public health and environmental protection, equitable and efficient distribution of cost to those responsible for waste generation, and conservation of natural resources achieved by recovery and recycling of wastes instead of their destruction.

This system should combine on-site (point of generation) treatment of some wastes, off-site (central facility) treatment for hazard elimination and recovery, and secure land disposal of residues that remain hazardous after treatment.

Estimates of total required treatment and disposal capacity, and the mix of on-site and off-site capacity, are keyed to hazardous waste source quantities, types, and geographical distribution; the degree of regulation and enforcement; and the timing of regulatory and enforcement implementation. The hazardous waste management scenario developed represents, in EPA's judgment, a system with the aforementioned characteristics. It is based on the best available source data and technology assessments, discussions with major waste generators and disposal firms, and consideration of the following criteria: earth sciences (geology, hydrology, soils, and climatology), transportation economics and risk, ecology, human environment, demography, resource utilization, and public acceptance.[6,7,9,10] The scenario assumes complete regulation, treatment, and disposal of all nonradioactive hazardous wastes (as defined in Appendix B) and anticipates issuance of regulations and vigorous enforcement of them at the earliest practicable time period.

The scenario that follows and the cost estimates derived from the scenario should be viewed with caution. Given any reasonable degree of dependence on private market choices on the part of waste generators and waste treatment and disposal firms, the actual implementation of a hazardous waste management program in the United States is not likely to follow predictable, orderly lines. Numerous interactive factors are likely to influence the shape and the cost of the system as it evolves—including such factors as the impact of air and water effluent regulations on waste stream volume and composition, the impact of uneven response to regulatory pressures from region to region, changes in technology, and shifting locational patterns. What follows, therefore, should be considered as one of many possible permutations of the system. Nonetheless, the scenario does represent EPA's current best judgment of a reasonable, environmentally adequate hazardous waste management system.

As noted previously, approximately 10 million tons (9 million metric tons) of nonradioactive hazardous wastes are generated per year. Of these, about 60 percent by weight are organics and 40 percent are inorganics; about 90 percent of these wastes are aqueous in form.

Economic analyses indicate that on-site treatment is generally justified only for dilute aqueous toxic metal wastes and only where the generation rate is high (Appendix E). From analyses of source data, it is estimated that about 15 percent of the total wastes (1.5 million tons or 1.36 million metric tons) are in the dilute aqueous toxic metal category and would be pretreated by generators on site. Since on-site facilities are anticipated to be small in scale compared to off-site facilities, about 50 on-site facilities each capable of handling approximately 30,000 tons (27,000 metric tons) per year would be economically justified. About one-third (0.5 million tons or 0.45 million metric tons) of pretreated wastes would require further processing at off-site facilities.

In this postulated scenario, therefore, most of the wastes (8.5 million tons or 7.7 million metric tons plus pretreatment residues) would be transported to off-site facilities for treatment and disposal. The size and location of treatment plants is likely to correspond to patterns of waste generation: Larger facilities would be located in major industrial regions, smaller facilities elsewhere. Background studies have identified the location of industrial waste production centers and the designs and unit costs of small-, medium-, and large-size processing facilities (Appendix F).

A reasonable prediction is that five large facilities, each capable of handling approximately 1.3 million tons (1.2 million metric tons) per year, would be created to serve five major industrial regions in the United States, and 15 medium-size treatment plants, each processing approximately 160,000 tons (145,000 metric tons), would be built elsewhere to provide reasonable access from other waste generation points. Such an array of treatment plants, taken in conjunction with existing privately owned facilities, is capable of processing all the nonradioactive hazardous waste generated in the United States at present, with a 25-percent margin for future growth in waste volume.

Processing reduces aqueous waste volume by about 50 percent and usually results in the elimination of hazard (detoxification, neutralization, decontamination, etc.). If the appropriate treatment processes are used, most processing residues will be harmless and disposal in ordinary municipal landfills will be possible. A small portion (5 percent—225,000 tons or 204,000 metric tons) of residues containing toxic metals would require disposal in special, secure landfills.

Under the assumption that maximum treatment for hazard elimination and volume reduction of extremely hazardous waste is carried out, no more than five (and possibly fewer) large-scale secure landfills would be required. Facilities would transport their toxic metal residues to such land disposal sites rather than operating secure landfills of their own given the scarcity of naturally secure sites, the difficulty in gaining public acceptance of such sites, the additional expense of artificially securing sites, and the relatively low costs of long-haul transport.

Costs

Based on the above scenario, cost estimates have been prepared for on- and off-site treatment facilities, secure disposal, and waste transportation. (The actual values used for estimation purposes are shown in Table 8; more detail is presented in Appendix F.) Estimates are based on comprehensive engineering cost studies. Each regional processing facility was assumed to provide a complete range of treatment processes capable of handling all types of hazardous wastes, and, therefore, each is much more costly than existing private facilities that are more specialized.

Based on these estimates, the development of this version of a national hazardous waste management system would require investments in new facilities of approximately $940 million. Average annual operating expenditures (including capital recovery, operating costs, and interest) of about $620 million would be required to sustain the program. In addition, administrative expenses of about $20 million annually for Federal and State regulatory programs would be necessary.

TABLE 8
COST ASPECTS (IN MILLIONS OF DOLLARS) OF AN EPA SCENARIO OF A NATIONAL HAZARDOUS WASTE MANAGEMENT SYSTEM

Item	Cost per unit		Number needed	Total capital required	Total annual cost*
	Capital needed	Annual operating*			
On-site facilities	1.4	0.73	51	71	37
Off-site facilities:					
Treatment (large)	86.0	57.1	5	430	286
Treatment (medium)	24.1	12.5	15	362	188
Secure disposal	2.5	1.2	5	13	6
Transport	†63.0	‡11	(§)	63	99
Total				¶939	616

*Includes capital recovery in 10 years and interest at 7 percent.
†Capital required based on new rail rolling stock.
‡Dollars per ton.
§Transport required for 9.0 million tons (8.25 million metric tons) of waste; average distance from generator to treatment facility is 150 miles.
¶Approximately $25 million has already been invested in current private sector off-site treatment facilities.

For this scenario, system costs fall into five broad categories: (1) on-site treatment (about 6 percent of total costs on an annualized basis), (2) transportation of wastes to off-site treatment facilities (16 percent), (3) off-site treatment (74 percent), (4) secure disposal (1 percent), (5) program administration (3 percent). The largest element of cost is off-site treatment. Treatment followed by land disposal of residues is not necessarily more expensive than direct disposal of untreated wastes in secure landfills. Treatment before disposal would buy greater long-range protection of public health and the environment.

Variations

Although the above scenario is reasonable and would satisfy requirements for environmentally adequate hazardous waste management, it is not presented as a hard-and-fast specification of what a national system should look like. There is no single optimum system given such uncertainties as hazardous waste generator response to air, water, and hazardous waste regulations; future directions in production and waste processing technology; timing and level of enforcement; and public reaction to site selection decisions. However, some comments can be made about variations in the system scenario presented.

It is unlikely that more large-scale and fewer medium-scale processing facilities would be constructed unless specifically mandated. The higher initial capital investment of large-scale processing facilities is warranted only where large market potential exists, i.e., in the major industrial regions. At present, addition of only two more large-scale facilities (over the five in the scenario) would provide sufficient capacity to treat all nonradioactive hazardous wastes. Stated another way, two more large-scale facilities could handle all the wastes for which 15 medium-size facilities were postulated in the scenario. However, resulting increased costs of transportation from generators to these larger treatment facilities (because average transport distances would increase) would offset cost reductions due to better economies of scale (Figures 3 and 4). The net result would be a significant loss in convenience and increase in transportation risks for a fairly insignificant saving in capital cost and a higher operating cost.

Construction of a larger number of medium- or small-scale plants (and consequently fewer large-scale plants) tends to drive capital costs up sharply (Figure 3). Total system operating costs also rise because transportation cost savings are not sufficient to offset lost economies of scale (Figure 4). Transportation risk would decline because of shorter haul distances, but inspection and enforcement costs would increase because of the larger number of plants requiring surveillance. As will be discussed, however, a private sector system may consist of more smaller plants and thus may result in higher total costs.

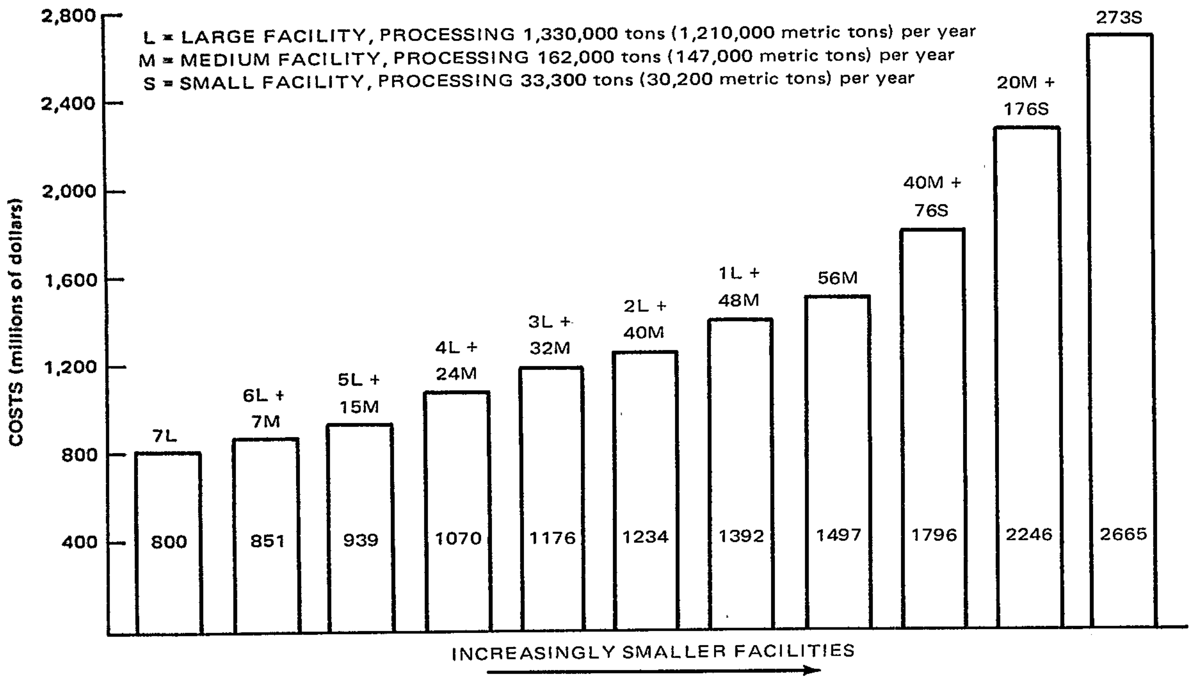

Figure 3. Fixed capital cost sensitivity of a national hazardous waste management system to fluctuations in number and size of facilities. Each configuration includes $71 million for on-site facilities, $13 million for secure land disposal, and from $41 million to $114 million for new transportation equipment (based on average distance and estimated turnaround time).

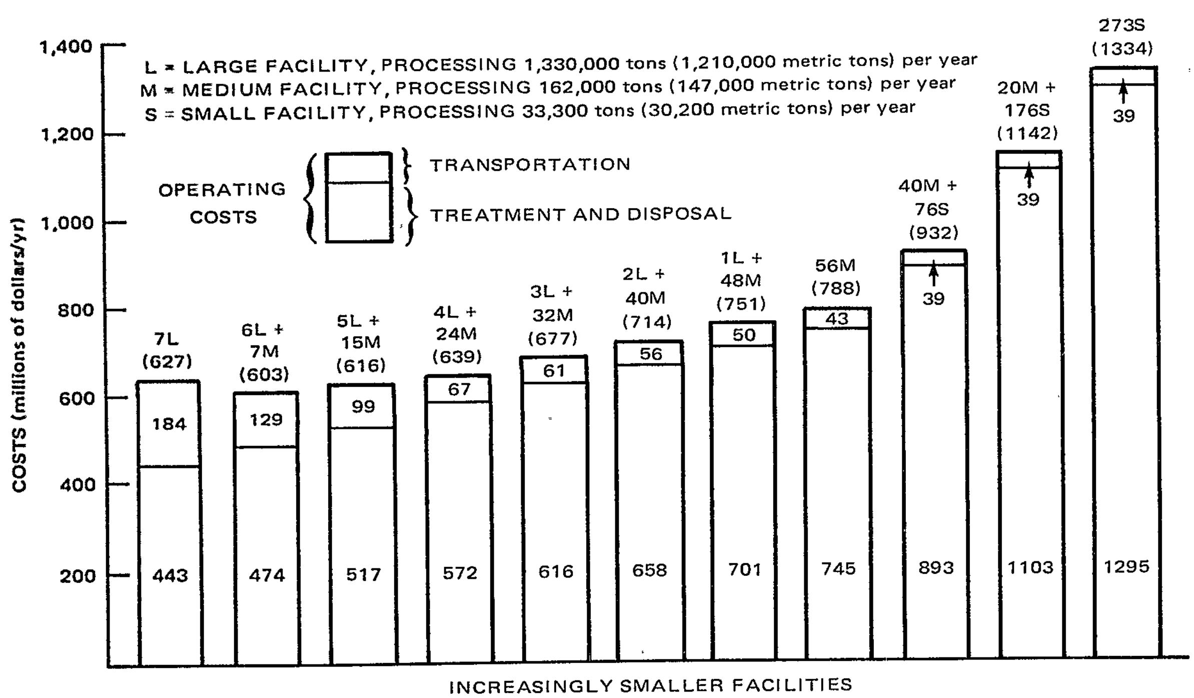

Figure 4. Operating cost sensitivity of a national hazardous waste management system to fluctuations in number and size of facilities. Each configuration includes $37 million in annual costs for on-site facilities and $6 million for secure land disposal.

There could be fewer disposal sites than assumed in the scenario if land availability and suitability and public acceptance problems arise. This outcome is likely if, for instance, only arid lands with no hydrologic connection to surface and ground waters are deemed acceptable as disposal sites; i.e., if disposal siting standards are extremely strict. Transportation costs would increase somewhat but not linearly with distance. For example, rail transport costs are estimated at $35 per ton for 1,000 miles and $49 per ton for 2,000 miles. Transport risks would be greater, but disposal risks and enforcement costs would decline because fewer sites would be easier to monitor.

On the other hand, as a policy decision, the Government could allow significantly more disposal relative to processing. Many more, or at least much larger, disposal sites would be required in this case since, for instance, approximately a 40-fold increase in tonnage going to secure disposal sites would result if processing were bypassed altogether. The total system capital cost would be reduced since treatment represents a large capital expense (Table 9). If disposal siting standards were very strict such that arid lands in the Western States were the only acceptable sites, transportation costs would increase substantially because of the large increase in tonnage transported over longer distances. In fact, in this case, annual operating costs for this "disposal only" option exceed annual costs for the treatment and disposal system scenario discussed.

Aside from economic considerations, what is more important in EPA's judgment is that the disposal only option could significantly increase public health and environmental risk, perhaps to an unacceptable level, given the long-term hazard of many toxic substances, particularly if such substances are not converted to relatively insoluble forms prior to disposal. Moreover, transport risks would undoubtedly increase.

TABLE 9
COMPARATIVE COSTS (IN MILLIONS OF DOLLARS) OF HAZARDOUS WASTE REGIONAL TREATMENT VERSUS DISPOSAL ONLY

Item	Regional treatment costs		Disposal only costs*	
	Fixed capital	Annual operating	Fixed capital	Annual operating
Treatment†	863	511	—	—
Disposal‡	13	6	386	257
Transportation§	63	¶99	252	490
Total	939	616	638	747

*Cost data are from two large secure land disposal sites, both in the Western States, with 10 million tons per year of untreated hazardous wastes shipped directly to these sites. The average distance between waste generators and secure land disposal sites is 2,000 miles.

†On-site treatment, 1.0 million tons; off-site treatment, 9.0 million tons.

‡Secure land disposal regional treatment, 0.225 million tons; disposal only, 10.0 million tons. Secure land disposal costs are based on preliminary Office of Solid Waste Management Programs estimates.

§Indicated transportation costs represent a minimum because bulk shipment by railroad in 10,000-gallon tank cars was assumed for all cases.

¶Annual freight charges.

COST DISTRIBUTION TO USERS

With the need for a hazardous waste regulatory program and a hazardous waste management system to implement such a program, there is the fundamental issue of who should pay for creation and operation of the system. The two basic options are that hazardous waste generators pay or society pays. This issue hinges on the principle of equity of cost distribution and on an assessment of ability to pay.

Equity of Cost Distribution

The usual aim in environmental legislation is to cause costs to be internalized. Costs are internalized when the generator pays the full costs of actions for which he is responsible. In turn, he can either absorb the costs ("taxing" his stockholders) or pass on the costs in the price of his products and services (taxing those who benefit from the use of his products and services). Only those who have a direct relationship to the generator are required to pay for the generator's actions.

A publicly funded incentive distributes the costs inequitably by assigning costs incurred by a special group to the population at large, not in proportion to the use of waste-related products by that public but in proportion to income levels.

The regulatory approach internalizes the costs of hazardous waste management. It forces generators to pay for such management while it ensures that the practices are environmentally acceptable. The only portion of the program's cost that must be borne by the public as a whole is the small portion devoted to the actual preparation of the regulations and their enforcement, and the management of wastes generated by the Federal Government.

The regulatory strategy, therefore, results in equitable cost distribution. Only those institutions and individuals who benefit directly from the activities of hazardous material production and consumption are required to bear the costs of waste disposal, and the costs borne are directly proportional to the amount and type of wastes generated. Most hazardous wastes are generated by industry and the Federal Government rather than municipalities. The strategy adopted for dealing with air and water pollution from industrial sources has been the regulatory strategy. Thus, this approach is consistent with the total thrust of environmental control efforts. A subsidy strategy to industry would represent a new departure.

It could be argued that if some sector of the economy is unable to bear the costs of a regulatory program by nature of its institutional situation, fiscal support of that sector may be justified to enable it to meet the regulatory requirements without serious harm to the economy or interruption of vital services.

However, generators of most hazardous wastes are either private, profitmaking industrial organizations or governmental entities. Private corporations are capable of accepting the additional costs of environmental control that may be imposed by a hazardous waste regulatory program. They have the option of passing on such costs to their customers or absorbing the costs by reducing the return on investment to their owners. Government agencies have the usual capabilities available to such entities to seek budgetary support for legally mandated activities. Neither sector would fall into the hardship category if it had to pay the full costs of its waste generation.

Analysis of Cost Impacts

No detailed study has yet been performed to determine the cost burden of specific hazardous waste regulations relative to the sales, costs, investment levels, and employment levels of the industrial sectors that would be affected. Rough aggregate calculations have been done for the following sectors: chemicals, chemical products, petroleum refining, rubber production, ordnance, primary metal industries, pulp and paper, and mining. These aggregate calculations indicate that the costs of hazardous waste management would be roughly equivalent to 1 percent of the value of product shipments. Of course, the corresponding percent for some disaggregate categories may turn out to be much higher.

A general principle that recurs throughout this report is that the costs of hazardous waste management should be internalized in the prices of the commodities whose production has generated the hazardous waste. This principle is consistent with the President's environmental messages. The results of preliminary studies do not indicate that hazardous waste management costs would cause drastic industrial disruption. EPA is giving a high priority to detailed analysis of the costs and cost impacts of hazardous waste management.

Benefit/Cost Analysis

Because of the cost and price impacts that hazardous waste regulations could impose, careful consideration is being given to benefit/cost analyses. Hazardous waste regulations may be said to be "benefit determined" in the sense that they cover situations in which the benefit to society in the form of a hazard reduction is shown to be large. Thus, the first type of benefit/cost comparison is that involved in placing a hazardous waste on the regulatory list as a result of demonstrating that some regulatory option is preferable to the status quo. The second, and equally important, type of benefit/cost analysis is the comparison of all the options, each one involving different levels of benefit and cost. One may speak rhetorically about rendering a substance completely harmless, but in fact that is only one option. That option may have to be chosen in cases for which the associated benefits are large. In other cases, benefit/cost comparisons may support a different process alternative. To the extent possible, EPA tends to use benefit/cost analyses to explore the full range of technological options for each hazardous waste.

ROLE OF THE PRIVATE SECTOR

As discussed earlier, processing economics appear to favor off-site treatment and disposal in most instances. A private hazardous waste services industry exists which already offers off-site treatment and disposal services, but currently available off-site capacity is clearly insufficient to handle the entire tonnage of hazardous waste materials that would ultimately be brought under control. In light of this, it is obvious that off-site capacity must be significantly expanded if environmentally adequate hazardous waste treatment and disposal is to take place.

EPA believes that private industry should and will respond to the proposed regulatory program, but there are a number of questions related to the nature of that response: Will adequate capacity be forthcoming? Can environmentally sound operations be assured? Can reasonable user charges be assured? Can the private sector provide long-term care of treatment, storage, and disposal sites? These questions are taken up in what follows. The general issue of the Government's role is discussed separately.

Capacity Creation

The central question is whether a regulatory program will result in sufficient investment in new capacity by the private sector. Basic issues of capacity creation include the availability of investment capital and the willingness to invest capital in view of the risks involved, i.e., the factors influencing investment. Related to the broad question of private investment are other issues dealing with the availability of trained manpower and the availability of suitable land for facility siting.

Private Investment Sources. Under a regulatory program, capital is likely to be available from at least three private sources: hazardous waste service firms, generators, and solid waste management conglomerates.

In the initial stages of a regulatory program (e.g., the first year), no major new investments are likely to be required. Existing service firms will respond to new demand by increasing their throughput. Soon, however, demand is likely to outstrip supply of such services in a climate of vigorous enforcement, and new investments will be required.

The ability of present service firms to provide internal capital and to attract outside investments has been limited because of generally poor earning records in the past. This situation results from the absence of regulatory and economic incentives for generators to utilize their services. Increased regulatory activity, however, should improve the fiscal abilities of these companies over time by increasing their rate of facility utilization and (under conditions of strong demand) by increasing the prices they can command for services. In fact, the utilization and earnings rates of most of these firms have been increasing as industries respond to water pollution control regulation. This will improve the ability of this industry to retain earnings for investment and also its ability to attract outside capital. This source of capital, however, is expected to be limited in the early years of a regulatory program.

Two other sectors of the economy, however, are expected to become more involved in capacity creation and to attract substantial investment capital to the field.

Major generators of hazardous wastes (e.g., the chemical and metal industries) will have a strong interest in assuring that off-site facilities will be made available for their use because off-site handling will be more economical. These financially strong organizations—some of which already operate treatment and disposal systems for their own use—may enter the service field by acquisition or other routes or may underwrite the activities of others by provision of long-term contracts or use of other devices.

During the past 5 years, large and financially strong private solid waste management "conglomerates" have emerged, offering management services for nonhazardous wastes. These organizations have established strong lines of credit at attractive interest rates. Although most of these firms lack the technical know-how to manage hazardous wastes today, they are likely to acquire know-how and to enter this field under the stimulus of a regulatory program in a logical extension of their current services to industry. Some have already established a position in this field by the acquisition of hazardous waste management subsidiaries.

As a result, it is concluded that sources of private capital to build new capacity potentially is available. This does not mean, however, that it will be forthcoming.

Factors Influencing Investment. Private sector investment in hazardous waste management facilities entails significant risks, and these risks generally increase as the size of the proposed facilities increases. There are uncertainties regarding waste generator response to air, water, and hazardous waste regulations; generators may install new production processes which result in fewer wastes or wastes with different characteristics; generators may elect to treat wastes on site; future breakthroughs in processing technology may render the proposed plant prematurely obsolete; further environmental standards may impact on the proposed plant; economic forces may result in geographical shifts in waste generator plant locations; and there are uncertainties relating to the future activities of competitors.

These factors may (1) deter investment of any kind, (2) lead to investment in treatment processes only for wastes generated in high volume or for wastes that are relatively inexpensive to treat, (3) lead to investment in smaller, less risky facilities that are more expensive to operate on a unit cost basis, or (4) lead to processing plant siting only in locations where major industrial waste sources are assured.

In view of these uncertainties, the degree and timing of private capital investment in new capacity will depend heavily on the quantity of waste regulated and the level and timing of enforcement. Also, the ultimate private sector network that results may include many smaller facilities and therefore represent, in the aggregate, a more expensive system than the scenario depicted.

Quantity of Waste Regulated. Regulations that affect a significant tonnage of waste will spur investments more than regulatory activity aimed at a small proportion of the Nation's hazardous wastes.

A regulatory program is most likely to be aimed at the control of specific waste compounds rather than the waste streams in which the compounds occur. Justification of regulatory action must be tied to health and environmental effects, which can be established most conclusively by studying the effects associated with specific chemicals.

Unlike the regulator, the generator must dispose of and the service firm must manage waste streams that may contain a number of hazardous substances in mixture.

Background studies performed for EPA have provided useful data on the composition of waste streams. These data indicate that regulatory control of a limited number of the most hazardous substances could result in the treatment and disposal of a substantial proportion of the total waste stream. Several hazardous substances are usually present in chemical and metallurgical hazardous waste discharges, and selective treatment of one or two components of the waste does not appear to be economical. Not all hazardous substances must be regulated immediately, in other words, to cause most wastes to be treated and disposed of under controlled conditions.

This suggests that regulatory activity can move ahead based on regulation of groups of a few substances at a time—in a manner similar to that adopted to implement the hazardous effluent provisions of air and water mandates—while still ensuring that substantial quantities of hazardous wastes will be treated.

Level and Timing of Enforcement. The key to capacity creation appears to be vigorous enforcement of regulations to force the use of existing capacity by generators. Enforcement of regulations wherever possible will impose costs on generators which may exceed costs of treatment and disposal in new facilities more appropriately located relative to regions of waste generation and will build pressure for rapid investments. Such enforcement will also create incentives for new ventures by ensuring markets for services.

The regulatory approach most likely to result in private investment would be one that encouraged incremental additions to capacity by mandating their use as soon as they are created. The approach should be tied to a terminal date by which all regulated wastes must be managed as mandated.

The incremental approach has the drawback that it initially impacts more heavily on generators that are near existing treatment and disposal facilities. Thus, other generators that have no such services available to them have a potential advantage. However, this approach protects the public and the environment as soon as possible wherever it *is* possible.

The incremental approach is contrasted to a strategy where regulations are announced at one point in time but provide some reasonable time for creation of capacity nationwide by generators or their agents before any enforcement takes place. This latter approach would provide fewer incentives for investment in increments of capacity and, by bunching capital demand in the reasonable waiting period, would also tax the fiscal capacities of industry to respond. If no capacity is created by the deadline period, appeals to delay enforcement would be likely.

In summary, timely investment of private capital to create capacity is anticipated if the regulatory program affects a substantial portion of the Nation's hazardous wastes and if a vigorous but incremental enforcement approach over time is adopted. These conditions will assure an investor that the facilities he builds will be used, but will avoid excessive demands on available capital at the outset of the program.

Government activity in some fiscal role can potentially speed up timing of investments by private service firms where high investment risks must be overcome; this is discussed later in more detail. A governmental fiscal role, however, is also subject to a number of constraints.

Availability of Manpower. The technology of hazardous waste processing is capital intensive, and a significant increase in capacity will require only a limited expansion of labor. Much of the expertise required for the expansion of the hazardous waste management industry already exists in the metallurgical and petrochemical industries and the engineering and construction firms that service these. Similarly, the skills required at local, State, and Federal levels of government are essentially the same as those necessary for the operation of air and water pollution control programs. Capacity creation is not thought to be constrained by a shortage of manpower under any reasonable implementation timeframe (for example, 5 years).

Availability of Land. Land suitable for the siting and operation of hazardous waste treatment facilities has been identified as part of EPA's background studies (Appendix F). There is no shortage of appropriate land for treatment facilities in the vicinity of or immediately within the Nation's major hazardous waste generation regions.

Land used for disposal by burial should be secure, i.e., it should be sealed off from underlying groundwaters by impervious materials. Ideally, such sites should be located in areas where cumulative precipitation is less than evaporation and transpiration so that rain cannot accumulate in the sealed landfills. Such conditions prevail only in the western desert regions.

Ideal conditions for disposal sites need not be present if the secure landfill is located near hazardous waste treatment plants where water accumulations can be removed from the disposal site and treated in the plant. Sites with appropriate geological features are available in areas other than the Western States.

Probably the most important potential problem associated with the land-use aspect of hazardous waste management is that of public resistance to the location of such facilities in their communities. Although EPA's public attitudes survey indicates public support of central treatment and disposal of hazardous wastes under controlled conditions, it is not at all certain that the public will express the same attitude when faced with an actual siting decision.

Although siting problems are anticipated by EPA, there are indications that such constraints can be overcome. The private hazardous waste management industry and AEC contractors have been able to obtain sites in most cases. Treatment and ultimate disposal facilities will represent employment in areas that are of necessity low in population density (if sites are chosen to minimize safety hazard) and in need of industrial development.

Environmentally Sound Operation

The private sector, following a profit motive, has incentives to run only as good a hazardous waste management operation as it takes to obtain and keep business and to comply with governmental regulations. Customers may demand more stringent operations to benefit their image or for legal and other reasons, but the private sector hardly can be expected to go all out to maximize the environmental soundness of its operations.

It is anticipated, however, that environmentally acceptable operation of private facilities can be assured by appropriate governmental and citizen activities. The basic standards and regulations governing hazardous waste management operations must not only be environmentally adequate in themselves but also must provide for effective administrative and legal sanctions against potential offenders. Adoption of appropriate criteria for facility licensing can filter out candidates who do not possess resources sufficient to provide sound facility construction, operation, maintenance, and surveillance. Vigorous inspection and enforcement by Government, with the attendant threat of licensing suspension or revocation actions, can assure sound operations over time.

If the regulatory legislation contains provisions for citizen suits, which is likely given the trend of recent environmental legislation, citizens may bring legal pressure to bear on both the Government and private industry to force compliance with existing Federal, State, and local regulations.

Reasonable User Charges

The issue of whether a private market situation will result in reasonable user charges is dependent upon quite complex interactions involving facility scale and location, risk, competition, and transportation rates.

As has been discussed, significant economies of scale are possible in the processing of toxic waste. To the extent that such economies are realized and passed on to users of processing facilities, user charges will be reasonable. To the extent that economies of scale are not achieved or that economies are achieved but savings are absorbed as monopoly profits, charges for the use of processing facilities may be unreasonable.

Unfettered operation of the market system may not result in the construction of plants of optimal size initially. Because of a desire to minimize or avoid the risk factors discussed earlier, there may be a tendency to build a number of small, high unit cost plants where one large economical plant would suffice. On the other hand, although small plants may result in higher unit costs of operation, their lower investment requirements may spur competition and reduce opportunities for monopoly profits. Thus, in the scenario described earlier in which large plants with large investment costs and low operating costs predominate, there is potential for monopolistic behavior and, consequently, unreasonably high profits and user charges. The possibility of monopoly is increased by the relatively few companies nationally which have the resources and technical qualifications to enter this field.

Factors other than the risks associated with large investments tend to counter monopolistic behavior, however. Given the relatively low cost of transport in comparison to processing costs and the relative insensitivity of transport charges to increase in haul distances, tradeoffs between transportation charges and at-the-plant user charges should result in some overlap among service regions and thus should stimulate competition. A second potential limitation on unreasonably high user charges is the ability of waste generators to operate their own waste processing plants if projected processing charges appear excessive. Also, the Federal Government could use the processing and disposal of its own wastes, which would be sent to the low bidder on a service contract, as leverage to keep charges reasonable. The revenue and cost information which the Federal Government typically requires as part of the procurement process should itself provide a means of tracking the reasonableness of processing charges on a continuing basis.

Although it is difficult to predict how these opposing forces will operate under a free market situation, there is no indication at this time of the need for additional Government control (beyond that derived from Federal Government procurement) of hazardous waste service charges. Competition exists now in the general absence of specific hazardous waste regulations, and additional competition is anticipated if new regulatory legislation is passed. Overall system costs, even if many small plants are the rule (Figure 4), should not be so unreasonably high that they merit Federal intervention.

Long-Term Care

As indicated earlier, some nonradioactive hazardous wastes cannot be converted to an innocuous form with presently available technology, and some residues from waste treatment processes may still be hazardous. Such materials require special storage or disposal and must be controlled for long periods of time.

In some respects such materials resemble long-lived radioactive wastes: both are toxic and retain essentially forever the potential for public health and environmental insult. There are differences, however: Nonradioactive hazardous wastes normally do not generate heat nor do they require radiation shielding.

Until recently, essentially all radioactive wastes were generated by the Federal Government itself as a result of nuclear weapon, naval propulsion, and other programs. This established a precedent for Federal control of radioactive wastes that has carried over to the commercial nuclear power generation and fuel reprocessing industry. No such precedent exists for nonradioactive hazardous wastes from industrial sources.

AEC has established the policy of "engineered storage" for long-lived radioactive wastes because of difficulties in assuring long-term control of these wastes if they are disposed of on or under the land or in the ocean. Designs of such storage facilities will vary with the nature of the wastes involved, but the general principle is to provide long-lived containerized, or otherwise separated, easily retrievable storage units. These units generally will require heat removal, radiation shielding, surveillance, and security.

The storage and disposal facility requirements for nonradioactive hazardous wastes are anticipated to be less severe than for radioactive wastes since heat removal and shielding are not required, but many of the problems remain. Such facilities should be secure in the sense that there are no hydrologic connections to surface and ground waters. Long-term physical security and surveillance of storage and land disposal sites are required. Also, there should be contingency plans for sealing off the facilities or removing the wastes if hydrologic connections are subsequently established by earthquakes or other phenomena.

From an institutional viewpoint, the private sector is not well suited for a role in which longevity is a major factor. Private enterprises may abandon storage and disposal sites because of changes in ownership, better investment opportunities, bankruptcy, or other factors. If sites are abandoned, serious questions of legal liability could arise. This issue led the State of Oregon, in its recently adopted hazardous waste disposal program, to require that all privately operated hazardous waste disposal sites be deeded to the State and that a performance bond be posted as condition for obtaining a license to operate such a site.

Traditionally, waste generators pay a one-time fee for waste disposal. If this concept were carried over to hazardous waste disposal, private operators of disposal sites would have to charge fees sufficient to cover expenses of site security and surveillance for a long, but indeterminant, time period. Another option would be to consider hazardous waste disposal as a form of long-term storage. Generators would then pay rent in perpetuity. Because of such factors as uncertainties of future market conditions and inflation, neither of these options would appeal to either the waste generator or disposer, nor would the options preclude legal problems if either party were to file for bankruptcy.

There are grounds, therefore, to consider the role of the private sector in hazardous waste storage and disposal as fundamentally different in character from its role in hazardous waste treatment. EPA believes that, given a regulatory stimulus, the private sector can and will provide necessary facilities for hazardous waste treatment that are operated in an environmentally sound manner with reasonable user charges. However, the issue of long-term care of privately owned and operated hazardous waste storage and disposal sites poses significant problems not easily resolved. Some form of Federal or State intervention may be required.

ROLE OF GOVERNMENT

The implementation strategy described assigns to Government the limited role of promulgating and enforcing regulations. In view of the potential problems discussed, however, a more extensive Government role may be justified under certain circumstances. Options for more extensive Government intervention which might be determined to be required include performance bonding, financial assistance, economic regulation, use of Government land, and Government ownership and operation of facilities.

Performance Bonding

The Government could require a performance bond of private firms as a condition for issuing a license or permit for operation of hazardous waste treatment or disposal facilities. The bond would help to ensure environmentally sound operation of processing facilities and long-term care of disposal sites. This system is used, for example, by the State of Oregon for all hazardous waste disposal sites and by the State of Kentucky for radioactive waste disposal sites.

Performance bonding presents a paradox, however. The bond must be large to be effective, but the larger the bond, the more likely it is to inhibit investment. Used unwisely, the performance bond concept could result in no private sector facilities or in a monopolistic situation with a very limited number of large firms in the business.

EPA believes that a performance bonding system, wisely applied, could be beneficial in establishing the fiscal soundness of applicant firms. (If fiscally weak, the firm could not be bonded.) The bonding system could be adopted within a regulatory program in the licensing procedures with very little, if any, cost to Government.

Financial Assistance

Some form of fiscal support of capacity creation may be justified if the private sector fails to invest the capital needed for new facilities. If that happens, environmental damage will continue and the potential hazard to public health and safety will increase.

Current indications are that private capital will begin to flow under a regulatory approach. It may be argued, however, that capital flow may be slow and uneven on a national basis. In some areas capacity may be created, in others not. Investors might play a wait-and-see game because of potential risks, etc. In such a situation governmental fiscal support might speed up implementation or ensure that all generators have facilities available for use.

A governmental fiscal role in capacity creation is not warranted—on equity and other grounds discussed earlier—unless capital flow is actually very slow and adverse environmental effects are resulting from the investment rate. If support is warranted, various types of support are likely to have different effects.

Indirect Support. A loan guarantee program, probably the most indirect form of fiscal support available, may be more effective in speeding up implementation than direct, massive support of construction. If capital is available (in the absolute sense) but is not obtainable practically because of risks associated with investments in such ventures, a loan guarantee program can induce investments by removing or cushioning the risk. At the same time, such a program would be less vulnerable to budgetary constraints and less likely to lead to a slowdown in private investments than direct support.

A loan program, while preferable to direct support on equity grounds, would depend on budget availability and would act to slow down implementation.

Other indirect approaches, such as investment incentives based on investment credits or rapid writeoff provisions, are comparable to a loan program in that they have a budgetary impact (by affecting Government tax income) but would be less likely to slow down implementation because no positive budgetary action would be required to implement such support.

These approaches, much like direct support, would be difficult to justify for a part of the Nation only—that is, to support building of capacity only in areas where private action is not resulting in construction.

Direct Support. Direct fiscal support might conceivably take the form of construction grants or direct Government construction of facilities. Such action can ensure capacity creation. Programs of this type, even in the environmental area, have often failed to meet originally established timing goals because of budgetary constraints and other factors. To the extent that local government involvement is sought in a Federal program, a further potential for delay is introduced. The availability of public funding also has a stifling effect on private initiative. It is economically unwise to invest private money if public funds are available.

This approach, while it can guarantee that ultimately capacity will be built, does not promise to be effective in speeding up the implementation rate. Where the objective is to provide capacities in regions where investments are lagging, direct fiscal support is extremely difficult to justify for only one area to the exclusion of others.

The advisability of Government construction support may also be viewed in the context of Government competition with private industry. A fledgling service industry exists. These firms would object to the entrance of the Government into the field as a competitor (direct Government construction) or Government action to set up competition (grant programs). To the extent that private resources have already been committed to this field, great care would have to be exercised to avoid driving existing firms out of the market with the resultant economic loss to the Nation. It may be necessary on equity grounds to compensate existing companies for their investments—by outright purchase or post-factum grant support. Determining the value of these companies' investments may be difficult in the face of probably increasing demand for their services.

Economic Regulation

The Congress could mandate a hazardous waste management system patterned after the public utility concept. In this type of system, Government could set up franchises with territorial limits and regulate user charge rates.

The hazardous waste management field shares many characteristics of currently regulated industries in any case. There are public service aspects, relatively few plants are required per region, and these facilities are capital intensive. Further, there is potential for natural geographic monopolies because barriers to a second entrant in a given region are high.

Government control of plant siting, scale, and rates could lessen the potential for environmental impacts and provide greater incentive for private sector investment since there would be no threat of competition and consequently less risk of failure. On the other hand, some companies may not enter the field on a utility basis because of potentially lower rate of return on investment. Further, lack of competition could inhibit new technology development.

Economic restrictions can be applied directly through a governmental franchise board or commission or indirectly through administrative actions such as licensing and permitting. Government control of franchising shifts the burden of market determination and related business decisions into the public sector, which is not inherently better equipped to make such decisions than is private industry.

Licensing and permitting of treatment and disposal facilities appear to be better approaches for the exercise of economic control since they can be used to influence (rather than dictate) plant locations, sizes, and rates. Some form of Government control over such facilities is desirable in any case to ensure their proper operation.

Administrative rather than direct regulatory actions would be less costly to Government. New legislation would be required to authorize either direct or indirect economic sanctions.

Use of Federal or State Land

Although suitable sites for hazardous waste processing facilities are generally available to the private sector, adverse public reaction to such sites may preclude their use. If this occurs, it may be necessary to make public lands available to private firms. These lands could be leased or made available to private firms. These lands could be leased or made available free of charge, depending on circumstances. As noted earlier, the State of Oregon requires that hazardous waste facilities be located on State-owned land; other States may elect to follow this precedent.

There are compelling reasons for the use of public lands for hazardous waste disposal sites. The need for long-term care of disposal sites and the potential problems associated with private sector ownership of such sites have been discussed previously. Publicly owned disposal sites could be leased to private operating firms, but legal title would remain with the governmental body.

Use of Federal or State lands for privately operated hazardous waste processing or disposal sites is one means of reducing the capital cost and risk of private sector investment while reducing environmental risk as well. Conceivably, some form of Government influence over user charges could be a condition of the lease, in order to avoid potential monopolistic behavior on the part of the lessee. The initial cost to Government of these measures would be minimal; however, Government maintenance of disposal sites may be necessary if the lessee defaults.

Government Ownership and Operation of Facilities

The option of Government ownership and operation of facilities provides maximum control over the economic and environmental aspects of hazardous waste management. The issues of potential monopolistic behavior (and consequent unreasonably high user charges) and long-term care of hazardous waste disposal sites could be circumvented. Environmentally sound construction and operation of processing and disposal facilities could be assured but would be dependent on public budgets for implementation. Resource recovery could be mandated.

Public lands suitable for hazardous waste processing and disposal sites exist in the Western States but may not be available in the Eastern States. If Government ownership and operation of facilities is mandated by Congress, the Government may have to purchase private lands for this purpose. The potential for adverse public reaction would be present.

The Government does operate some hazardous waste treatment, storage, and disposal facilities now, but these are generally limited to handling wastes generated by Government agencies. There is no obvious advantage of Government operation of facilities intended to treat and dispose of hazardous wastes originating in the private sector. In fact, under Government operation, there could be a tendency for selection of more expensive technology than is actually required and less incentive for efficient, low-cost operation.

This option represents, of course, the maximum cost to Government of those considered here. If use of Government-owned and Government-operated facilities is mandated, capital and operating costs of processing plants can be recovered through user charges. Some subsidy of disposal operations is likely, however, since security and surveillance of disposal sites are required in perpetuity.

SUMMARY

For a hazardous waste regulatory program, issues of implementation of a nonradioactive hazardous waste management system hinge on the incentives for and inherent problems of private sector response and the appropriate role of Government. Past experience with air and water environmental regulation over industrial processes indicates that the private sector will invest in pollution control facilities if regulations are vigorously enforced. EPA anticipates that similar private sector investment in hazardous waste processing facilities will be forthcoming if a regulatory program is legislated and enforced. There is no real need for massive Government intervention or investment in such facilities. The makeup of a hazardous waste processing system fully prescribed by free market forces is difficult to predict, however.

The storage and ultimate disposal of hazardous residues presents a significant problem of basically different character since the private sector is not well suited to a role of long-term care of disposal sites. Options for Government action to mitigate this problem include (1) making new or existing Federal- and State-owned and Federal- and State-operated disposal sites available to private industry; (2) leasing Federal or State lands to the private sector, subject to a performance bonding system; (3) allowing private ownership and operation of storage and disposal sites, subject to strict Federal or State controls. The optimum control scheme will depend upon the nature of the regulatory program, but Federal or State control of storage and land disposal sites is clearly implied in any case.

On balance, EPA believes that, with the possible exception noted, the preferred approach to system implementation is to allow the private sector system to evolve under appropriate regulatory controls, to monitor closely this evolution, and to take remedial governmental action if necessary in the future.

Section 5

FINDINGS AND RECOMMENDATIONS

FINDINGS

Under the authority of Section 212 of the Solid Waste Disposal Act, as amended, EPA has carried out a study of the hazardous waste management practices of industry, Government, and other institutions in the United States. The key findings of this study are presented in this section.

Current management practices have adverse effects. Hazardous waste management practices in the United States are generally inadequate. With some exceptions, wastes are disposed of on the land without adequate controls and safeguards. This situation results in actual and potential damage to the environment and endangers public health and safety.

Causes of inadequate management are economics and absence of legislative control. The causes of inadequate hazardous waste management are twofold. First, costs of treating such wastes for hazard elimination and of disposing of them in a controlled manner are high. Second, legislation which mandates adequate treatment and disposal of such wastes is absent or limited in scope. The consequence is that generators of hazardous wastes can use low-cost but environmentally unacceptable methods of handling these residues.

Authorities for radioactive wastes are adequate. Under the authority of the Atomic Energy Act of 1954, as amended, the management of radioactive wastes is placed under control. Although the actual implementation of the act may be improved, the legislative tools for accomplishing such an end exist.

Air and water pollution control authorities are adequate. The Clean Air Act of 1970 and the FWPCA of 1972 provide the necessary authorities for the regulation of the emission of hazardous compounds and materials to the air and to surface waters from point sources.

Legislative controls over hazardous waste land disposal are inadequate. The legislative authorities available for the control of hazardous waste deposition on land—and the consequent migration of such wastes into the air and water media from land—are not sufficient to result in properly controlled disposal. This legislative gap literally invites the use of land as the ultimate sink for materials removed from air and water.

Land protection regulation is needed. In order to close the last available uncontrolled sink for the dumping of hazardous waste materials and thus to safeguard the public and the environment, it is necessary to place legislative control over the disposal of hazardous wastes. In the absence of such control, cost considerations and the competitive posture of most generators of waste will continue to result in dangerous and harmful practices with both short-range and long-term adverse consequences.

The technology for hazardous waste management generally is adequate. A wide array of treatment and disposal options is available for management of most hazardous wastes. The technology is in use today, but the use is not widespread because of economic barriers in the absence of legislation. Transfer and adaptation of existing technology to hazardous waste management may be necessary in some cases. Treatment technology for some hazardous wastes is not available (e.g., arsenic trioxide and arsenites and arsenates of copper, lead, sodium, zinc, and potassium). Additional research and development is required as the national program evolves. However, safe and controlled storage of such wastes is possible now until treatment and disposal technology is developed.

A private hazardous waste management industry exists. A small service industry has emerged in the last decade offering waste treatment services to industry and other institutions. This industry is operating below capacity because its services are high in cost relative to other disposal options open to generators. The industry is judged capable of expanding over time to accept most of the Nation's hazardous wastes.

Hazardous waste management system costs are significant. Estimates made by EPA indicate that investments of about $940 million and operating costs (including capital recovery) of about $620 million per year will be required to implement a nationwide hazardous waste management system which combines on-site (point of generation) treatment of some wastes, off-site (central facility) treatment for hazard elimination and recovery, and secure land disposal of residues which remain hazardous after treatment.

The private sector appears capable of responding to a regulatory program. Indications are that private capital will be available for the creation of capacity and that generators of waste will be able to bear the costs of management under new and more exacting rules. Private sector response to a demand created by a regulatory program cannot be well defined, however, and the characteristics of the resulting hazardous waste management system cannot be definitely prescribed. Uncertainties inherent in a private sector system include availability of capital for facility construction and operation in a timely manner for all regions of the Nation, adequacy of facility locations relative to waste generators such as to minimize environmental hazard and maximize use, reasonableness of facility use charges in relation to the cost of services, and long-term care of hazardous waste storage and disposal facilities (i.e., such facilities will be adequately secured for the life of the waste, irrespective of economic pressures on private site operators).

Several alternatives for Government action are available if such actions are subsequently determined to be required: If capital flow was very slow and adverse environmental effects were resulting from the investment rate, financial assistance would be possible in indirect forms such as loans, loan guarantees, or investment credits, or direct forms such as construction grants. If facility location or user charge problems arose, the Government could impose a franchise system with territorial limits and user charge rate controls. Long-term care of hazardous waste storage and disposal facilities could be assured by mandating use of Federal or State land for such facilities.

RECOMMENDATIONS

Based on the findings, it is recommended that *Congress enact national legislation mandating safe and environmentally sound hazardous waste management.*

EPA has proposed such legislation to Congress, embodying the conclusions of studies carried out under Section 212 of the Solid Waste Disposal Act.

The proposed Hazardous Waste Management Act of 1973 calls for authority to regulate the treatment and disposal of hazardous wastes. A copy of the proposed act is presented in Appendix G. The key provisions of the proposed legislation are the following: (1) authority to designate hazardous wastes by EPA; (2) authority to regulate treatment and disposal of selected waste categories by the Federal Government at the discretion of the Administrator of EPA; (3) authority for the setting of Federal treatment and disposal standards for designated waste categories; (4) State implementation of the regulatory program subject to Federal standards in most cases; (5) authority for coordination and conduct of research, surveys, development, and public education.

EPA believes that no further Government intervention is appropriate at this time. It is EPA's intention to carry on its studies and analyses; EPA may make further recommendations based on these continuing analyses.

Appendix A

IMPACT OF IMPROPER HAZARDOUS WASTE MANAGEMENT ON THE ENVIRONMENT

Improper management of hazardous materials or wastes is manifested in numerous ways. Waste discharges into surface waters can decimate aquatic plant and animal life. Contamination of land and groundwaters can result from improper storage and handling techniques, accidents in transport, or indiscriminate disposal acts.

A few of the many cases documented by EPA which illustrate hazardous waste mismanagement are listed categorically in the following compilation. Most of these examples are water pollution related because there have been more monitoring and enforcement actions in this area.

WASTE DISCHARGE HAZARDS

Improper Arsenic Disposal

Because of the lack of treatment and recovery facilities, arsenic waste materials generally are disposed of by burial. This practice presents future hazards since the material is not rendered harmless.

As a result of arsenic burial 30 years ago on agricultural land in Perham, Minnesota, several people who recently consumed water contaminated by the deposit were hospitalized. The water came from a well that was drilled near this 30-year-old deposit of arsenic material. Attempts to correct this contamination problem are now being studied. Proposed methods of approach include (1) excavating the deposit and contaminated soil and diluting it by spreading it on adjacent unused farmland, (2) covering the deposit site with a bituminous or concrete apron to prevent groundwater leaching, (3) covering the deposit temporarily and excavating the soil for use as ballast in future highway construction in the area, (4) excavating the material and placing it in a registered landfill. None of these methods is particularly acceptable since the hazardous property of the material is not permanently eradicated, but they at least protect the public health and safety in the short run.

Lead Waste Hazard

Annual production of organic lead waste from manufacturing processes for alkyl lead in the San Francisco Bay area amounts to 50 tons (45.4 metric tons). This waste was previously disposed of in ponds at one industrial waste disposal site. Attempts to process this waste for recovery resulted in alkyl lead intoxication of plant employees in one instance; in another instance, not only were plant employees affected, but employees of firms in the surrounding area were exposed to an airborne alkyl lead vapor hazard. Toll collectors on a bridge along the truck route to the plant became ill from escaping vapors from transport trucks. Currently, the manufacturers that generate organic lead waste are storing this material in holding basins at the plants pending development of an acceptable recovery process.

Cyanide and Phenol Disposal

A firm in Houston, Texas, as early as 1968 was made aware that its practice of discharging such hazardous wastes as cyanides (25.40 pounds per day, or 11.5 kilograms per day), phenols (2.1 pounds per day, or 0.954 kilogram per day), sulfides, and ammonia into the Houston ship channel was creating severe environmental debilitation. The toxic wastes in question are derived from the cleaning of blast furnace gas from coke plants. According to expert testimony, levels as low as 0.05 milligram per liter of cyanide effluent are known to be lethal to shrimp and small fish of the species found in the Galveston Bay area.

Alternative disposal methods involving deep-well injection were recommended by the firm and the Texas Water Quality Board. EPA rejected this proposal and the firm in question was enjoined by the courts to cease and desist discharging these wastes into the ship channel. Subsequently, the courts have ruled in favor of EPA that deep-well injection of these wastes is not an environmentally acceptable disposal method at this site.

Arsenic Contamination

A chemical company in Harris County, Texas, that produces insecticides, weed killers, and similar products containing arsenic has been involved in litigation over the discharge of arsenic waste onto the land and adjacent waters. Charges indicate that waste containing excessive arsenic was discharged into, or adjacent to, Vince Bayou causing arsenic-laden water drainage into public waters. This company and its predecessor have a long history of plant operation at this site. Earlier, waste disposal was accomplished by dumping the waste solids in open pits and ditches on company property. This practice was abandoned in 1967 in favor of a proposed recycling process. However, as of August 1971, actions were taken on behalf of the county to enjoin manufacturing operations at the plant because of alleged excessive arsenic discharge into the public waters. No other information is available regarding the current status of court actions or disposal practices.

Insecticide Dumping

Mosco Mills, Missouri. In mid-1970, an applicator rinsed and cleaned a truck rig after dumping unused Endrin into the Cuivre River at Mosco Mills, Missouri. This act resulted in the killing of an estimated 100,000 fish, and the river was closed to fishing for 1 year by the Missouri Game and Fish Commission.

Waterloo, Iowa. In mid-1972, a chemical manufacturing company in Waterloo, Iowa, burned technical mevinphos (phosdrin), resulting in gross contamination to the plant area. Approximately 2,000 pounds (908 kilograms) of previously packaged material were dumped and left for disposal. After discussion with EPA Region VII office personnel and appropriate Iowa agencies, the area was neutralized with alkali and certain of the materials were repackaged for disposal by a private hazardous waste disposal firm in Sheffield, Illinois.

Trace Phenol Discharge

During 1970, the Kansas City, Missouri, water supply contained objectionable tastes and odors due to a phenolic content. It was alleged, and subsequent investigation indicated, that fiber-glass waste dumped along the river bank upstream was the source of the tastes and odors. The waste was coated with phenol and was possibly being washed into the river. Action was taken to have the dump closed and sealed.

Discharge of Hydrocarbon Gases Into River

In July 1969, an assistant dean at the University of Southern Mississippi died of asphyxiation while fishing in a boat in the Leaf River near Hattiesburg, Mississippi. The victim's boat drifted into a pocket of propane gas that reputedly had been discharged into the river through a gasline terminal wash pipe from a petroleum refinery.

Cyanide Discharge

Part of the Lowry Air Force Base Bombing Range, located 15 miles (24.1 kilometers) east of Denver, was declared surplus and given to Denver as a landfill site. As of July 1972, the Lowry site was accepting, with the exception of highly radioactive wastes, any wastes delivered without inquiry into the contents and without keeping anything more than informal records of quantities delivered.

Laboratory tests of surface drainage have indicated the presence of cyanide in ponded water downstream from the site. Significant amounts of cyanide are discharged in pits at the disposal site, according to the site operator. Short-lived radioactive wastes from a nearby medical school and a hospital are also accepted at this site. These wastes are apparently well protected but are dumped directly into the disposal ponds rather than being buried separately.

The Denver County commissioners received a complaint that some cattle had died as the result of ingesting material washed downstream from this site. Authorities feel this occurred because of runoff caused by an overflow of the disposal ponds into nearby Murphy Creek after a heavy rainstorm.

Arsenic Dump: Groundwater Contamination

A laboratory company in the north-central United States has been utilizing the same dump site since 1953 for solid waste disposal. Of the total amount (500,000 cubic feet or 14,150 cubic meters) dumped as of 1972, more than half is waste arsenic. There are several superficial monitoring wells (10 to 20 feet deep or 3.05 to 6.10 meters deep) located around the dump site. Analyses of water samples have produced an arsenic content greater than 175 parts per million. The dump site is located above a limestone bedrock aquifer, from which 70 percent of the nearby city's residents obtain their drinking and crop irrigation water. There are some indications that this water is being contaminated by arsenic seepage through the bedrock.

Poisoning of Local Water Supply

Until approximately 2 years prior to June 1972, Beech Creek, Waynesboro, Tennessee, was considered pure enough to be a source of drinking water. At that time, waste polychlorinated biphenyls (PCB) from a nearby plant began to be deposited in the Waynesboro city dump site. Dumping continued until April 1972. Apparently the waste, upon being off-loaded at the dump, was pushed into a spring branch that rises under the dump and then empties into Beech Creek. Shortly after depositing of such wastes began, an oily substance appeared in the Beech Creek waters. Dead fish, crawfish, and waterdogs were found, and supported wildlife also was being affected (e.g., two raccoons were found dead). Beech Creek had been used for watering stock, fishing, drinking water, and recreation for decades. Presently, the creek seems to be affected for at least 10 miles (16.09 kilometers) from its source and the pollution is moving steadily downstream to the Tennessee River. Health officials have advised that the creek should be fenced off to prevent cattle from drinking the water.

MISMANAGEMENT OF WASTE MATERIALS

In the presence of locally imposed air and water effluent restrictions and prohibitions, industrial concerns attempt to manage disposal problems by storage, stockpiling, and lagooning. In many instances, the waste quantities become excessive and environmental perils evolve as a result of leaching during flooding or rupturing of storage lagoons. Reported instances of this type of waste management problem are shown in the following.

Fish Kill

On June 10, 1967, a dike containing an alkaline waste lagoon for a steam generating plant at Carbo, Virginia, collapsed and released approximately 400 acre-feet (493,400 cubic meters) of fly ash waste into the Clinch River. The resulting contaminant slug moved at a rate of 1 mile per hour (1.6 kilometers per hour) for several days until it reached Norris Lake in Tennessee, whereupon, it is estimated to have killed 216,200 fish. All food organisms in the 4-mile (6.43-kilometer) stretch of river immediately below Carbo were completely eliminated. The practice of waste disposal by lagooning is a notoriously inadequate method which lends itself to negligence and subsequent mishaps.

Phosphate Slime Spill

On December 7, 1971, at a chemical plant site in Fort Meade, Florida, a portion of a dike forming a waste pond ruptured, releasing an estimated 2 billion gallons (7.58 billion liters) of slime composed of phosphatic clays and insoluble halides into Whidden Creek. Flow patterns of the creek led to subsequent contamination of the Peace River and the estuarine area of Charlotte Harbor. The water of Charlotte Harbor took on a thick milky white appearance. Along the river, signs of life were diminished, dead fish were sighted, and normal surface fish activity was absent. No living organisms were found in Whidden Creek downstream of the spill or in the Peace River at a point 8 miles downstream of Whidden Creek. Clam and crab gills were coated with the milky substance, and in general all benthic aquatic life was affected in some way.

Mismanagement of Heterogeneous Hazardous Waste

A firm engaged in the disposal of spent chemicals generated in the Beaumont-Houston area ran into considerable opposition in Texas and subsequently transferred its disposal operations to Louisiana. In October 1972, this firm was storing and disposing of toxic chemicals at two Louisiana locations: De Ridder and De Quincy. At the De Ridder site, several thousand drums of waste (both metal- and cardboard-type, some with lids and some without) were piled up at the end of an airport runway apron within a pine tree seed orchard. Many of the drums were popping their lids and leaking, and visible vapors were emanating from the area. The pine trees beside the storage area had died. At the same time, the firm was preparing to bury hundreds of drums of hazardous wastes at the De Quincy location, which is considered by EPA to be hydrogeologically unsuitable for such land disposal. Finally, court action enjoined this firm from using the De Ridder and De Quincy sites; however, the company has just moved its disposal operations near Villa Platte in Evangeline Parish, where the same problems exist.

Arsenic Waste Mishap

Since August 1968, a commercial laboratory in Myerstown, Pennsylvania, has disposed of its arsenic waste by surface storage within the plant area (form of waste materials not known). This practice apparently has led to contamination of the ground and subsequent migrations into groundwaters through leaching, ionic migration actions, etc., abetted by the geologic and edaphic character of the plant site. In order to meet discharge requirements and/or eliminate the waste hazard, the company has had to design and construct a system of recovery wells to collect the arsenic effluent from groundwaters in the area. Recovered arsenic and current arsenic waste (previously stored on the land) are now retained in storage lagoons. Presumably, the sludge from these lagoons is periodically reclaimed in some way. Lagoons of this type are generally not well attended and frequently result in environmental catastrophes.

Contaminated Grain

Grant County, Washington. In 1972, mercury-treated grain was found at the Wilson Creek dump in Grant County, Washington, by an unsuspecting farmer. He hauled it to his farm for livestock feed. The episode was discovered just before the farmer planned to utilize the grain.

Albuquerque, New Mexico. Three children in an Albuquerque, New Mexico, family became seriously ill, in 1970, after eating a pig that had been fed corn treated with a mercury compound. Local health officials found several bags of similarly treated corn in the community dump.

Radioactive Waste

Low-level radioactive waste is lying exposed on about 10 acres (4.05 hectares) of ground in Stevens County, Washington, and is subject to wind erosion. The waste comes from an old uranium processing mill. County and State officials are concerned because, although it is of low radioactivity level, it is the same type that caused the public controversy at Grand Junction, Colorado.

Waste Stockpiling Hazard: Two Cases

King County, Washington: Case 1. All types of waste chemicals have been dumped into the old Dodgers No. 5 Coal Mine shaft in King County, Washington, for years. Much of this practice has stopped but sneak violations still occur.

King County, Washington: Case 2. In the same county, expended pesticides that are very susceptible to fire have been stored in old wooden buildings in the area. Several fires have occurred. In addition, large numbers of pesticide containers have been stacked at open dumps.

Chlorine Holding Pond Breach

A holding pond and tanks at a chemical manufacturing plant in Saltville, Virginia, failed, spilling chlorine, hypochlorites, and ammonia into the north fork of the Holston River. River water samples showed concentration levels at 0.5 part per million hypochlorite and 17.0 parts per million of fixed ammonia. Dead fish were sighted along the path of the flow in the river.

Malpractice Hazard

Several drums of a 15-year-old chemical used for soil sterilization were discovered in the warehouse of the weed control agency in Bingham County, Idaho. The chemical was taken to a remote area where it was exploded with a rifle blast. Had it been disturbed only slightly while in storage, several people would have been killed.

Explosive Waste

In Kitsap County, Washington, operations at a naval ammunition depot involved washing RDX (a high explosive) out of shells from 1955 to 1968, and the resulting wash water went into a dump. In routine monitoring of wells in the area, the RDX was found in the groundwater and in several cases the concentrations exceed the health tolerance level of 1 part per million.

Unidentified Toxic Wastes

A disposal company undertook to dispose of some drums containing unidentified toxic residues. Instead of properly disposing of this material, the company dropped these drums at a dump located in Cabayon, Riverside County, California. Later, during a heavy flood, the drums were unearthed, gave off poisonous gases, and contaminated the water. Steps were taken to properly dispose of the unearthed drums.

Container Reclamation

At a drum reclaiming plant in northern California, 15 men were poisoned by gases given off from drums. It is presumed that this incident occurred because of inadequate storage procedures by the company involved.

Stockpiling of Hazardous Waste

Several sheep and cattle and a foxhound died, and many cattle became seriously affected, on two farms close to a factory producing rodenticides and pesticides in Great Britain. (This case illustrates the similarity of problems that exist in highly industrialized nations.) The drainage from the factory led into a succession of ponds to which the animals had unrestricted access and from which they are therefore likely to have drunk. Investigations showed that a field on the site was a dumping ground for large metal drums and canisters, many of which had rusted away, and their contents were seeping into the ground. Residues from the manufacture of fluoroacetamide were dumped on the site and percolated into the drainage ditches leading to the farm ponds. Veterinary evidence indicated the assimilation of fluoroacetamide was possible if the animals had drunk contaminated water. Ditches and ponds were dredged and the sludge deposited on a site behind the factory. All sludges and contaminated soil were subsequently excavated, mixed with cement, put into steel drums capped with bitumen, and dumped at sea. The presence of fluoroacetamide in the soil and associated water samples persisted at very low but significant levels and thus delayed the resumption of normal farming for nearly 2 years.

Pesticides in Abandoned Factory

In the summer of 1972, approximately 1,000 pounds (454 kilograms) of arsenic-containing pesticide were discovered in an abandoned factory building in Camden County, New Jersey. The building used to belong to a leather tannery that had discontinued its operations.

Groundwater Contamination by Chromium- and Zinc-Containing Sludge

An automobile manufacturing company in the New York area is regularly disposing of tank truck quantities of chromium- and zinc-containing sludge through a contract with a trucking firm that in turn has a subcontract with the owner of a private dump. The sludge is dumped in a swampy area, resulting in contamination of the groundwater. The sludge constitutes a waste residue of the automobile manufacturer's paint priming operations.

Disposal of Chromium Ore Residues

A major chemical company is currently depositing large quantities of chromium ore residues on its own property in a major city on the East Coast. These chromium ore residues are piled up in the open, causing probable contamination of the groundwater by leaching into the soil.

Dumping of Cadmium-Containing Effluents Into the Hudson River

A battery plant in New York State for years was dumping large amounts of cadmium-containing effluents into the Hudson River. The sediment resulting from the plant's effluents contained about 100,000 parts per million of cadmium. The firm now has agreed to deposit these toxic sediments in a specially insulated lagoon.

Pesticide Poisoning

On July 3, 1972, a 2½-year-old child in Hughes, Arkansas, became ill after playing among a pile of 55-gallon (208-liter) drums. He was admitted to the hospital suffering from symptoms of organophosphate poisoning. The drums were located approximately 50 feet (15 meters) from the parents' front door on city property. The city had procured the drums from an aerial applicator to be used as trash containers. The residents were urged to pick up a drum in order to expedite trash collection. It has been determined that these drums contained various pesticides, including methyl parathion, ethyl parathion, toxaphene, DDT, and others. The containers were in various states of deterioration, and enough concentrate was in evidence to intoxicate a child or anyone else who came into contact with it.

Improper Disposal of Aldrin-Treated Seed and Containers

On July 9, 1969, in Patterson, Louisiana, the owner of a farm noticed several pigs running out of a cane field; some of the animals appeared to be undergoing convulsions. It appears that aldrin-treated seed and containers had been dumped on the land in a field and that the pigs, running loose, had encountered this material. Eleven of the pigs died. Analysis of rumen contents showed 230.7 parts per million aldrin and 1.13 parts per million dieldrin.

Improper Pesticide Container Disposal

In May 1969, in Jerome, Idaho, Di-Syston was incorporated into the soil in a potato field. The "empty" paper bags from the pesticide were left in the field, and the wind blew them into the adjacent pasture. Fourteen head of cattle died, some with convulsions, after licking the bags. Blood samples showed 0.0246 part per million Di-Syston.

Ocean Dumping of Chemical Waste

The Houston Post reported in December 1971 that large quantities of barrels containing chemical wastes had turned up in shrimpers' nets in the Gulf of Mexico approximately 40 miles (64.3 kilometers) off the Texas coastline. In addition to physical damage to nets and equipment caused by the barrels, the chemical wastes caused skin burning and eye irritation among exposed shrimper crewmen. Recovered barrels reportedly bore the names of two Houston-area plants, both of which apparently had used a disposal contractor specializing in deep-sea disposal operations.

RADIOACTIVE WASTE DISPOSAL

National Reactor Testing Station

In October 1968, the Idaho Department of Health and the former Federal Water Quality Administration made an examination of the waste treatment and disposal practices at the AEC National Reactor Testing Station (NRTS) near Idaho Falls, Idaho. There were three types of plant wastes being generated: radioactive wastes, chemical or industrial wastes, and sanitary wastes. It was found that there were no observation wells to monitor the effects of ground burial on water quality, that low-level radioactive wastes were being discharged into the groundwater, that chemical and radioactive wastes had degraded the groundwater beneath the NRTS, and that some sanitary wastes were being discharged into the groundwater supply by disposal wells.

In a report issued in April 1970, authorities recommended that AEC abandon the practice of burying radioactive waste above the Snake Plain aquifer, remove the existing buried wastes to a new site remote to the NRTS and hydrologically isolated from groundwater supplies, and construct observation wells needed to monitor the behavior and fate of the wastes.

Decommissioning of AEC Plant

The Enrico Fermi nuclear reactor just outside of Detroit is closing. However, there still remains a substantial waste management problem. The owner of the plant has set aside $4 million for decommissioning the plant. A preliminary decommissioning plan and cost estimate have been submitted to AEC. However, AEC acknowledges that costs and procedures for decommissioning are still unknown since few nuclear plants (and never one such as Fermi) have been decommissioned. As of this date, an answer is still being sought to this waste disposal problem.

Nuclear Waste Disposal

After a fire on May 11, 1969, at the Rocky Flats plutonium production plant near Denver, Colorado, it was discovered that since 1958 the company that operated the plant had been storing 55-gallon drums of laden oil contaminated with measurable quantities of plutonium outside on pallets. The drums corroded and the plutonium-contaminated oils leaked onto the soil in the surrounding area. Soil sample radioactivity measurements made in 1970 and 1971 at various locations on the Rocky Flats site indicated that the contamination of the surrounding area was 100 times greater than that due to worldwide fallout. The increase in radioactivity as defined by the health and safety laboratory of AEC was attributed to the plutonium leakage from the stored 55-gallon drums rather than any plutonium that might have been dispersed as a result of the 1969 fire. Later, the area where the plutonium-contaminated laden oil was spilled was covered with a 4-inch slab of asphalt and isolated by means of a fence. The 55-gallon drums were moved to a nearby building and the plutonium was salvaged from the oil. The oil was dewatered and solidified into a greaselike consistency. Then the drums and the solidified oil were sent to and buried at the NRTS at Idaho Falls, Idaho.

Appendix B

HAZARDOUS WASTE STREAM DATA

Identifying and quantifying the Nation's hazardous waste streams proved to be especially formidable because historically there has been little interest in quantifying specific amounts of waste materials, with the exception of radioactive wastes.

Distribution and volume data by Bureau of Census regions were compiled on those nonradioactive waste streams designated as hazardous (Table 10). The approach used is predicated on the assumption that the hazardous properties of a waste stream will be those of the most hazardous pure compound within that waste stream. Wastes containing compounds with values more than or equal to threshold levels established for the various hazardous properties are classified as hazardous. This approach takes advantage of the available hazard data on pure chemicals and avoids speculation on potential compound interactions within a waste stream. A list follows to illustrate types of chemical compounds in the Nation's waste streams that could be regarded as hazards to public health and the environment:

Miscellaneous inorganics

Ammonium chromate
Ammonium dichromate
Antimony pentafluoride
Antimony trifluoride
Arsenic trichloride
Arsenic trioxide
Cadmium (alloys)
Cadmium chloride
Cadmium cyanide
Cadmium nitrate
Cadmium oxide
Cadmium phosphate
Cadmium potassium cyanide
Cadmium (powdered)
Cadmium sulfate
Calcium arsenate
Calcium arsenite
Calcium cyanides
Chromic acid
Copper arsenate
Copper cyanides
Cyanide (ion)
Decaborane
Diborane
Hexaborane
Hydrazine
Hydrazine azide
Lead arsenate
Lead arsenite
Lead azide
Lead cyanide
Magnesium arsenite
Manganese arsenate
Mercuric chloride
Mercuric cyanide
Mercuric diammonium chloride
Mercuric nitrate
Mercuric sulfate
Mercury
Nickel carbonyl
Nickel cyanide
Pentaborane-9
Pentaborane-11
Perchloric acid (to 72 percent)
Phosgene (carbonyl chloride)
Potassium arsenite
Potassium chromate
Potassium cyanide
Potassium dichromate
Selenium
Silver azide
Silver cyanide

- Sodium arsenate
- Sodium arsenite
- Sodium bichromate
- Sodium chromate
- Sodium cyanide
- Sodium monofluoroacetate
- Tetraborane
- Thallium compounds
- Zinc arsenate
- Zinc arsenite
- Zinc cyanide

Halogens and interhalogens

- Bromine pentafluoride
- Chlorine
- Chlorine pentafluoride
- Chlorine trifluoride
- Fluorine
- Perchloryl fluoride

Miscellaneous organics

- Acrolein
- Alkyl leads
- Carcinogens
- Copper acetoarsenite
- Copper acetylide
- Cyanuric triazide
- Diazodinitrophenol (DDNP)
- Dieldrin
- Dimethyl sulfate
- Dinitrobenzene
- Dinitro cresols
- Dinitrophenol
- Dinitrotoluene
- Dipentaerythritol hexanitrate (DPEHN)
- Gelatinized nitrocellulose (PNC)
- Glycol dinitrate
- Gold fulminate
- Lead 2,4-dinitroresorcinate (LDNR)
- Lead styphnate
- Mannitol hexanitrate
- Mercury compounds (organic)
- Methyl parathion
- Nitroaniline
- Nitrocellulose
- Nitroglycerin
- Parathion
- Picric acid
- Potassium dinitrobenzfuroxan (KDNBF)
- Silver acetylide
- Silver tetrazene
- Tetrazene
- VX [ethoxymethylphosphoryl-*N*,*N*-dipropoxy-(2,2)-thiocholine]

Organic halogen compounds

- Aldrin
- Chlordane
- Chlorinated aromatics
- Chloropicrin
- Copper chlorotetrazole
- DDD
- DDT
- 2,4-D (2,4-dichlorophenoxyacetic acid)
- Demeton
- Endrin
- Ethylene bromide
- Fluorides (organic)
- GB [propoxy-(2)-methylphosphoryl fluoride]
- Guthion
- Heptachlor
- Lewisite (2-chloroethenyl dichloroarsine)
- Lindane
- Methyl bromide
- Methyl chloride
- Nitrogen mustards (2,2′,2″-trichlorotriethylamine)
- Pentachlorophenol
- Polychlorinated biphenyls (PCB)
- Tear gas (CN) (chloroacetophenone)
- Tear gas (CS) (2-chlorobenzylidene malononitrile)

It should be noted that this list is not an authoritative enumeration of hazardous compounds but a sample list which will be modified on the basis of further studies. Compounds on the list should not be construed as those to be regulated under the proposed Hazardous Waste Management Act. Table 11 identifies those radioactive isotopes that are considered hazardous from a disposal standpoint. Detailed data sheets describing the volumes, constituents, concentrations, hazards, disposal techniques, and data sources for each waste stream are available in EPA Contract No. 68-01-0762.

TABLE 10

SUMMARY DATA FOR NONRADIOACTIVE WASTE STREAMS*

Waste stream title	Standard industrial code	Percentage by geographic area†									Volume (lb/yr)	Remarks
		NE	MA	ENC	WNC	SA	ESC	WSC	M	W		
Aqueous inorganic:												
Chromate wastes from textile dyeing	22	0.101	0.178	0.034	0.005	0.568	0.034	0.014	0.006	0.060	2×10^7, maximum	
Chlorine production brine sludges	2812	.02	.11	.10	–	.19	.22	.24	–	.12	1×10^8	
Potassium chromate production wastes	2819	.19	.06	.015	.005	.60	.10	.01	.01	.01	1×10^6	
Cellulose ester production wastes	2821	.10	.21	.21	.16	.14	.07	.10	–	.02	5×10^7	
Intermediate agricultural product wastes (nitric acid)	287	.005	.075	.145	.074	.299	.207	.090	.046	.058	2×10^5	
Production works from ammonium sulfate	2873	–	–	.040	–	–	–	–	.96	–	1×10^3	
Copper- and lead-bearing petroleum refinery wastes	291	.001	.102	.175	.056	.019	.031	.417	.039	.160	8×10^8	
Chrome tanning liquor	31	.22	.29	.29	.03	.086	.05	.004	–	.03	2×10^7	
Mirror production wastes	3231	.09	.25	.23	.01	.28	.10	.04	–	–	9×10^6	
Cold finishing wastes	331	.03	.34	.43	.01	.07	.02	.05	.04	.01	5×10^9	
Consolidated steel plant wastes	331	.02	.33	.42	.02	.09	.02	.03	.05	.02	5×10^8	
Stainless steel pickling liquor	3312	.050	.259	.404	.026	.068	.055	.044	.028	.067	5×10^7	
Brass mill wastes	333	.04	.29	.01	.25	.01	.04	.04	.13	.19	5×10^7	
Metal finishing wastes:	33	.115	.179	.379	.046	.050	.015	.036	.011	.169	4×10^7	Cyanide solution
Aluminum anodizing bath with drag out		.115	.179	.379	.046	.050	.015	.036	.011	.169	8×10^6	Metal sludges
Brass plating wastes		.115	.179	.379	.046	.050	.015	.036	.011	.169	Not available	–
Cadmium plating wastes		.131	.285	.321	.045	.049	.023	.036	.007	.103	1×10^6	
Chrome plating wastes		.115	.179	.379	.046	.050	.015	.036	.011	.169	Not available	
Cyanide copper plating wastes		.115	.179	.379	.046	.050	.015	.036	.011	.169	2×10^6	
Finishing effluents		.115	.179	.379	.046	.050	.015	.036	.011	.169	Not available	
Metal cleaning wastes		.115	.179	.379	.046	.050	.015	.036	.011	.169	Not available	
Plating preparation wastes		.115	.179	.379	.046	.050	.015	.036	.011	.169	Not available	
Silver plating wastes		.115	.179	.379	.046	.050	.015	.036	.011	.169	Not available	
Zinc plating wastes		.115	.179	.379	.046	.050	.015	.036	.011	.169	Not available	
Metal finishing chromic acid	34	.244	.198	.149	.095	.081	.032	.031	.041	.031	4.4×10^7	
Graphic arts and photography wastes	3555	.06	.19	.20	.08	.15	.06	.09	.13	.04	4×10^3	
Electronic circuitry manufacturing wastes	36	.143	.342	.170	.037	.053	.019	.032	.039	.165	5×10^5	
Aircraft plating wastes	372	.123	.158	.117	.093	.057	.013	.095	.019	.325	4×10^7	
Cooling tower blowdown	–	.005	.150	.170	.060	–	.58	–	.035	–	2×10^7	As chromate
Subtotal											7×10^9	
Organic:												
Cosynthesis methanol production wastes	2818	–	–	.05	–	.05	–	.90	–	–	1×10^6	Sludge
Formaldehyde production wastes	2818	–	–	.02	–	.05	–	.93	–	–	8×10^5	Sludge
n-Butane dehydrogenation butadiene production wastes	2818	–	–	.03	–	–	–	.02	–	.05	3×10^5	Sludge
Rubber manufacturing wastes	2822	–	.07	.14	–	.11	.11	.50	–	.07	1×10^6	
Benzoic herbicide wastes (DOD)	2879	.168	.130	.009	–	.447	–	–	–	.246	3×10^1	
Chlorinated aliphatic herbicide wastes (DOD)	2879	.196	.062	.027	–	.649	–	.010	.057	–	5×10^3	
Phenyl urea herbicide wastes (DOD)	2879	.539	.059	–	–	.343	.059	–	–	–	2×10^3	
Halogenated aliphatic hydrocarbon fumigant wastes (DOD)	2879	1.0	–	–	–	–	–	–	–	–	2×10^2	
Organophosphate pesticide wastes (DOD)	2879	.0007	.014	.010	–	.033	–	–	.014	.929	1×10^5	
Phenoxy herbicide wastes	2879	.0002	.0001	.0007	–	.0008	.849	.149	.0002	.0004	8×10^6	

NOTE–Footnotes appear on the last page of the table.

TABLE 10

SUMMARY DATA FOR NONRADIOACTIVE WASTE STREAMS—*Continued*

Waste stream title	Standard industrial code	Percentage by geographic area									Volume (lb/yr)	Remarks
		NE	MA	ENC	WNC	SA	ESC	WSC	M	W		
Carbonate pesticide manufacturing (DOD)	2879	—	—	—	.006	.848	—	—	—	.145	3×10^2	
Polychlorinated hydrocarbon pesticide wastes (DOD)	2879	.097	.142	.018	.003	.096	.004	.033	.017	.591	1×10^5	
Miscellaneous organic pesticide manufacturing waste (DOD)	2879	—	.026	.012	.002	.257	—	—	—	.702	3×10^4	
Contaminated and waste industrial propellants and explosives	2892	—	—	—	—	—	—	—	.344	.655	3×10^5	
Contaminants and waste from primary explosives production	2892	—	.096	.001	.898	—	.001	—	.003	.001	4×10^6	
Nitrocellulose base propellant contaminated waste	2892	—	.041	—	.457	.492	—	—	.009	—	9×10^6	
High explosive contaminated wastes	2892	—	.005	.094	.394	.397	.027	.004	.023	.012	1×10^7	
Incendiary contaminated wastes	2892	—	—	—	—	—	—	1.0	—	—	6×10^5	
Production of nitroglycerin	2892	—	—	—	—	.42	.19	—	—	.39	7×10^5	
Solid waste from old primers and detonators	2892	—	.005	.430	.454	.001	.006	—	.084	.014	3×10^5	
Wastes from production of nitrocellulose propellants and smokeless powder	2892	—	.060	.046	.387	.477	—	.006	.025	—	6×10^6	
Waste high explosives	2892	.002	.006	.346	.174	.218	.104	.127	.010	.001	1×10^7	
Waste incendiaries	2892	—	.014	.002	.002	—	—	.718	.009	.255	8×10^5	
Waste nitrocellulose and smokeless powder	2892	—	—	—	—	—	—	—	.406	.594	2×10^6	
Waste nitroglycerin	2892	—	—	.01	—	.50	.22	—	.004	.266	5×10^5	
Nonutility polychlorinated biphenyl wastes	2899	.037	.221	.372	.153	.040	.041	.057	.009	.072	8×10^6	
Gasoline blending wastes	2911	.006	.086	.159	.055	.025	.025	.477	.033	.134	4×10^8	
Reclaimers residues	2992	.040	.120	.205	.081	.135	.082	.139	.044	.155	3×10^8	
Coke plant raw waste	3312	.02	.33	.41	.01	.07	.02	.06	.06	.02	8×10^7	
Military arsenical wastes	9711	—	.002	.001	—	.015	.031	.001	.024	.926	3×10^6	
Outdated or contaminated tear gas	9711	—	.138	.189	—	.022	.044	.252	.144	.209	3×10^8	
Subtotal											1×10^9	
Aqueous organic:												
Dimethyl sulfate production wastes	2611	—	(‡)	—	—	(‡)	—	—	—	—	2×10^5	Still bottoms
Acetaldehyde via ethylene oxidation	281	.015	.170	.156	.047	.156	.111	.265	.020	.060	8×10^7	
Residue from manufacture of ethylene dichloride/vinyl chloride	2821	—	.021	.015	—	.163	.171	.533	—	.117	2×10^7	
Nitrobenzene from rubber industry wastes	2822	—	.07	.14	—	.11	.11	.50	—	.07	5×10^9	Probably too dilute to be of concern
Drug manufacturing wastes	283	.056	.348	.183	.089	.100	.033	.060	.011	.115	5×10^9	Probably too dilute to be of concern
Chlorinated hydrocarbon pesticide production wastes	2879	.115	.148	.136	.073	.141	.057	.093	.054	.183	2×10^8	
Miscellaneous organic herbicide production wastes	2879	.076	.135	.124	.080	.156	.062	.108	.059	.200	4×10^8	
Organo-phosphate pesticide production wastes	2879	.115	.148	.136	.073	.141	.057	.093	.054	.183	6×10^7	
Organic pesticide production wastes	2879	.115	.148	.136	.073	.141	.057	.093	.054	.183	3×10^8	
Phenoxy herbicide production wastes	2879	.076	.135	.124	.080	.156	.062	.108	.059	.200	4×10^7	
Subtotal											1×10^{10}	

Solid, slurry, or sludge:												
Recovered arsenic from refinery flues (stored)	1021	—	—	—	—	—	—	—	—	1.00	4×10^7	Tacoma, Wash.
Sodium dichromate production wastes	2819	—	.150	.243	—	.437	—	.170	—	—	3×10^8	
Solvent-based paint sludge	285	.044	.243	.269	.072	.103	.041	.069	.012	.147	4×10^7	
Water-based paint sludge	285	.044	.243	.269	.072	.103	.041	.069	.012	.147	3×10^7	
Tetraethyl and tetramethyl lead production wastes	2869	—	—	—	—	—	—	.63	—	.37	3×10^5	
Urea production wastes	2873	—	.05	.09	.18	.09	.15	.29	—	.14	2×10^5	Dry basis
Benzoic herbicide contaminated containers	2879	—	—	.655	.154	.006	.017	—	.009	.160	2×10^4	
Calcium arsenate contaminated containers	2879	.03	.02	.08	.07	.16	.16	.35	.09	.03	6×10^3	
Carbonate pesticide contaminated containers	2879	.0008	.016	.382	.070	.022	.108	.321	.020	.060	5×10^4	
Chlorinated aliphatic pesticide contaminated containers	2879	.381	—	.076	.418	—	.105	.010	—	.010	1×10^4	
Dinitro pesticide contaminated containers	2879	.496	.168	.023	.017	.228	—	.003	.006	.165	2×10^4	
Lead arsenate contaminated containers	2879	.03	.02	.08	.07	.17	.17	.35	.03	.08	1×10^4	
Mercury fungicide contaminated containers	2879	.02	.03	.04	.03	.28	.32	.05	.01	.22	5×10^2	
Miscellaneous organic insecticide contaminated containers	2879	.148	.084	.054	.039	.197	.143	.148	.017	.170	4×10^4	
Organic arsenic contaminated containers	2879	—	.007	—	—	.011	.764	.218	—	—	5×10^3	
Organic fungicide contaminated containers	2879	.048	.125	.047	.028	.441	.001	.036	.007	.266	8×10^4	
Organophosphorus contaminated containers	2879	.043	.050	.018	.125	.139	.192	.175	.049	.208	1×10^5	
Phenoxy contaminated containers	2879	.035	.033	.196	.321	.031	.030	.067	.141	.146	2×10^5	
Phenyl urea contaminated containers	2879	.106	.085	.106	.033	.106	.424	.042	.003	.095	9×10^3	
Polychlorinated hydrocarbon contaminated containers	2879	.017	.107	.019	.138	.306	.211	.133	.024	.044	2×10^5	
Triazine contaminated containers	2879	.147	.121	.320	.372	.013	.003	.011	.002	.011	6×10^4	
Miscellaneous organic pesticide contaminated containers	2879	.014	.162	.385	.068	.162	.123	.041	.014	.034	1×10^4	
Petroleum refining still bottoms	2911	.006	.086	.159	.055	.025	.025	.477	.033	.134	2×10^4	
Petroleum waste brine sludges	2911	.002	.06	.09	.011	.12	.10	.55	.022	.045	4×10^6	
Iron manufacturing waste sludge	331	.05	.05	.56	.02	.12	.03	.09	.05	.03	6×10^6	
Arsenic trioxide from smelting industry	333	—	.03	.015	.07	.005	.01	.10	.70	.07	2×10^7	
Selenium production wastes	3339	—	.75	—	—	—	—	—	.25	—	2×10^4	
Duplicating equipment manufacturing wastes	3555	—	1.00	—	—	—	—	—	—	—	7×10^5	Upstate New York
Refrigeration equipment manufacturing wastes	3585	.013	.232	.408	.096	.040	.069	.086	.011	.045	2×10^8	
Battery manufacturing waste sludge	3691	.117	.043	—	.118	.117	—	—	.118	—	5×10^7	
Arsenic trichloride recovered from coal	49	.05	.23	.07	.05	.33	.25	—	.07	—	6×10^6	
Military paris green (stored)	9711	—	—	1.00	—	—	—	—	—	—	3×10^4	
Stored military mercury compounds	9711	.47	—	—	.51	—	—	—	—	.02	2×10^2	
Subtotal											7×10^8	
Aqueous inorganic (insufficient quantity or distribution data):												
Zinc ore roasting acid wash	1031					Not available					Not available	
Mercury ore extraction wastes	1092	—	—	—	—	—	—	—	.28	.72	Not available	
Cadmium ore extraction wastes	1099					Not available					2×10^8	
Mercury bearing textile wastes	22					Not available					Not available	
Wastes from pulp and paper industry	26	.11	.11	.19	.04	.23	.08	.10	.03	.11	Negligible	
Cadmium-selenium pigment wastes	28					Not available					Not available	
Waste or contaminated perchloric acid	28					Not available					Negligible	
Arsine production wastes	2813	(‡)	(‡)	(‡)	—	—	(‡)	(‡)	—	(‡)	1×10^4	
Borane production wastes	2813	—	1.0	—	—	—	—	—	—	—	Negligible	
Nickel carbonyl production wastes	2813	—	1.0	—	—	—	—	—	—	—	Negligible	
Waste bromine pentafluoride	2813	—	—	—	—	—	—	1.0	—	—	Negligible	
Waste chlorine pentafluoride	2813	—	—	(‡)	—	—	—	(‡)	—	—	Negligible	
Waste chlorine trifluoride	2813	—	—	(‡)	—	—	—	(‡)	—	—	Negligible	

TABLE 10

SUMMARY DATA FOR NONRADIOACTIVE WASTE STREAMS—*Concluded*

Waste stream title	Standard industrial code	Percentage by geographic area*									Volume (lb/yr)	Remarks
		NE	MA	ENC	WNC	SA	ESC	WSC	M	W		
Chromate wastes from pigments and dyes	2816	.015	.170	.156	.047	.156	.111	.265	.020	.060	1×10^{11} (§)	
Arsenic wastes from purification of phosphoric acid	2819	.015	.170	.156	.047	.156	.111	.265	.020	.060	Negligible	
Contaminated fluorine	2819	.007	.101	.166	.075	.147	.207	.147	.054	.096	Negligible	
Cyanide production wastes	2819	.007	.101	.166	.075	.147	.207	.147	.054	.096	2×10^{11} (§)	
Waste from manufacture of mercuric cyanide	2819	—	1.0	—	—	—	—	—	—	—	Negligible	
Waste from production of barium salts	2819	.007	.101	.166	.075	.147	.207	.147	.054	.096	Negligible	
Urethane manufacturing wastes	2821	.046	.121	.101	.018	.404	.182	.101	—	.027	2×10^{12} (§)	
Wastes from polycarbonate polymer production	2821	.046	.121	.101	.018	.404	.182	.101	—	.027	2×10^{12} (§)	
Pharmaceutical arsenic wastes	283	.056	.348	.183	.089	.100	.033	.060	.011	.115	Negligible	
Pharmaceutical mercurial wastes	283	.056	.348	.183	.089	.100	.033	.060	.011	.115	Negligible	
Wood preservative wastes	2865	.007	.029	.117	.060	.267	.141	.174	.042	.162	2×10^{11} (§)	
Contaminated antimony pentafluoride	2869	—	(‡)	(‡)	—	—	—	(‡)	—	—	Negligible	
Contaminated antimony trifluoride	2869	—	(‡)	(‡)	—	—	—	(‡)	—	—	Negligible	
Hydrazine production wastes	2869	(‡)	(‡)	—	—	(‡)	—	(‡)	—	—	Not available	
Agricultural chemical production wastes	287	.005	.075	.145	.074	.299	.207	.090	.046	.058	2×10^{12} (§)	
Agricultural pesticide arsenic wastes	2879	.005	.075	.145	.074	.299	.207	.090	.046	.058	2×10^{12} (§)	
Mercuric fungicide production wastes	2879	.005	.075	.145	.074	.299	.207	.090	.046	.058	2×10^{12} (§)	
Pesticide arsenate wastes	2879	.005	.075	.145	.074	.299	.207	.090	.046	.058	2×10^{12} (§)	
Pesticide arsenic wastes	2879	.005	.075	.145	.074	.299	.207	.090	.046	.058	2×10^{12} (§)	
1080 production wastes and contaminated lots	2879	—	(‡)	—	—	(‡)	1.0	—	—	—	Negligible	Production of sodium fluoracetate
Wastes from pesticide-herbicide manufacture (arsenites)	2879	.005	.075	.145	.074	.299	.207	.090	.046	.058	2×10^{12} (§)	
Electrical fuse manufacturing wastes	2899	.037	.221	.372	.153	.039	.040	.057	.009	.072	2×10^{12} (§)	
Beryllium salt production wastes	3339	—	1.0	—	—	—	—	—	—	—	Negligible	
Thallium production wastes	3339	—	—	—	—	—	—	1.0	(‡)	—	Negligible	Small amount in Colorado
Rotogravure printing plate wastes	3555	.105	.446	.320	.051	.019	—	.028	—	.031	1×10^{12} (§)	
Computer manufacturing wastes	3573	.143	.342	.170	.037	.053	.019	.032	.039	.165	1×10^{12} (§)	
Electronic tube production wastes	367	.143	.342	.170	.037	.053	.019	.032	.039	.165	Not available	
Magnetic tape production wastes	3679	.171	.336	.165	.120	.077	.016	.060	—	.060	Not available	
Battery manufacturing wastes	3691	.030	.236	.289	.111	.103	.029	.056	.012	.134	1.1×10^{12}	
Mercury cell battery wastes	3692	.060	.138	.556	.049	.074	.019	.017	(¶)	(¶)	1.1×10^{12} (§)	
Railroad engine cleaning	40					Not available					Not available	
Arsenic wastes from transportation industry	40					Not available					Not available	
Military cadmium wastes from plating	9711					Not available					Not available	
Military sodium chromate	9711					Not available					Not available	
Subtotal											2×10^{8}	
Organic (insufficient quantity or distribution data):												
Spent wood-preserving liquors	2491	.007	.029	.117	.060	.267	.141	.174	.042	.162	2×10^{12} (§)	
Off-specification "agent orange" defoliant	9711					Not available					Not available	

Paint stripping wastes, Vance Air Force Base, Oklahoma	9711	—	—	—	—	—	—	1.0	—	—	Not available	
Subtotal											Not available	
Aqueous organic (insufficient quantity or distribution data):												
Synthetic fiber production wastes	2824	.046	.121	.101	.018	.404	.182	.101	--	.027	2×10^{12} (§)	
Dye manufacturing wastes	2865	.015	.170	.156	.047	.156	.111	.265	.020	.060	1×10^{11} (§)	
Nitrile pesticide wastes	2879	.005	.075	.145	.074	.299	.207	.090	.046	.058	2×10^{12} (§)	
Organic arsenicals from production of cacodylates	2879	—	.200	.800	—	—	—	—	—	—	Not available	
Torpedo process wastes	2879	—	—	—	—	—	1.0	--	—	—	Negligible	
Utilities and electrical station waste	49					Not available					3×10^7	
Wastes from production of chloropicrin	9711	—	(‡)	—	—	—	—	(‡)	—	(‡)	Negligible	
Subtotal											3×10^7	
Solid, slurry, or sludge (insufficient quantity or distribution data):												
Wastes from seed industry	011	.017	.088	.371	.213	.053	.060	.081	.023	.094	Not available	
Contaminated orchard soil	0175	.05	—	.15	—	.33	—	.35	.03	.09	Unknown	
Old or contaminated thallium and thallium sulfate rodenticide	2879	.005	.075	.145	.074	.299	.207	.090	.046	.058	Not available	
Highly contaminated soil	9711	—	—	—	—	—	—	--	1.00	—	3×10^9 (not included in total)	Stored at Rocky Mountain Arsenal
Spent filter media from military operations	9711					Not available					Not available	
Waste chemicals from military	9711					Not available					3×10^5	
Explosives from military ordnance	9711					Not available					4×10^8	
Drugs and contraband seized by customs	—					Not available					Not available	
Etiological materials from commercial production	—					Not available					3×10	
Subtotal											4×10^8	
Total											2×10^{10}	

*This is an updated version of the table that appeared in the first edition of this report.

†NE = New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont; MA = Mid Atlantic: New Jersey, New York, and Pennsylvania; ENC = East North Central: Illinois, Indiana, Michigan, Ohio, and Wisconsin; WNC = West North Central: Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota; SA = South Atlantic: Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, and West Virginia; ESC = East South Central: Alabama, Kentucky, Mississippi, and Tennessee; WSC = West South Central: Arkansas, Louisiana, Oklahoma, and Texas; M = Mountain: Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming; W = West (Pacific): Alaska, California, Hawaii, Oregon, and Washington.

‡Exists but quantity is unknown.

§Total liquid discharge for the larger 3-digit standard industrial code category.

¶Percentage for the Mountain and Pacific areas combined is 0.087.

TABLE 11
POTENTIALLY HAZARDOUS RADIONUCLIDES*

Nuclide	Half-life (years)	Source†	Nuclide	Half-life (years)	Source†
H-3	12.33	1, 2, 3	Sm-151	93	1
Be-10	1,600,000	2	Eu-152	13	1
C-14	5,730	2	Eu-154	8.6	1
Na-22	2.601	2	Eu-155	4.8	1
Cl-36	301,000	2	Gd-153	.662	1
Ar-39	269	2	Ho-166m	1,200	1
Ca-41	130,000	2	Tm-170	.353	3
Ca-45	.447	2	Ta-182	.315	3
V-49	.907	2	W-181	.333	2
Mn-54	.856	2	Ir-192m	241	3
Fe-55	2.7	2	Pb-210‡	22.3	1, 2
Co-60	5.27	2, 3	Bi-210	3,500,000	1
Ni-59	80,000	2	Po-210	.379	2, 3
Ni-63	100	2	Ra-226‡	1,600	1, 2
Se-79	65,000	1	Ra-228‡	5.75	1
Kr-85	10.73	1	Ac-227‡	21.77	1
Sr-90‡	29	1, 3	Th-228‡	1.913	1
Zr-93‡	950,000	1	Th-229‡	7,340	1
Nb-93m	12	1, 2	Th-230‡	77,000	1, 2
Nb-94	20,000	2	Pa-231‡	32,500	1
Mo-93	3,000	2	U-232‡	72	1
Tc-99	213,000	1	U-233‡	158,000	1
Ru-106‡	1.011	1, 3	U-234‡	244,000	1
Rh-102m	.567	1	U-236	23,420,000	1
Pd-107	6,500,000	1	Np-237	2,140,000	1
Ag-110m	.690	1	Pu-236‡	2.85	1
Cd-109	1.241	1	Pu-238‡	87.8	1, 3, 2
Cd-113m	14.6	1	Pu-239	24,390	1, 2
Sn-121m	50	1	Pu-240‡	6,540	1, 2
Sn-123	.353	1	Pu-241‡	15	1, 2
Sn-126	100,000	1	Pu-242‡	387,000	1
Sb-125	2.73	1, 2	Am-241‡	433	1, 3
Te-127m	.299	1	Am-242m‡	152	1
I-129	15,900,000	1	Am-243‡	7,370	1
Cs-134	2.06	1	Cm-242‡	.446	1, 3
Cs-135	2,300,000	1	Cm-243‡	28	1
Cs-137‡	30.1	1, 3	Cm-244‡	17.9	1, 3
Ce-144‡	.779	1, 3	Cm-245‡	8,500	1
Pm-146	5.53	1	Cm-246‡	4,760	1
Pm-147	2.5234	1, 3	Cm-247‡	15,400,000	1

*Criteria for inclusion of nuclides: (1) They must have half-lives greater than 100 days. Nuclides with half-lives less than 100 days are assumed to decay to insignificance before disposal or are included in their long half-life parents. Note that this excludes nuclides such as I-131 with an 8.065-day half-life. (2) They shall not be naturally occurring because of their own long half-lives. This table excludes such nuclides as K-40, Rb-87, Th-232, U-235, and U-238 with half-lives greater than 10^8 years. There are also 75 potentially hazardous radionuclides that occur in research quantities that have not been included in this table.

†Source terms: 1 = Found in high-level radioactive wastes from fuel reprocessing plants, both Government and industry. 2 = Found in other nuclear power wastes such as spent fuel cladding wastes, reactor emissions, and mine and mill tailings. 3 = Found in wastes of nonnuclear power origin such as nuclear heat sources, irradiation sources, and biomedical applications.

‡Indicates hazardous daughter radionuclides are present with the parent.

It is important to emphasize that although Table 10 is sufficiently accurate for planning purposes, the indicated total national nonradioactive hazardous waste volume of 10 million tons (9 million metric tons) per year is not a firm number but an estimate based on currently available information. A more accurate indication of actual waste volumes will become available only after a comprehensive national waste inventory has been accomplished for specific waste streams.

Appendix C

DECISION MODEL FOR SCREENING AND SELECTING HAZARDOUS COMPOUNDS AND RANKING HAZARDOUS WASTES

A preliminary decision model was developed for interim use in order to screen and select hazardous compounds and rank hazardous wastes. The decision model used for purposes of this study is not nearly as sophisticated as that required for standard-setting purposes. An explanation of the terminology and definitions utilized are included.

It is essential to make a clear distinction between development and application of criteria for purposes of designating hazardous wastes and development and application of a priority ranking system for hazardous wastes despite the fact that similar or related data must be manipulated. The distinction is that the hazardous waste criteria relate solely to the intrinsic hazard of the waste on uncontrolled release to the environment regardless of quantity or pathways to man or other critical organisms. Therefore criteria such as toxicity, phytotoxicity, genetic activity, and bioconcentration are utilized.

In contrast, in the development of a priority ranking system, it is obvious that the threat to public health and environment from a given hazardous waste is strongly dependent upon the quantity of the waste involved, the extent to which present treatment technology and regulatory activities mitigate against the threat, and the pathways to man or other critical organisms.

DEFINITIONS OF ABBREVIATIONS USED IN THE SCREENING MODEL

Maximum permissible concentration (MPC) levels: Levels of radioisotopes in waste streams which if continuously maintained would result in maximum permissible doses to occupationally exposed workers and which may be regarded as indices of the radiotoxicity of the different radionuclides.

Bioconcentration (bioaccumulation, biomagnification): The process by which living organisms concentrate an element or compound to levels in excess of those in the surrounding environment.

National Fire Protection Association (NFPA) category 4 flammable materials: Materials including very flammable gases, very volatile flammable liquids, and materials that in the form of dusts or mists readily form explosive mixtures when dispersed in air.

NFPA category 4 reactive materials: Materials which in themselves are readily capable of detonation or of explosive decomposition or reaction at normal temperatures and pressures.

Lethal dose fifty (LD_{50}): A calculated dose of a chemical substance which is expected to kill 50 percent of a population of experimental animals exposed through a route other than respiration. Dose concentration is expressed in milligrams per kilogram of body weight.

Lethal concentration fifty (LC_{50}): A calculated concentration which when administered by the respiratory route is expected to kill 50 percent of a population of experimental animals during an exposure of 4 hours. Ambient concentration is expressed in milligrams per liter.

Grade 8 dermal irritation: An indication of necrosis resulting from skin irritation caused by application of a 1-percent chemical solution.

Median threshold limit (96-hour TLm): That concentration of a material at which it is lethal to 50 percent of the test population over a 96-hour exposure period. Ambient concentration is expressed in milligrams per liter.

Phytotoxicity: Ability to cause poisonous or toxic reactions in plants.

Median inhibitory limit (*ILm*): That concentration at which a 50-percent reduction in the biomass, cell count, or photosynthetic activity of the test culture occurs compared to a control culture over a 14-day period. Ambient concentration is expressed in milligrams per liter.

Genetic changes: Molecular alterations of the deoxyribonucleic or ribonucleic acids of mitotic or meiotic cells resulting from chemicals or electromagnetic or particulate radiation.

CRITERIA FOR SCREENING AND SELECTION

The screening criteria are based purely on the inherent or intrinsic characteristics of the waste as derived from its constituent hazardous compounds. The problem in seeking a set of criteria becomes one of establishing for public health and the environment some acceptable level of tolerance. Wastes displaying characteristics outside of these predetermined tolerance levels are designated as hazardous. This approach requires that defensible thresholds be selected for each tolerance level. For example, if the toxicity threshold is defined as an LD_{50} of 5,000 milligrams per kilogram of body weight or less, all wastes displaying equal or lower mean lethal dose levels would be designated hazardous. Similar numeric threshold values were developed for other basic physical, chemical, or biological criteria utilized in the screening phase of the decision model. Ideally then, the decision criteria for designating hazardous wastes could be based upon numeric evaluations of intrinsic toxicological, physical, and chemical data.

In addition, a criteria system for screening hazardous wastes must retain a degree of flexibility. This is self-evident because all potential wastes, let alone their composition, cannot now be identified. Consequently, it appears that a technically sound and administratively workable criteria system must have levels of tolerance against which any waste stream can be compared.

As a result, a preliminary screening model was developed as illustrated in Figure 5. Each stage of the screening mechanism compares the characteristics of a waste stream to some preset standard. Qualification due to any one or more screens automatically designates a waste as hazardous.

PRIORITY RANKING OF WASTES

There is little doubt that, on the basis of intrinsic properties alone, many wastes will qualify as hazardous wastes. Therefore it was necessary to rank these wastes in priority fashion so that those presenting the most imminent threats to public health and the environment receive the greatest attention.

To assess the magnitude of the threat posed by hazardous wastes is difficult. Such a determination requires input concerning the inherent hazards of the wastes, the quantities of waste produced, and the ease with which those hazards can be eliminated or circumvented. These considerations were incorporated into numerical factors, which in turn were used to determine the priority of concern of a particular waste. The final numerical factor is designed to represent the volume of the environment potentially polluted to a critical level by a given waste. The assumption is made that all sectors of the environment are equally valuable so that a unit volume of soil is as important as a unit volume of water or air. This simplification does not reflect the fact that atmospheric and aquatic contaminants are more mobile than terrestrial ones but does recognize the problem of environmental transfer from one phase to another.

The numerical factor is derived by dividing the volume of a waste by its lowest critical product. This may be expressed mathematically as

$$R = \frac{Q}{CP}$$

where

R = ranking factor
Q = annual production quantity for the waste being ranked
CP = critical product for the waste being ranked

CP is the value of the lowest concentration at which any of the hazards of concern become manifest in a given environment multiplied by an index representative of the waste's mobility into that environment. Hence, for a waste that will be discharged to water or to a landfill where leaching will

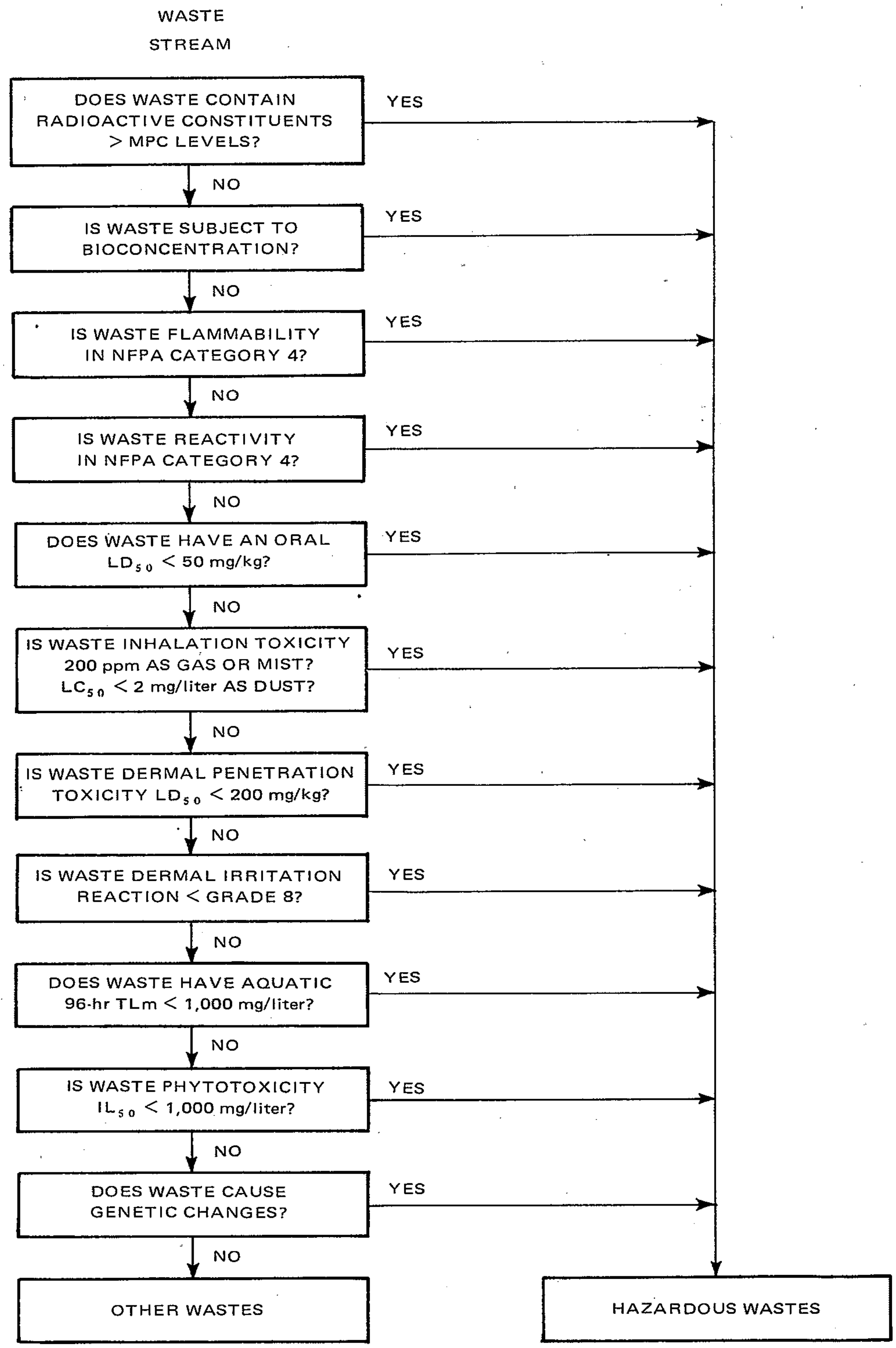

Figure 5. Flowchart of the hazardous waste screening model.

occur, the product might be the 96-hour TLm to fish for that waste (e.g., 1 milligram per liter) multiplied by its solubility index (SI). SI is defined as a dimensionless number between 1 and infinity obtained by dividing 10^6 milligrams per liter by the solubility of the waste in milligrams per liter. A waste soluble in water to 500,000 milligrams per liter has a solubility index calculated as follows:

$$SI = \frac{10^6}{5 \times 10^5}$$

$$= 2$$

This presumes that all wastes miscible in water or soluble to more than 1,000,000 milligrams per liter will have similar mobility patterns and thus should receive a maximum index of 1. CP for the example waste would then be calculated as follows:

$$CP = 96\text{-hr TLm} \times SI$$
$$= 1 \text{ milligram per liter} \times 2$$
$$= 2 \text{ milligrams per liter}$$

Similarly, for atmospheric pollutants, CP might be LC_{50} multiplied by the volatility index. This index would be derived by dividing atmospheric pressure under ambient conditions by the vapor pressure of the waste. Potential for suspension of dusts in air would be given a mobility index of 1.

The aqueous and atmospheric environments are of greatest concern since discharge to the land represents major hazard in the form of volatilization of wastes or leaching. Where data are available on phytotoxicity or other hazards related to direct contact with wastes in soil, CP for ranking would be derived from use of the critical concentration at which the hazard becomes apparent and a mobility index of 1.

Actual waste stream data are most desirable for use in the priority ranking formulation. However, since such data are generally lacking, the additive estimations recommended for interim use can be employed for priority ranking until waste stream data become available.

Appendix D

SUMMARY OF HAZARDOUS WASTE TREATMENT AND DISPOSAL PROCESSES

The objectives of hazardous waste treatment are the destruction or recovery for reuse of hazardous substances and/or the conversion of these substances to innocuous forms that are acceptable for uncontrolled disposal. Several unit processes are usually required for complete treatment of a given waste stream. In some cases, hazardous residues that cannot be destroyed, reused, or converted to innocuous forms result from treatment. These residues, therefore, require controlled storage or disposal.

This appendix presents a description of each of the treatment and disposal processes examined during this study. No claim is made that these hazardous waste treatment processes or combinations of processes and storage or disposal methods are environmentally acceptable. Treatment technology can be grouped into the following categories: physical, chemical, thermal, and biological. These processes are all utilized to some extent by both the public and private sectors. However, treatment processes have had only limited application in hazardous waste management because of economic constraints, and, in some cases, because of technological constraints.

The physical treatment processes are utilized to concentrate waste brines and remove soluble organics and ammonia from aqueous wastes. Processes such as flocculation, sedimentation, and filtration are widely used throughout industry, and their primary function is the separation of precipitated solids from the liquid phase. Ammonia stripping is utilized for removing ammonia from certain hazardous waste streams. Carbon sorption will remove many soluble organics from aqueous waste streams. Evaporation is utilized to concentrate brine wastes in order to minimize the cost of ultimate disposal.

The chemical treatment processes are also a vital part of proper hazardous waste management. Neutralization is carried out in part by reacting acid wastes with basic wastes. Sulfide precipitation is required in order to remove toxic metals like arsenic, cadmium, mercury, and antimony. Oxidation-reduction processes are utilized in treating cyanide and chromium-6 bearing wastes.

Thermal treatment methods are used for destroying or converting solid or liquid combustible hazardous wastes. Incineration is the standard process used throughout industry for destroying liquid and solid wastes. Pyrolysis is a relatively new thermal process that is used to convert hazardous wastes into more useful products, such as fuel gases and coke.

Biological treatment processes can also be used for biodegrading organic wastes; however, careful consideration needs to be given to the limitations of these processes. These systems can operate effectively only within narrow ranges of flow, composition, and concentration variations. Biological systems generally do not work on solutions containing more than 1 to 5 percent salts. Systems that provide the full range of biodegradation facilities usually require large land areas. Toxic substances present a constant threat to biological cultures. In summary, biological treatment processes should be used only when the organic waste stream is diluted and fairly constant in its composition.

Disposal methods currently used vary depending upon the form of the waste stream (solid or liquid), transportation costs, local ordinances, etc. Dumps and landfills are utilized for all types of hazardous wastes; ocean disposal and deep-well injection are used primarily for liquid hazardous wastes. Engineered storage or a secure landfill should be utilized for those hazardous wastes for which no adequate treatment processes exist.

Each of the processes evaluated by EPA is described in this appendix in some detail. An assessment of the waste handling capabilities is also included. The most widely applicable processes are incineration, neutralization, and reduction.

PHYSICAL TREATMENT

Reverse osmosis: The physical transport of a solvent across a membrane boundary, where external pressure is applied to the side of less solvent concentration so that the solvent will flow in the opposite direction. This allows solvent to be extracted from a solution, so that the solution is concentrated and the extracted solvent is relatively pure. Almost any dissolved solid can be treated by reverse osmosis, provided the concentrations are not too high and it is practical to adjust the pH to range from 3 to 8.

Dialysis: A process by which various substances in solution having widely different molecular weights may be separated by solute diffusion through semipermeable membranes. The driving force is the difference in chemical activity of the transferred species on the two sides of the membrane. The oldest continuing commercial use of dialysis is in the textile industry. Dialysis is particularly applicable when concentrations are high and dialysis coefficients are disparate. It is a suitable means of separation for any materials on the hazardous material list that form aqueous solutions.

Electrodialysis: Similar to dialysis in that dissolved solids are separated from their solvent by passage through a semipermeable membrane. It differs from dialysis in its dependence on an electric field as the driving force for the separation. Electrodialysis is applicable when it is desired to separate out a variety of ionized species from an un-ionized solvent such as water. Ionizable nitrates and phosphates [e.g., $Pb(NO_3)_2$, Na_3PO_4] are removed with varying degrees of efficiency. With regard to NDS's, electrodialysis is applicable for the treatment of waste streams for which it is desirable to reduce the concentrations of ionizable species in the intermediate range (10,000 to 500 parts per million) over a broad range of pH (e.g., 1 to 14). If an effluent of concentration lower than 500 parts per million is desired, the electrodialysis effluent could be fed into another treatment process.

Evaporation: The removal of solvent as vapor from a solution or slurry. This is normally accomplished by bringing the solvent to its boiling point to effect rapid vaporization. Heat energy is supplied to the solvent, and the vapor evolved must be continuously removed from above the liquid phase to prevent its accumulation. The vapor may or may not be recovered, depending on its value. Thus, the principal function of evaporation is the transfer of heat to the liquid to be evaporated. Evaporation processes are widely used throughout industry for the concentration of solutions and for the production of pure solvents. Evaporation represents the most versatile wastewater processing method available that is capable of producing a high-quality effluent. It is, however, one of the most costly processes and is therefore generally limited to the treatment of wastewater with high solids concentrations or to wastewater where very high decontamination is required (e.g., radioactive wastes).

Carbon sorption: A process in which a substance is brought into contact with a solid and is held at the surface or internally by physical and/or chemical forces. The solid is called the sorbent and the sorbed substance is called the sorbate. The amount of sorbate held by a given quantity of sorbent depends upon several factors, including the surface area per unit volume (or weight) of the sorbent and the intensity of the attractive forces. Activated carbon has been historically used to remove organic and other contaminants from water. Activated carbon sorption has been used to remove dissolved refractory organics from municipal waste streams and to clean up industrial waste streams. It has been used to remove some heavy metals and other inorganics from water. Carbon sorption can remove most types of organic wastes from water. Those that have low removal by carbon include short carbon chain polar substances such as methanol, formic acid, and perhaps acetone. This process is being utilized to treat herbicide plant wastes. Also, full-scale carbon sorption units have been successfully used for petroleum and petrochemical wastes.

Ammonia stripping: The removal of ammonia from alkaline aqueous wastes by stripping with steam at atmospheric pressure. The waste stream, at or near its boiling point, is introduced at the top of a packed or bubble cap tray-type column and contacted concurrently with steam. Ammonia, because of its high partial pressure over alkaline solutions, is readily condensed and reclaimed for sale, and liquid effluents from a properly designed steam stripping column will be essentially ammonia free. This process is quite useful in the treatment of ammonia-bearing wastes. However, it can also be used to remove various volatile and organic contaminants from waste streams.

Filtration: The physical removal of the solid constituents from the aqueous waste stream by means of a filter medium. A slurry is forced against the filter medium. The pores of the medium are small enough to prevent the passage of some of the solid particles; others impinge on the fiber of the medium. Consequently, a cake builds up on the filter, and after the initial deposition, the cake itself serves as the barrier. The capacity of this process is governed by the flow rate of the fluid filtrate through the bed formed by the solid particles. Most of the aqueous hazardous waste streams which contain solid constituents will be treated by this process.

Sedimentation (settling): A process used to separate aqueous waste streams from the particles suspended in them. The suspension is placed in a tank, and the particles are allowed to settle out; the fluid can then be removed from above the solid bed. The final state is that of a packed bed resembling a filter cake if the process is allowed to continue long enough. Sedimentation is widely used throughout industry for treatment of waste streams for which there is a need for separation of precipitated solids from the liquid phase.

Flocculation: A process used when fine particles in a waste stream are difficult to separate from the medium in which they are suspended. These waste constituents are in the low and fractional micrometer range of sizes; they settle too slowly for economic sedimentation and are often difficult to filter. Thus, this process is applied to gather these particles together as flocculates, which allows them to settle much faster. The resulting sediment is less dense and is often mobile. The particles also filter more readily into a cake which is permeable and does not clog. Like sedimentation, flocculation is widely used throughout industry for treatment of waste streams for which there is a need for separation of precipitated solids from the liquid phase.

CHEMICAL TREATMENT

Ion exchange: The reversible interchange of ions between a solid and a liquid phase in which there is no permanent change in the structure of the solid. It is a method of collecting and concentrating undesirable materials from waste streams. The mechanism of ion exchange is chemical, utilizing resins that react with either cations or anions. Ion exchange technology has been available and has been employed for many years for removing objectionable traces of metals and even cyanides from the various waste streams of the metal process industries. Objectionable levels of fluorides, nitrates, and manganese have also been removed from drinking water sources by means of ion exchange. Technology has been developed to the extent that the contaminants that are removed can be recycled, readily transformed into a harmless state, or safely disposed of.

Neutralization: A process utilized to prevent excessively acid or alkaline wastes from being discharged in plant effluents. Some of the methods used to neutralize such wastes are (1) mixing wastes such that the net effect is a near-neutral pH, (2) passing acid wastes through beds of limestone, (3) mixing acid with lime slurries, (4) adding proper proportions of concentrated solutions of caustic soda (NaOH) or soda ash to acid wastewaters, (5) blowing waste boiler-flue gas through alkaline wastes, (6) adding compressed CO_2 to alkaline wastes, (7) adding sulfuric acid to alkaline wastes. Neutralization is utilized in the precipitation of heavy metal hydroxides or hydrous oxides and calcium sulfate.

Oxidation: A process by which waste streams containing reductants are converted to a less hazardous state. Oxidation may be achieved with chlorine, hypochlorites, ozone, peroxide, and other common oxidizing agents. The method most commonly applied on a large scale is oxidation by chlorine. Oxidation is used in the treating of cyanides and other reductants.

Reduction: A process whereby streams containing oxidants are treated with sulfur dioxide to reduce the oxidants to less noxious materials. Other reductants that can be used are sulfite salts and ferrous sulfate, depending on the availability and cost of these materials. Reduction is used to treat chromium-6 and other oxidants.

Precipitation: A process of separating solid constituents from an aqueous waste stream by chemical changes. In this process, the waste stream is converted from one with soluble constituents to one with insoluble constituents. This process is applicable to the treatment of waste streams containing heavy metals.

Calcination: The process of heating a waste material to a high temperature without fusing in order to effect useful changes, such as oxidation or pulverization. Calcination is commonly applied in the processing of high-level radioactive wastes.

THERMAL TREATMENT

Incineration: A controlled process to convert a waste to a less bulky, less toxic, or less noxious material. Most incineration systems contain four basic components: a waste storage facility, a burner and combustion chamber, an effluent purification device when warranted, and a vent or a stack. The 11 basic types of incineration units are open pit, open burning, multiple chamber, multiple hearth, rotary kiln, fluidized bed, liquid combustors, catalytic combustors, afterburners, gas combustors, and stack flares. The type of waste for which each of these incineration units is best suited is detailed diagrammatically in Figure 6.

Pyrolysis: The thermal decomposition of a compound. Wastes are subjected to temperatures of about 1200 F ± 300 F (650 C ± 150 C), depending upon the nature of the wastes, in an essentially oxygen-free atmosphere. Without oxygen, the wastes cannot burn and are broken down (pyrolyzed) into steam, carbon oxides, volatile vapors, and charcoal. Most municipal and industrial wastes that are basically organic in nature can be converted to coke or activated charcoal and gaseous mixtures which may approach natural gas in heating values through the utilization of pyrolysis.

BIOLOGICAL TREATMENT

Activated sludge: A process in which biologically active growths are continuously circulated and contacted with organic waste in the presence of oxygen. Normally, oxygen is supplied to the system in the form of fine air bubbles under turbulent conditions. The activated sludge is composed of the biologically active growths and contains micro-organisms that feed on the organic waste. Oxygen is required to sustain the growth of the micro-organisms. In the conventional activated sludge process, incoming wastewater is mixed with recycled activated sludge and the mixture is aerated for several hours in an aeration tank. During this period, adsorption, flocculation, and various oxidation reactions take place which are responsible for removing much of the organic matter from the wastewater. The effluent from the aeration tank is passed to a sedimentation tank where the flocculated micro-organisms or sludge settles out. A portion of this sludge is recycled as seed to the influent wastewater. The activated sludge process has been applied very extensively in the treatment of refinery, petrochemical, and biodegradable organic wastewaters.

Aerated lagoon: The use of a basin of significant depth [usually 6 to 17 feet (1.83 to 5.19 meters)] in which organic waste stabilization is accomplished by a dispersed biological growth system and where oxygenation is provided by mechanical or diffused aeration equipment. Aerated lagoons have been used successfully as an economical means to treat industrial wastes where high-quality effluents are not required.

Trickling filter: The use of artificial beds of rocks or other porous media through which the liquid from settled organic waste is percolated. In the process, the waste is brought into contact with air and biological growths. Settled liquid is applied intermittently or continuously over the top surface of the filter by means of a distributor. The filtered liquid is collected and discharged at the bottom. The primary removal of organic material is not accomplished through filtering or straining action. Removal is the result of an adsorption process similar to activated sludge which occurs at the surfaces of the biological growths or slimes covering the filter media. Trickling filters have been used extensively in the treatment of such industrial wastes as acetaldehyde, acetic acid, acetone, acrolein, alcohols, benzene, butadiene, chlorinated hydrocarbons, cyanides, epichlorohydrin, formaldehyde, formic acid, ketones, monoethanol-

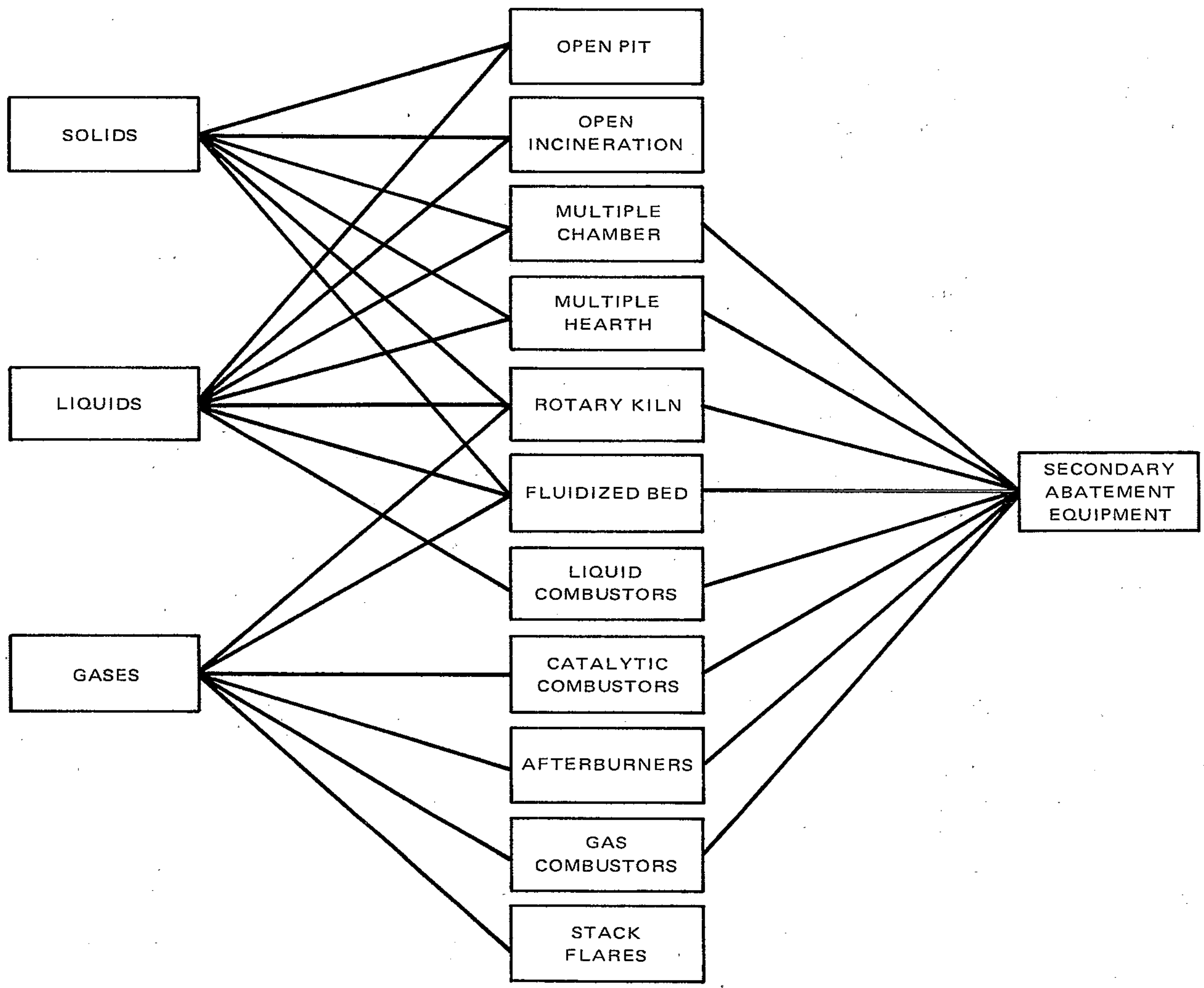

Figure 6. Types of incinerators and their applications.

amines, phenolics, propylenedichloride, terpenes, ammonia, ammonium nitrate, nylon and nylon chemical intermediates, resins, and rocket fuels.

Waste stabilization ponds: The use of large shallow basins [usually 2 to 4 feet (0.61 to 1.22 meters) deep] for the purpose of purifying wastewater by storage under climatic conditions that favor the growth of algae. The conversion of organics to inorganics, or stabilization, in such ponds results from the combined metabolic activity of bacteria, algae, and surface aeration. Waste stabilization ponds have been widely used where land is plentiful and climatic conditions are favorable. They have been used extensively in treating industrial wastewaters when a high degree of purification is not required. More recently, stabilization ponds have proven to be successful in treating steel mill wastes.

ULTIMATE DISPOSAL

Landfill disposal: A well-controlled and sanitary method of disposal of wastes upon land. Common landfill disposal methods are (1) mixing with soil, (2) shallow burial, (3) combinations of these. The utilization of landfill procedures for the disposal of certain hazardous waste materials at an NDS, in an industrial environment, or in municipal applications will undoubtedly be required in the future.

Deep-well disposal: A system of disposing of raw or treated filtered hazardous waste by pumping it into deep wells where it is contained in the pores of permeable subsurface rock separated from other groundwater supplies by impermeable layers of rock or clay. Subsurface injection has been extensively used in the disposal of oil field brines (between 10,000 and 40,000 brine injection wells in the United States). The number of industrial waste injection wells in the United States has increased to more than 100. Injection wells can be used by virtually any type of industry that is located in a proper geologic environment and that has a waste product amenable to this method. Some industries presently using this method are chemical and pharmaceutical plants, refineries, steel and metal industries, paper mills, and coke plants.

Land burial disposal: A method adaptable to those hazardous materials that require permanent disposal. Disposal is accomplished by either near-surface or deep burial. In near-surface burial, the material is deposited either directly into the ground or is deposited in stainless steel tanks or concrete-lined pits beneath the ground. In land burial, the waste is transported to a selected site where it is prepared for final burial. At the present time, near-surface burial of both radioactive and chemical wastes is being conducted at several AEC and commercially operated burial sites. Pilot plant studies have been conducted for deep burial in salt formations and hard bedrock. Land burial is a possible choice for the hazardous materials that require complete containment and permanent disposal. This includes radioactive wastes as well as highly toxic chemical wastes. At the present time, only near-surface burial is used for the disposal of most wastes.

Ocean dumping: The process of utilizing th ocean as the ultimate disposal sink for all types of waste materials (including hazardous wastes). There are three basic techniques for ocean disposal of hazardous wastes. One technique is bulk disposal for liquid or slurry-type wastes. Another technique is stripping obsolete or surplus World War II cargo ships, loading the ships with obsolete munitions, towing them out to sea, and scuttling them at some designated spot. The third technique is the sinking at sea of containerized hazardous toxic wastes. The broad classes of hazardous wastes dumped at sea have been categorized as follows: industrial wastes; obsolete, surplus, and nonserviceable conventional explosive ordinance; chemical warfare wastes; and miscellaneous hazardous wastes.

Engineered storage: A potential system to be utilized for those hazardous wastes (especially radioactive) for which no adequate disposal methods exist. An engineered storage facility would have applicability until such time as a method for permanent disposal of these wastes is developed. A near-ground-surface engineered storage facility must provide safe storage of the solidified hazardous wastes for long periods of time and retrievability of the wastes at any time during this storage. The ultimate goal is to transfer these wastes to a permanent disposal site when a suitable site is found. This process is being proposed for the long-term storage of high-level radioactive wastes; some low-level radioactive wastes will probably also go into engineered storage facilities.

Detonation: A process of exploding a quantity of waste with sudden violence. Detonation can be performed by several means which include thermal shock, mechanical shock, electrostatic charge, or contact with incompatible materials. Detonation of a single waste may be followed by secondary explosions or fire. Detonation is most commonly applied to explosive waste materials. However, several flammable waste streams can also be detonated.

Appendix E

DECISION MAPS FOR ON-SITE VERSUS OFF-SITE TREATMENT AND DISPOSAL

When a hazardous waste generator elects to treat or dispose of his hazardous waste in an environmentally acceptable manner, he must make the important economic decision as to whether a particular waste stream should be processed on site or off site at some regional treatment facility. In order to make a sound business decision between these options, an industrial manager must consider a number of variables such as the following: the chemical composition of the particular waste stream, the on-site availability and unit cost of a satisfactory treatment process, the quantity of the waste stream, and the distance to and user charge of the nearest off-site processing facility.

To provide a general insight into the economics of this problem, information was compiled on eight commonly occurring industrial hazardous waste stream types, and a mathematical model was formulated. The mathematical model resulted in economic decision maps for each of the eight industrial waste categories (Figures 7 through 15). (Nine decision maps appear because two maps are included for heavy metal sludges.)

As a result of this analysis, it was concluded that economic considerations favor the off-site treatment and disposal of seven out of the eight waste stream types examined. Only in the case of dilute aqueous heavy metals (Figure 15) is the strategy of on-site treatment more economical.

The decision map for concentrated heavy metals (Figure 7) is typical. The following discussion will identify and interpret, point by point, those aspects of the map that are considered significant.

Point A on the map represents data collected for a sample of actual waste sources. This point is defined by the mean separation between sources (the average distance between some waste sources actually found within a particular region) and the mean source size (size as measured by waste stream volume). The position of Point A on the map shows whether the on-site or off-site treatment alternative is economically preferable. Here, Point A lies comfortably within the "off-site" region of the map; therefore, off-site treatment of wastes collected from multiple sources is the most logical choice.

The vertical lines corresponding to the smallest and largest sources in the sample are also shown for perspective. For each of the stream types, an attempt was made to include the largest single producer of the waste in the country.

Two other points on the map are of interest. Point B defines the separation between sources that would be required if on-site processing is to be feasible, assuming no change in the sample mean. For concentrated heavy metals, this change-of-strategy separation distance is 360 miles (580 kilometers) compared to the mean value of 81 miles (131 kilometers).

Point C defines the source size at which on-site processing becomes feasible for sources separated by the sample mean separation. For concentrated heavy metals, this size is 16 million gallons (61 million liters) per year, compared to the sample mean of 325,000 gallons (1.2 million liters) per year and a sample maximum of 950,000 gallons (3.6 million liters) per year. Clearly, off-site processing is preferable for concentrated heavy metal wastes. A mean volume concentrated heavy metal waste producer would have to be nearly 400 miles (640 kilometers) from any other similar waste producer before on-site treatment would become attractive.

An examination of the succeeding eight decision maps (Figures 8 through 15) makes it apparent that

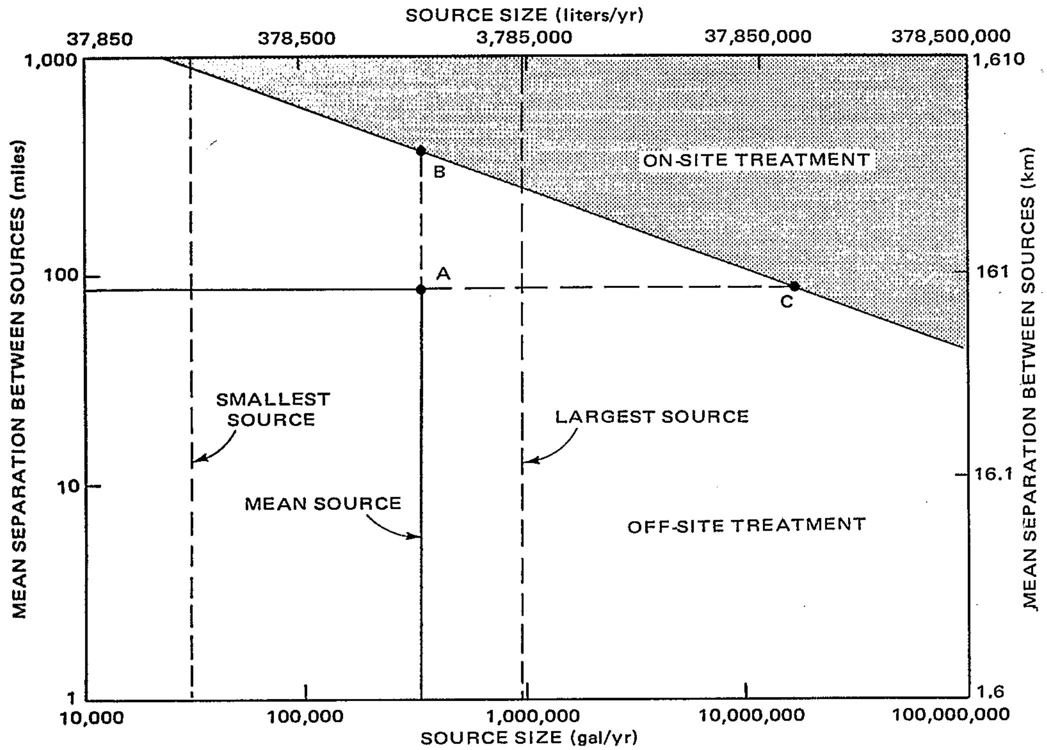

Figure 7. Concentrated heavy metals.

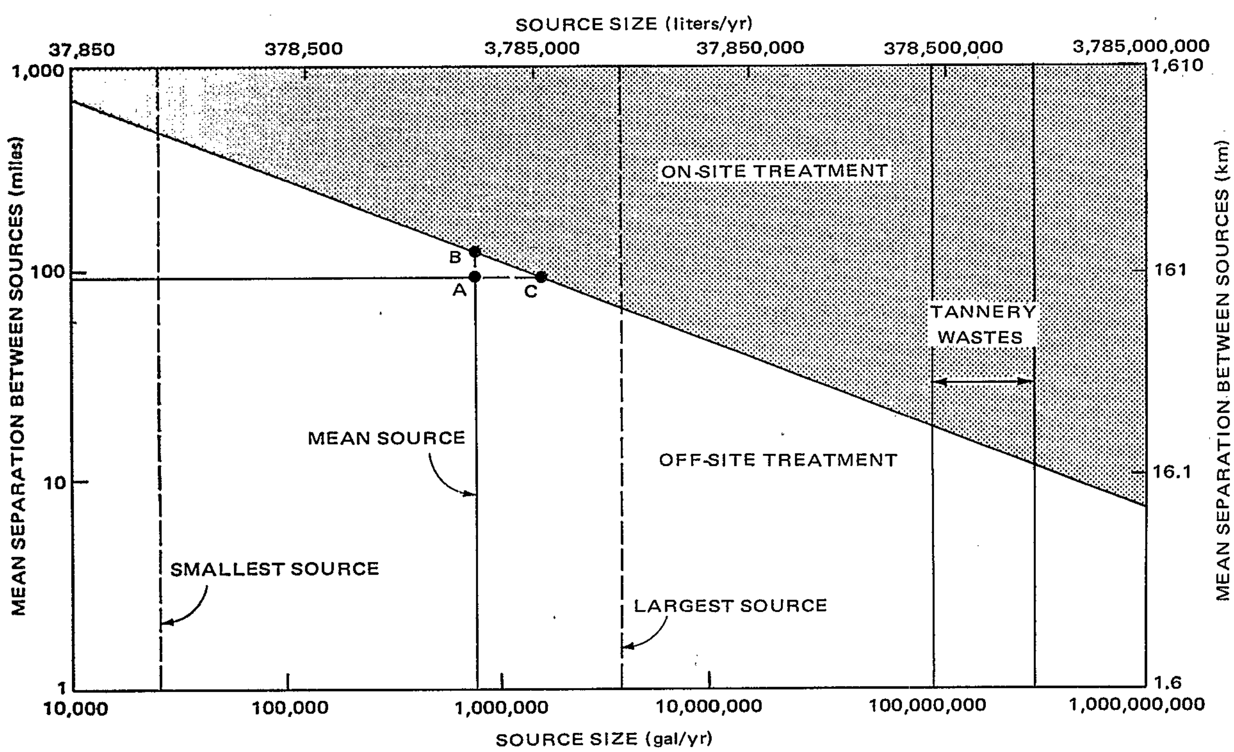

Figure 8. Dilute metals with organic contamination.

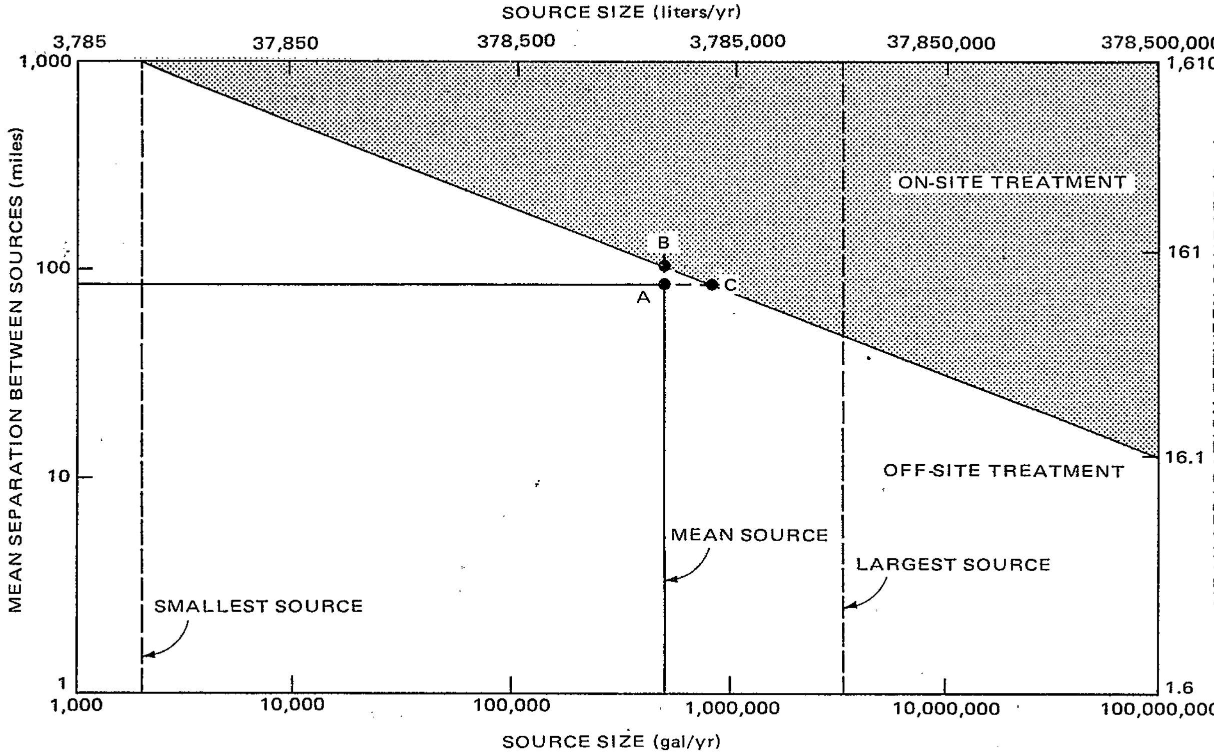

Figure 9. Asphalt encapsulation of heavy metal sludges.

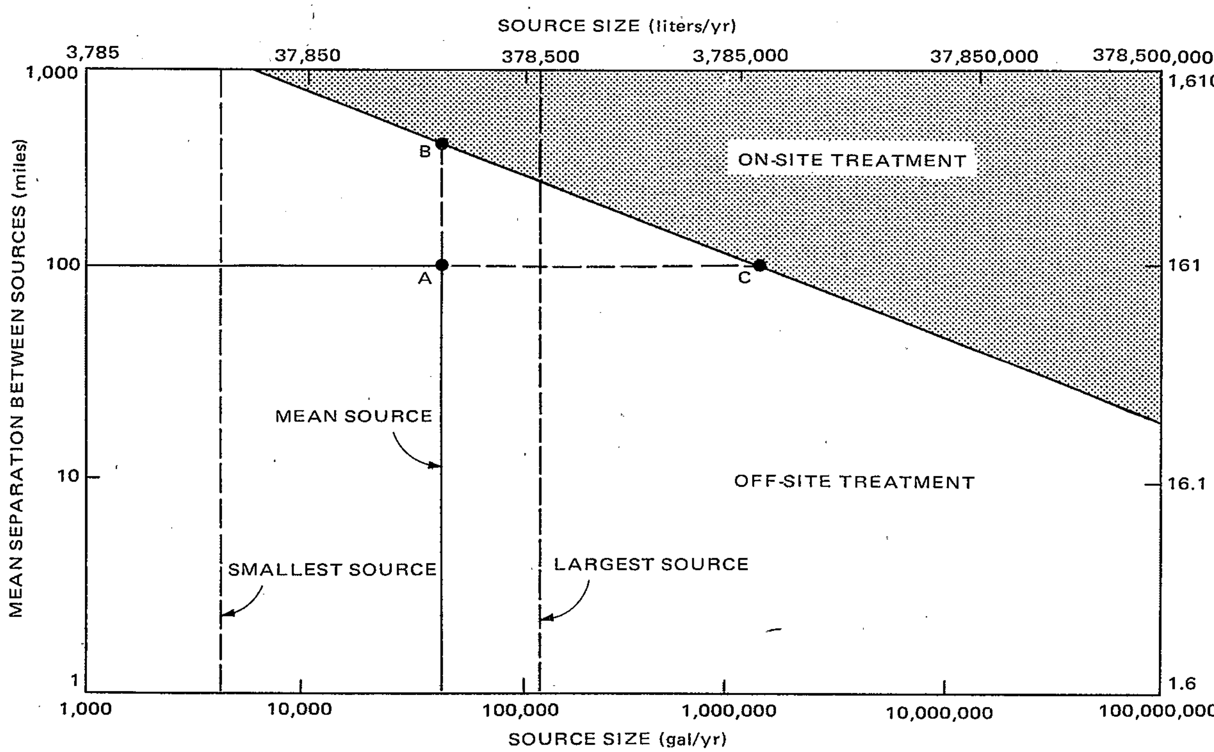

Figure 10. Cement encapsulation of heavy metal sludges.

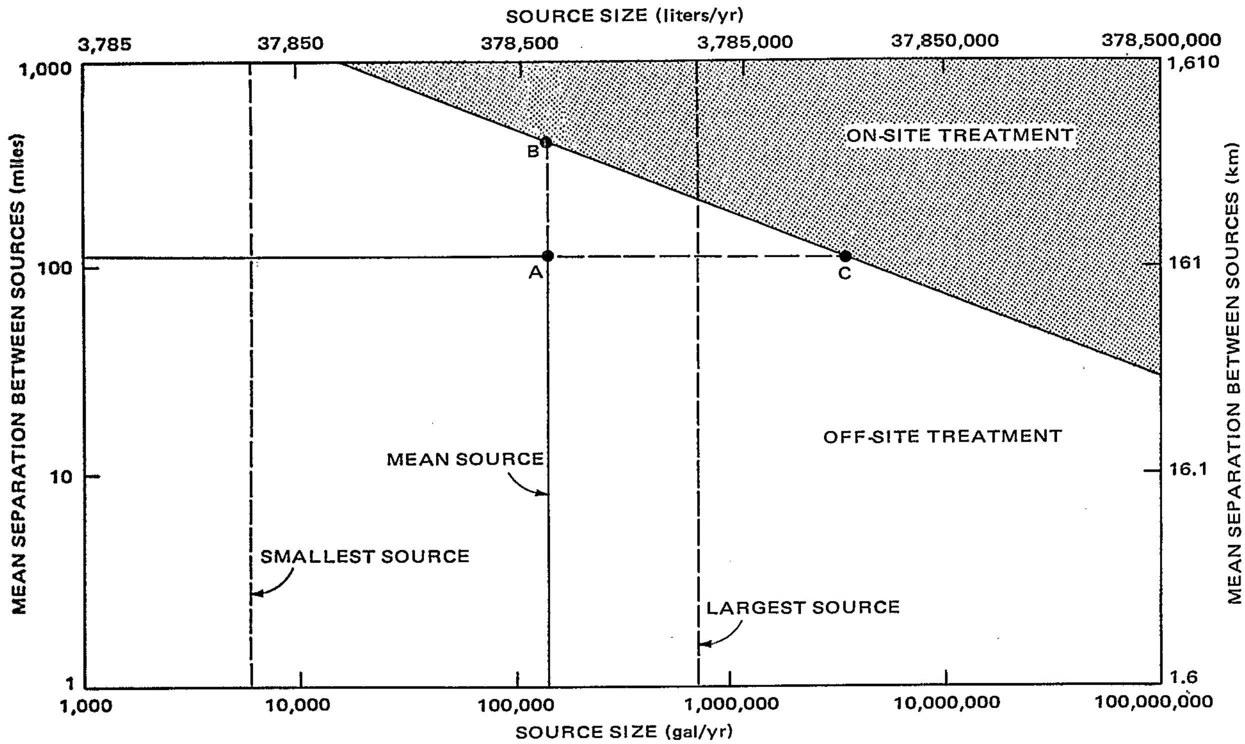

Figure 11. Concentrated cyanides.

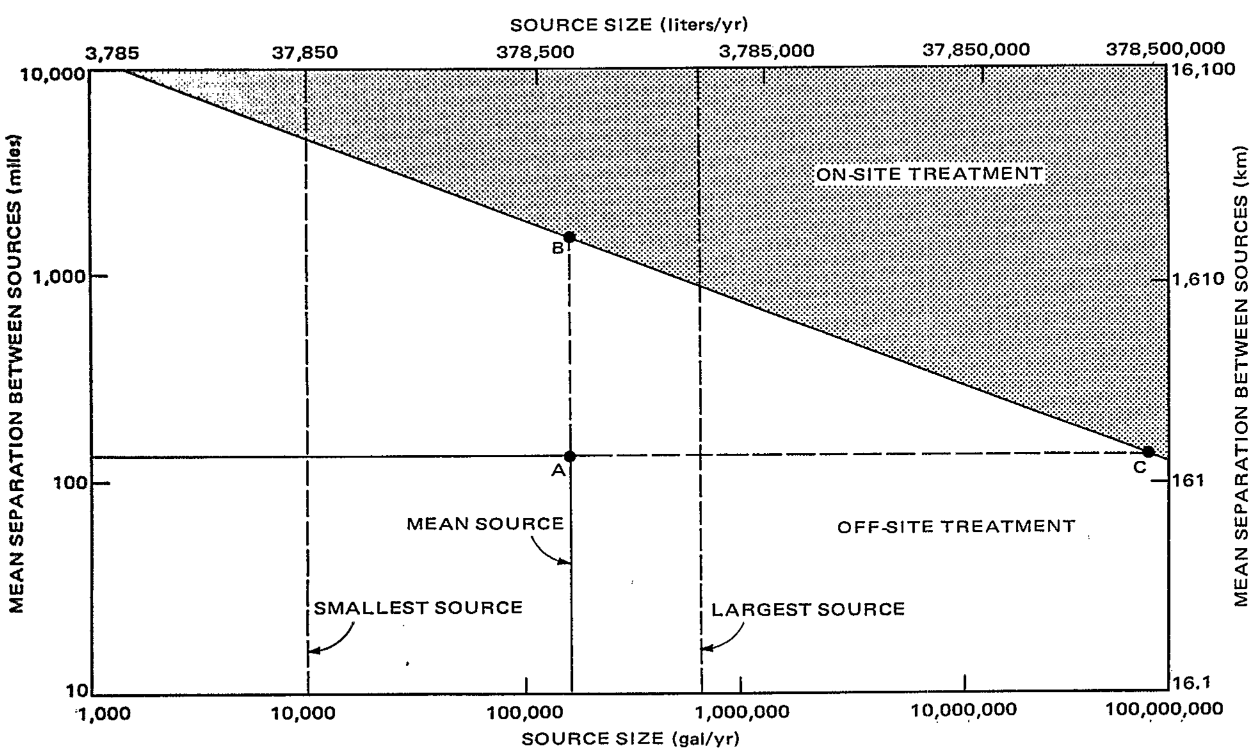

Figure 12. Liquid chlorinated hydrocarbons.

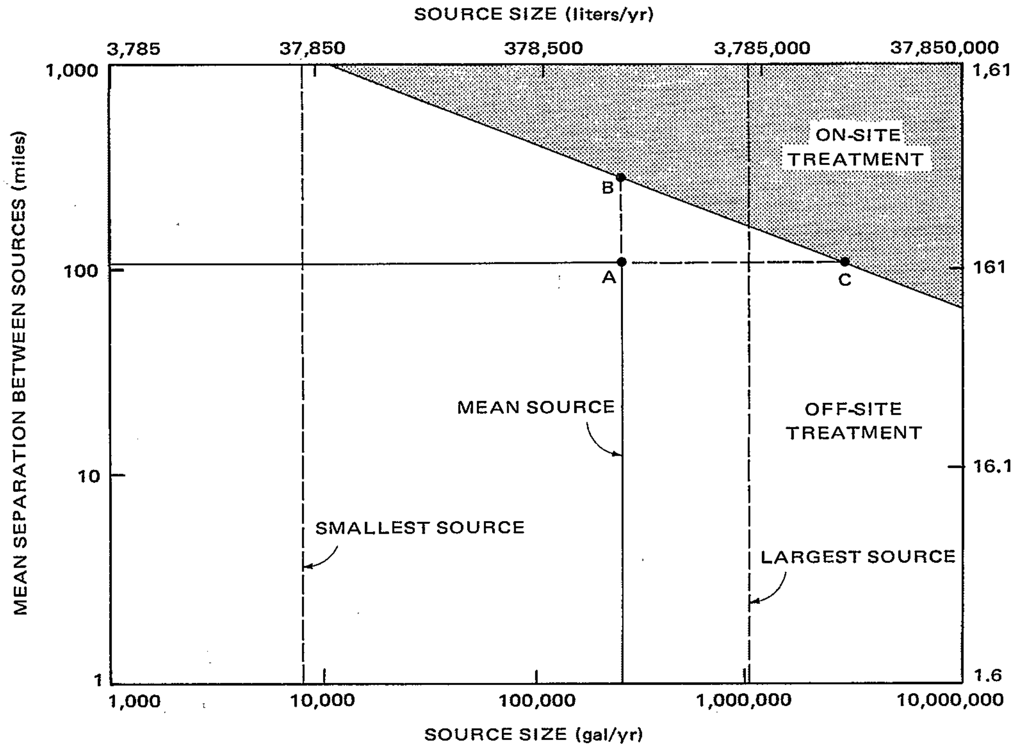

Figure 13. Dilute cyanides.

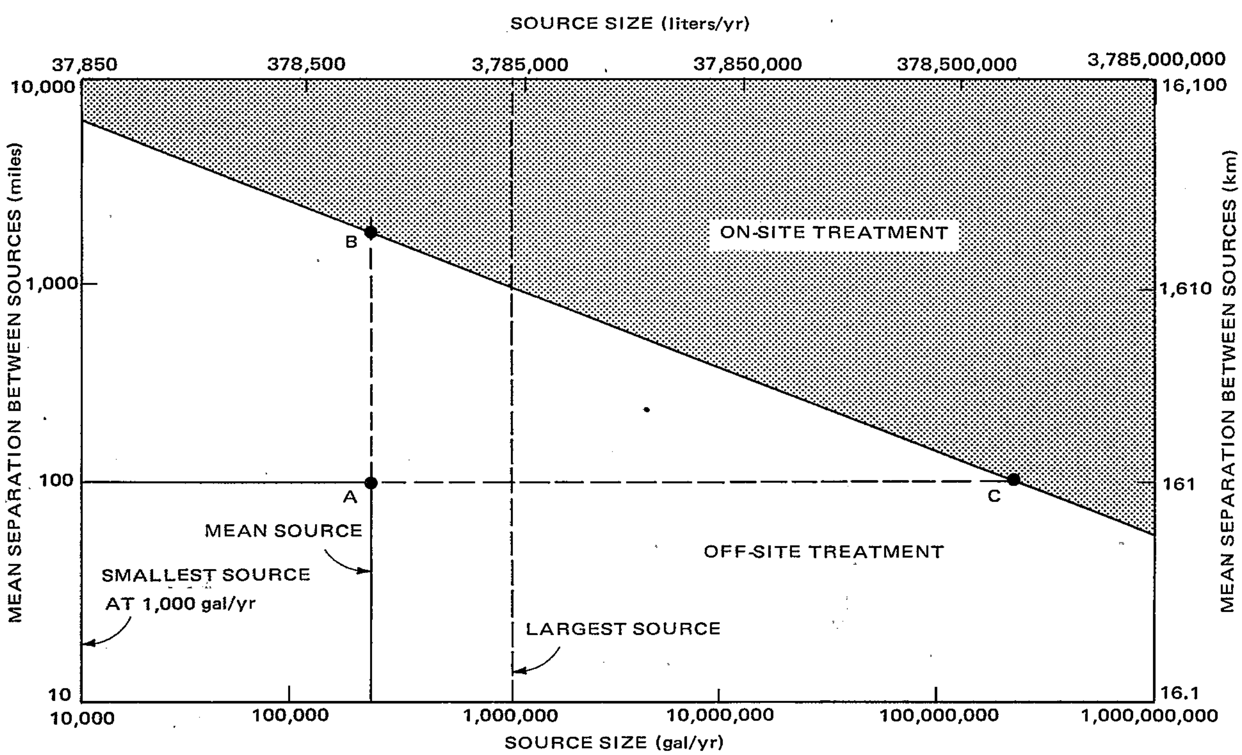

Figure 14. Chlorinated hydrocarbon and heavy metal slurries.

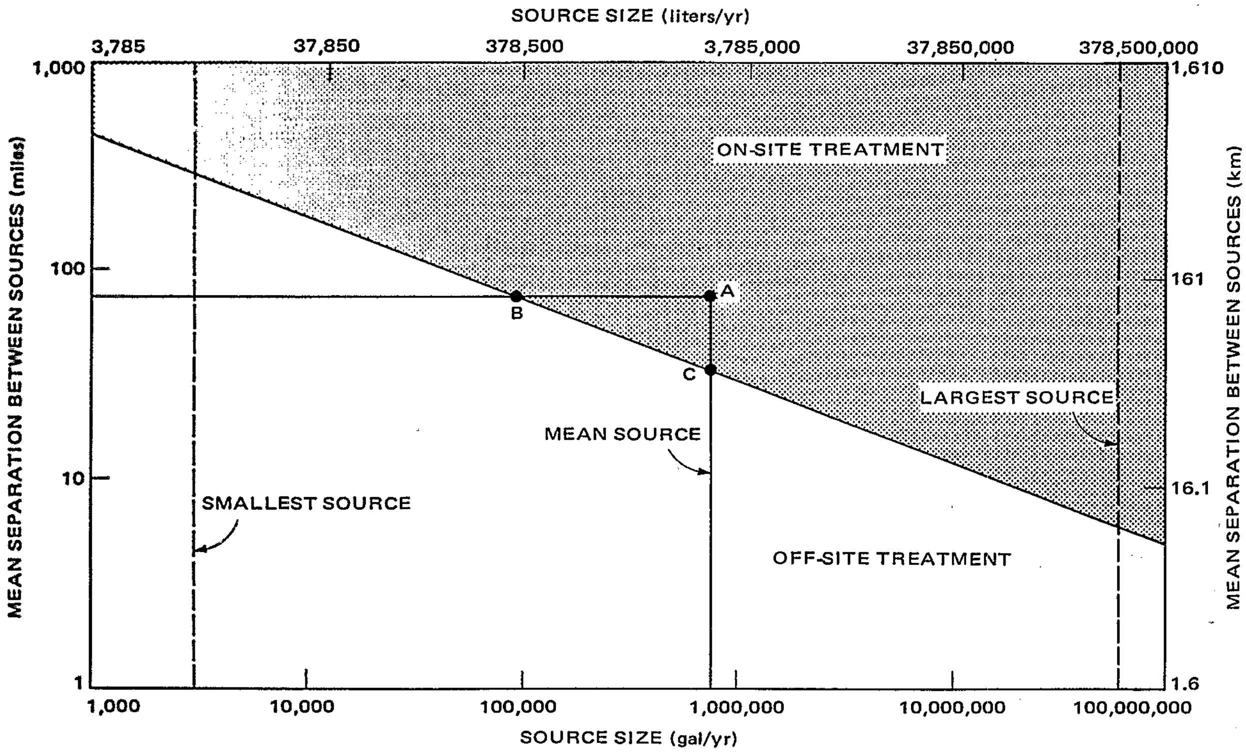

Figure 15. Dilute heavy metals.

each is different because each particular waste stream has its own cost characteristics as a result of different treatment and/or disposal requirements. Only in the case of dilute heavy metals (Figure 15) is the above-defined Point A within the "on-site" region of the map. Accordingly, the average generator of dilute heavy metal wastes would logically choose on-site treatment. Development of the model on which the decision maps are based was made in an earlier study.[31] Included among other important results of that particular study are discussions of location and spacing of regional treatment facilities.

Appendix F

SUMMARY OF THE HAZARDOUS WASTE NATIONAL DISPOSAL SITE CONCEPT

In the course of investigating the NDS concept for hazardous wastes as mandated by Section 212 of the Solid Waste Disposal Act (P.L. 89-272, amended by P.L. 91-512), important and relevant information was developed. Appendixes B and D, respectively, provide a list of hazardous wastes subject to treatment at such sites and summaries of current methods of treatment and disposal. This appendix summarizes the findings related to site selection, methods and processes that are likely to be used at a typical site, and costs for developing and maintaining such sites. An earlier study contains the detailed analyses performed and the rationale for this information.[1]

SITING OF HAZARDOUS WASTE TREATMENT AND DISPOSAL FACILITIES

The general approach to the site selection process was to first regionalize the conterminous United States into 41 multicounty regions (spheres of influence for major industrial waste production areas, which are closely related to hazardous waste production areas, served as the basis for regional delineation):

(1) Seattle, Tacoma, Everett, and Bellingham, Washington

(2) Portland, Oregon; Vancouver and Longview, Washington

(3) San Francisco Bay Area, California

(4) Ventura, Los Angeles, and Long Beach, California

(5) San Diego, California

(6) Phoenix, Arizona

(7) Salt Lake and Ogden, Utah

(8) Idaho Falls and Pocatello, Idaho

(9) Denver, Colorado

(10) Santa Fe and Albuquerque, New Mexico

(11) El Paso, Texas

(12) Fort Worth, Dallas, and Waco, Texas

(13) Austin, San Antonio, and Corpus Christi, Texas

(14) Houston, Beaumont, Port Arthur, Texas City, and Galveston, Texas

(15) Oklahoma City, Tulsa, and Bartlesville, Oklahoma

(16) Wichita, Topeka, and Kansas City, Kansas

(17) Omaha and Lincoln, Nebraska; Des Moines, Iowa

(18) Minneapolis, St. Paul, and Duluth, Minnesota

(19) Cedar Rapids, Michigan; Burlington and Dubuque, Iowa; Peoria, Illinois

(20) St. Louis, Missouri; Springfield, Illinois

(21) Memphis, Tennessee

(22) Shreveport, Baton Rouge, and New Orleans, Louisiana; Jackson, Mississippi

(23) Mobile and Montgomery, Alabama; Tallahassee, Florida; Biloxi and Gulfport, Mississippi; Columbus, Georgia

(24) Huntsville and Birmingham, Alabama; Atlanta and Macon, Georgia; Chattanooga and Nashville, Tennessee

(25) Louisville, Frankfort, and Lexington, Kentucky; Evansville, Indiana

(26) Albany, Troy, and Schenectady, New York

(27) Indianapolis, Indiana; Cincinnati and Dayton, Ohio

(28) Chicago and Kankakee, Illinois; Gary, South Bend, Hammond, and Fort Wayne, Indiana

(29) Midland, Saginaw, Grand Rapids, Detroit, Dearborn, and Flint, Michigan; Toledo, Ohio

(30) Columbus, Cleveland, Youngstown, and Akron, Ohio

(31) Pittsburgh, Johnstown, and Erie, Pennsylvania

(32) Charleston, West Virginia; Portsmouth and Norfolk, Virginia

(33) Charleston, South Carolina; Savannah and Augusta, Georgia

(34) Winston-Salem, Raleigh, Greensboro, and Charlotte, North Carolina

(35) Baltimore, Maryland

(36) Philadelphia, Allentown, and Harrisburg, Pennsylvania; Camden and Elizabeth, New Jersey; Wilmington, Delaware

(37) New York, New York; Newark and Paterson, New Jersey

(38) Buffalo, Rochester, Syracuse, and Watertown, New York

(39) Boston, Massachusetts

(40) Orlando, Tampa, and Miami, Florida

(41) Little Rock, Pine Bluff, and Hot Springs, Arkansas

Thirty-six waste treatment regions were identified, based upon the distance from the 41 major industrial waste production centers. These are shown in Figure 16. Distances of about 200 miles (322 kilometers) in the East and 250 miles (402 kilometers) in the West were selected as the maximum distances any treatment site should be from the industrial waste production centers in a given subregion. Some of the regions do not contain an industrial waste production center; however, their boundaries are defined by surrounding regions containing waste production centers. No region was generally permitted to cross any major physiographic barrier. Notably, the regions are smaller in the East than in the West.

Criteria for site selection were defined. The major emphasis was placed on health and safety and environmental considerations. It was recognized early that two general types of sites would need to be identified: waste processing plant sites and long-term hazardous waste disposal and storage sites. Site selection criteria and numerical weightings are presented in Table 12.

Based on the site selection criteria, a ranking, screening, and weighting procedure was developed and applied to all counties located in the 36 regions which cover the country. The county-size areal unit appeared to be of manageable size for the survey. The output lising of all 3,050 counties in the conterminous United States, grouped by regional ratings, is too voluminous for inclusion here.[1] This listing allows for the orderly and rational selection of counties within each region, for site-specific reconnaissance, and for later detailed field studies that would be required in order to prove out the feasibility of a candidate site. From the total list that rates and ranks all counties, 74 appear to be potentially the best areas for locating hazardous waste treatment and disposal sites. These are presented as follows by State:

State:	*County:*
Alabama	Sumter*
Arizona	Dallas
	Yuma
California	Fresno
	Inyo
	Kern*
	Ventura
Colorado	Weld
Connecticut	Hartford
Florida	Alachua
Georgia	Dooley*
Iowa	Howard
Illinois	Jasper
	Livingston*
	Ogle
	Vermilion
Indiana	Jackson
Kansas	Ellsworth
Kentucky	Franklin
Maryland	Carroll
Massachusetts	Franklin*
	Worcester
Michigan	Isabella*
	Shiawassee
Mississippi	Lincoln
Missouri	Audrain
Montana	Custer
Nebraska	Kearney
Nevada	Nye*
	Pershing
	Washoe
New Jersey	Sussex

*Potential site for large-size processing facility.

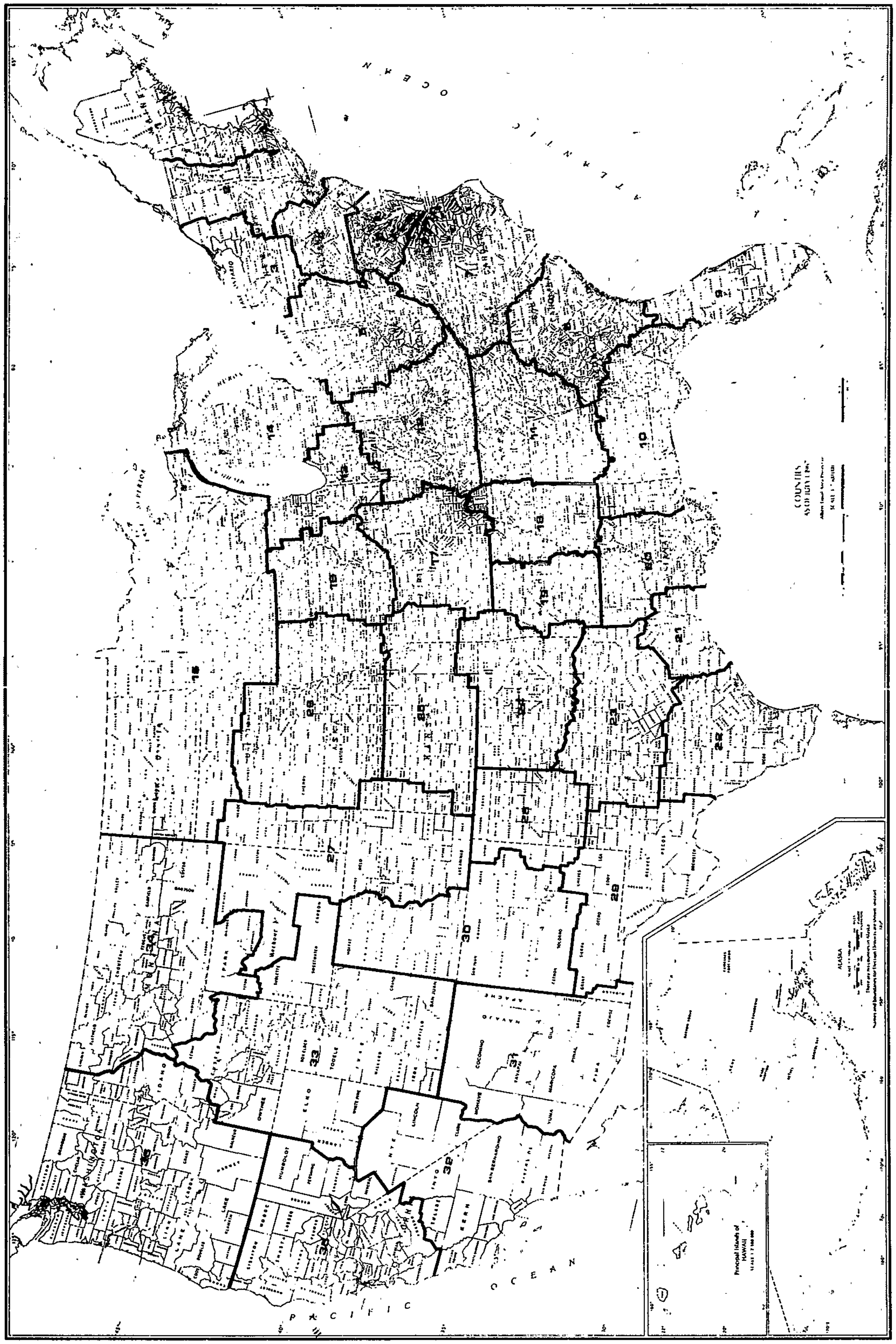

Figure 16. Site selection regions.

TABLE 12
SITE SELECTION CRITERIA

General criteria	Weighting
Earth sciences (geology, hydrology, soils, climatology)	31
Transportation (risk, economics)	28
Ecology (terrestrial life, aquatic life, birds and wildfowl)	18
Human environment and resources utilization (demography, resource utilization, public acceptance)	23
Total	100

New Mexico	Eddy
	Quay
	San Juan
New York	Albany
	Onondaga
	Otsego
	Steuben
	Wyoming
North Dakota	Grand Forks
Ohio	Carroll
	Darke
	Wayne
Oklahoma	Atoka
	Custer
	Kay
Oregon	Deschutes
Pennsylvania	Clinton
	Montgomery
	York*
South Carolina	Barnwell
	Greenwood
Tennessee	Gibson
	Montgomery
Texas	Bell
	Erath*
	Gillespie
	Grimes
	Harris*
	Haskell
	Kendall
	Polk
	Sutton
Utah	Tooele
Virginia	Brunswick
	Caroline
	Fluvana
	Pittsylvania
Washington	Benton
	Lincoln
West Virginia	Doddridge
Wyoming	Campbell
	Laramie

*Potential site for large-size processing facility.

In addition, the following are the existing or potential Federal and State hazardous waste treatment and disposal sites:

Existing sites operated by AEC:

- Fernald, Butler/Hamilton Counties, Ohio
- Hanford Works, Benton County, Washington
- Los Alamos Scientific Laboratory, Los Alamos County, New Mexico
- National Reactor Testing Station, Bingham County, Idaho
- Nevada Test Site, Nye County, Nevada
- Oak Ridge, Anderson County, Tennessee
- Pantex Plant, Randall County, Texas
- Rocky Flats Plant, Jefferson County, Colorado
- Savannah River Plant, Aiken County, South Carolina

Existing sites operated by DOD:

- Anniston Army Depot, Alabama
- Edgewood Arsenal, Maryland
- Lexington Bluegrass Army Depot, Kentucky
- Newport Army Ammunition Plant, Indiana
- Pine Bluff Arsenal, Arkansas
- Pueblo Army Depot, Colorado
- Rocky Mountain Arsenal, Colorado
- Tooele Army Depot, Utah
- Umatilla Army Depot, Oregon

State-licensed radioactive waste sites:*

- Barnwell, South Carolina
- Beatty, Nevada
- Hanford Works, Washington
- Morehead, Kentucky
- West Valley, New York

*The Sheffield, Illinois, site is directly licensed through AEC but is not operated by AEC.

Data on the Beatty, Nevada; Hanford, Washington; and Morehead, Kentucky, sites are presented in Tables 13 to 15.

It should be noted that the suitability of a particular candidate site can only be determined by additional field studies, field testing, and technical analyses of the data.

HAZARDOUS WASTE MANAGEMENT METHODS AND COSTS

The approach used in this phase of the study involved development of a model facility capable of processing a wide variety of hazardous wastes (excluding radioactive wastes or chemical warfare agents generated or stored at AEC or DOD installations). Conceptual design and cost estimates were prepared for a complete waste management system to process and dispose of the wastes. In addition to treatment and disposal, peripheral functions such as transportation, storage, and environmental monitoring were also considered.

The basic objective of waste treatment at a hazardous waste processing facility is the conversion of hazardous substances to forms that are acceptable for disposal or reuse. Since the majority of hazardous waste streams are complex mixtures containing several chemical species, treatment for removal and/or conversion of certain nonhazardous substances from the waste stream will also be required in order to comply with pollution control regulations. In a number of instances, treatment for the nonhazardous substances will dictate the type of process used and will entail the most significant operational costs (e.g., acid neutralization).

Broad treatment capability in a central processing facility will permit the processing of many nonhazardous wastes which could give the facility the advantage of economy of scale. In order to maintain a competitive position in the waste processing field in the case of a privately operated facility, it is anticipated that all wastes which can be processed with some return on investment will be accepted. It is possible that the volume of nonhazardous wastes will exceed the volume of hazardous wastes, perhaps by wide margins, in many areas. Inclusion of non-

TABLE 13
REPRESENTATIVE COMMERCIAL RADIOACTIVE WASTE BURIAL SITE CHARACTERISTICS: BEATTY, NEVADA, SITE

Ownership	State of Nevada, leased to the Nuclear Engineering Company, Inc.
Population density in area	Virtually uninhabited
Distance from nearest town	About 12 miles (19 kilometers) southeast of Beatty
Area:	
Site	80 acres (32 hectares)
Controlled land	No land controlled—desert
Communications	Good; U.S. highway 95
Precipitation	2.5-5.0 inches (6.35-12.7 centimeters) per year
Drainage	Adequate
Bedrock:	
Depth	Estimated to be 575+ feet (175+ meters)
Type	Sedimentary and metamorphic
Surficial material:	
Depth	575 feet (175 meters)
Type	Alluvial clay, sand, etc.
Groundwater:	
Depth	275-300 feet (84-92 meters)
Slope	Southeast, approximately 30 feet per mile (5.67 meters per kilometer)
Land and water use downstream	Very little, desert conditions
General soil characteristics	Semiarid desert; deep soil
Monitoring instruments and devices	14 survey instruments, film, air monitors, etc.
Trenches:	
Dimensions	650 by 50 by 20 feet (198 by 15.2 by 6.1 meters)
Design	Standard, drain to sump; 4-foot (1.2-meter) backfill; no water collected
Waste handling:	
Transportation	By company
Machinery	Tank truck, trailer trucks, bulldozer, 35-ton crane
Processing	Liquids solidified
Burial	Special nuclear materials spaced at bottom; slit trench for high-activity materials

TABLE 14

REPRESENTATIVE COMMERCIAL RADIOACTIVE WASTE BURIAL SITE CHARACTERISTICS: HANFORD, WASHINGTON, SITE

Ownership	State of Washington, leased to the Nuclear Engineering Company, Inc.
Population density in area	No resident population
Distance from nearest town	25 miles (40 meters) north of Richland
Area:	
Site	100 acres (40 hectares)
Controlled land	1,000 acres (405 hectares) State owned
Communications	Good; AEC Hanford reservation
Precipitation	6-8 inches (15-20 centimeters) per year
Drainage	Well drained
Bedrock:	
Depth	Estimated to be 250-450 feet (76-137 meters)
Type	Basalt
Surficial material:	
Depth	150-350 feet (47-107 meters)
Type	Silty sand, gravel, clay
Groundwater:	
Depth	240 feet (73 meters)
Slope	North and east, approximately 15-35 feet per mile (2.8-6.6 meters per kilometer)
Land and water use downstream	Columbia River—all uses
General soil characteristics	Little precipitation; deep, dry soil
Monitoring instruments and devices	Survey instruments, film, counters
Trenches:	
Dimensions	300 by 60 by 25 feet (92 by 18 by 7.6 meters)
Design	Standard; no water collects in sump
Waste handling:	
Transportation	By company
Machinery	Crane, shovel, bulldozer, forklifts, etc.
Processing	Liquids solidified
Burial	Special nuclear materials spaced; separate trench for ion-exchange resins

hazardous waste processing also increases the opportunities for resource recovery (e.g., recovery of metals, oils, and solvents).

It must be emphasized that the model facility developed in this study was primarily designed for processing hazardous wastes. Therefore, processing facilities designed for both hazardous wastes and nonhazardous wastes may be different in many respects. A number of factors will dictate individual design variations for a given facility. Foremost will be the volumes and types of wastes, both hazardous and nonhazardous, that will be received for processing. One facility may require many different processes whereas another may require only one. Furthermore, processes selected for the model facility are not intended to be all inclusive. A wide variety of processes, in addition to those selected for the model facility, is available to meet the needs of a particular location.

DESCRIPTION OF MODEL FACILITIES

Hazardous Waste Processing Facility

The model hazardous waste processing facility incorporates the various functions related to waste treatment and disposal at one central location. The facility is basically a chemical processing plant that has design features for safe operation in a normal industrial area. Effluents discharged from the facility will be limited to those that meet applicable water and air standards. Local solid waste disposal will be limited to nonhazardous wastes that are acceptable for burial at a conventional landfill. The conventional landfill may be located adjacent to the processing facility or a short distance away. In general, nonhazardous waste brines resulting from hazardous waste treatment will be disposed of by ocean dumping where appropriate to avoid potential quality impairment of fresh water sources. Land disposal of

TABLE 15

REPRESENTATIVE COMMERCIAL RADIOACTIVE WASTE BURIAL SITE CHARACTERISTICS: MOREHEAD, KENTUCKY, SITE

Ownership	State of Kentucky, leased to the Nuclear Engineering Company, Inc.
Population density in area	Sparse (rural—Maxey Flats)
Distance from nearest town	10 miles (16 kilometers) northwest of Morehead
Area:	
Site	200 acres (81 hectares)
Controlled land	1,000 acres (405 hectares)
Communications	Fair; State highway runs north and south
Precipitation	46 inches (117 centimeters) per year (heavy storms)
Drainage	Well drained
Bedrock:	
Depth	Estimated to be 50-75 feet (15-23 meters)
Type	Shale, sandstone, siltstone
Surficial material:	
Depth	Estimated to be 50-75 feet (15-23 meters)
Type	Shale, clay, siltstone
Groundwater:	
Depth	35-50 feet (11-15 meters) ["perched" 2-6 feet (0.61-1.83 meters)]
Slope	Erratic
Land and water use downstream	Very little nearby; no data exist at great distances
General soil characteristics	Very impermeable; good soil sorption
Monitoring instruments and devices	14 survey instruments, film, air monitors, etc.
Trenches:	
Dimensions	300 by 50 by 20 feet (92 by 15 by 6.1 meters)
Design	Standard, sump; water is pumped
Waste handling:	
Transportation	By company
Machinery	Crane, bulldozer, forklifts, etc.
Processing	Liquids solidified
Burial	Performed according to the *Radiation Safety Plan* developed by the Nuclear Engineering Company, Inc.

these brines is a potential alternative method that is less desirable and that will be used only in arid regions, and even there infrequently. All such disposal operations will be in accordance with applicable local, State, and Federal standards.

In order to accomplish treatment and disposal objectives, the facility will also contain equipment and structures necessary for transporting, receiving, and storing both wastes and raw material. Another important feature will be a laboratory which provides analytical services for process control and monitoring of effluent and environmental samples and pilot scale testing services to assure satisfactory operation of the processing plant. The latter normally is not required in a conventional chemical processing plant, but because of the highly variable nature of the waste feed in this case, pilot scale testing is considered essential.

Hazardous Waste Disposal Facility

For purposes of the model, the hazardous waste disposal facility will consist of a secure landfill and the appropriate equipment and structures necessary to carry out burial and surveillance of the hazardous solid wastes. Special measures are to be taken during backfilling to minimize water infiltration. It is possible that low-level radioactive burial sites currently used in arid regions of the Western United States could also be used, with appropriate segregation, for disposal of the hazardous solid wastes.

Process Selection

Conceptual design objectives for the model facility included broad treatment capability to permit processing of all hazardous wastes of significant volume generated across the country. Important process selection criteria include demonstrated applicability to the treatment and disposal of existing hazardous wastes and flexibility to handle a wide variety of different waste streams.

The objectives of waste processing at the model facility are the removal of hazardous and polluting substances and/or conversion of these substances to forms that are acceptable for disposal or reuse. From the hazardous waste identification portion of this study described in Section 2 and in Appendix B, it was determined that in order to accomplish these objectives the model facility should include treatment processes for neutralization of acids and bases, oxidation of cyanides and other reductants, reduction of chromium-6 and other oxidants, removal of heavy metals, separation of solids from liquids, removal of organics, incineration of combustible wastes, removal of ammonia, and concentration of waste brines.

Treatment processes selected for inclusion in the model facility were neutralization, precipitation, oxidation and reduction, flocculation and sedimentation, filtration, ammonia stripping, carbon sorption, incineration, and evaporation. Disposal processes selected were ocean dumping and landfill. (Appendix D describes the major characteristics of these processes.) A conceptual flow diagram, which integrates the various treatment steps in modular form, was developed for the model hazardous waste facility (Figure 17). The flow pattern represents that normally expected and provides for additional piping to permit alterations when necessary.

Cost Estimates

Design capacities, capital, and operating costs for typical small-, medium-, and large-size processing facilities are summarized in Table 16. The costs include estimates for land, buildings, laboratory offices, and auxiliary equipment. It should be noted that these cost data are based on preliminary estimates which have been developed from a number of basic assumptions, and are only intended to indicate the norm of a range of costs. The following list identifies in sequence those basic assumptions that have been utilized to arrive at the number, fixed capital, and operating costs of large, medium, and small hazardous waste treatment and disposal facilities.

(1) All hazardous wastes will be treated and disposed of in an environmentally acceptable manner.

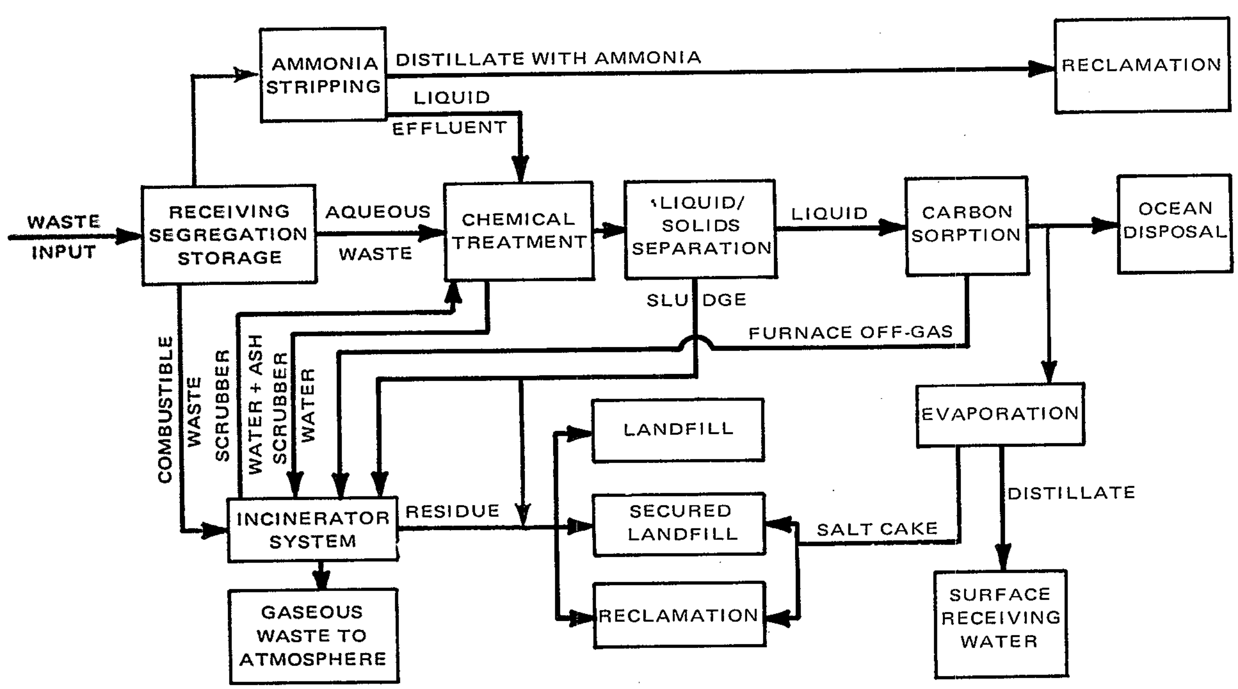

Figure 17. Conceptual modular flow diagram.

TABLE 16

PRELIMINARY MODULAR CAPITAL AND OPERATING* COST ESTIMATE SUMMARY FOR SMALL-, MEDIUM-, AND LARGE-SIZE PROCESSING FACILITIES

Module	Fixed capital cost (dollars)	Daily operating cost (dollars)	Average cost per 1,000 gallons† (dollars)	Average cost per ton (dollars)
Small-size facility:				
Aqueous waste treatment:‡				
Receiving and storage	1,262,000	1,881	66.20	
Ammonia stripping	298,700	461	18.40	
Chemical treatment	1,827,300	§3,298	150.50	
Liquid/solids separation	3,460,000	§3,888	¶80.10	
Carbon sorption	363,000	§758	17.50	
Evaporation	198,000	§635	14.60	
Rounded totals	7,410,000	10,900	347.00	
Incineration:**				
Incinerator	1,880,000	3,200		213.00
Scrubber wastewater treatment††	—	—		185.00
Rounded total				398.00
Medium-size facility:				
Aqueous waste treatment:‡‡				
Receiving and storage	3,270,000	6,424	46.40	
Ammonia stripping	773,800	952	7.80	
Chemical treatment	4,734,000	§11,307	84.70	
Liquid/solids separation	8,963,700	§9,516	¶39.60	
Carbon sorption	941,000	§1,578	7.40	
Evaporation	514,000	§2,173	10.20	
Rounded totals	19,200,000	32,000	196.00	
Incineration:§§				
Incinerator	4,873,000	7,000		94.60
Scrubber wastewater treatment¶¶	—	—		80.60
Rounded total				175.00
Large-size facility:				
Aqueous waste treatment:***				
Receiving and storage	11,543,000	38,150	33.60	
Ammonia stripping	2,731,500	3,180	3.18	
Chemical treatment	16,710,600	§60,630	53.83	
Liquid/solids separation	30,915,700	§34,687	¶17.18	
Carbon sorption	3,322,000	§6,290	3.62	
Evaporation	3,413,000	§15,947	9.16	
Rounded totals	68,600,000	159,000	121.00	
Incineration:†††				
Incinerator	17,201,700	27,374		45.10
Scrubber wastewater treatment‡‡‡	—	—		55.70
Rounded total				101.00

*Operation 260 days per year.
†3,785 liters.
‡Capacity: 25,000 gallons (94,600 liters) per day.
§Includes processing cost for incinerator scrubber wastewater.
¶Excludes processing cost for clarifying incinerator scrubber wastewater.
**Capacity: 15 tons (13.6 metric tons) per day.
††Capacity: 18,450 gallons (70,000 liters) per day.
‡‡Capacity: 122,000 gallons (462,000 liters) per day.
§§Capacity: 74 tons (67 metric tons) per day.
¶¶Capacity: 90,000 gallons (341,000 liters) per day.
***Capacity: 1,000,000 gallons (3,785,300 liters) per day.
†††Capacity: 607 tons (550 metric tons) per day.
‡‡‡Capacity: 738,000 gallons (2,800,000 liters) per day.

(2) All hazardous wastes will be treated prior to being disposed of at designated sites to minimize hazard and volume of wastes deposited on land.

(3) Treatment and disposal facilities will be dedicated to hazardous wastes. Treatment facilities should have those capabilities indicated in Table 16.

(4) Certain types and quantities of hazardous wastes will be treated on site (at the source) and others at off-site facilities. [The estimated total amount of hazardous wastes to be treated and disposed of is 1.0×10^7 tons (9×10^6 metric tons) per year. Approximately 4.0×10^6 tons (3.6×10^6 metric tons) are inorganic and 6.0×10^6 tons (5.4×10^6 metric tons) are organic.[1]]

(5) EPA economic studies indicate that on-site treatment facilities will be small plants treating primarily dilute aqueous acidic toxic metal wastes, which constitute approximately 15 percent by weight of all hazardous wastes. Small on-site facilities will be capable of neutralizing wastes and precipitating toxic metals from the wastes, but will produce a toxic residue which will require further treatment at off-site facilities. Small facilities will have a capacity of 2.94×10^4 tons (2.6×10^4 metric tons) per year. Approximately 51 small on-site facilities will be required to treat the estimated 1.5×10^6 tons (1.36×10^6 metric tons) per year. Approximately one-third of wastes treated on site [5×10^5 tons (4.5×10^5 metric tons) per year] will be shipped to off-site facilities for further treatment.

(6) To achieve economies of scale, off-site treatment facilities will be large- or medium-size treatment plants. Approximately 9.0×10^6 tons (8.2×10^6 metric tons) per year will be processed at off-site facilities. Large facilities will have a capacity of 1.33×10^6 tons (1.2×10^6 metric tons) per year, and

TABLE 17
CAPACITIES AND COSTS OF HAZARDOUS WASTE TREATMENT FACILITIES ASSUMED IN HAZARDOUS WASTE MANAGEMENT SYSTEM SCENARIO

Item	Off site			On site small facility
	Large facility	Medium facility	Small facility	
Capacity:				
Aqueous waste processing:				
Gallons per day	1,000,000	122,000	25,000	25,000
Liters per day	3,800,000	462,000	95,000	95,000
Tons per day (9 pounds per gallon)	4,500	550	113	113
Metric tons per day (9 pounds per gallon)	4,080	498	102	102
Combustible waste processing:				
Tons per day	607	74	15	—
Metric tons per day	550	67	14	—
Total processing:				
Tons per day	5,107	624	128	113
Metric tons per day	4,627	565	116	102
Tons per year	1,330,000	162,000	33,300	29,400
Metric tons per year*	1,210,000	147,000	30,200	26,600
Cost:				
Fixed capital (dollars)	86,000,000	24,100,000	9,300,000	1,400,000
Operating:				
Dollars per day	186,400	39,000	14,100	2,265
Dollars per year†	48,500,000	10,130,000	3,660,000	589,000
With capital writeoff‡ (dollars per year)	57,100,000	12,540,000	4,590,000	729,000
Approximate number of facilities required§	5	15	—	51
Total fixed capital costs (million dollars)¶	430	362	—	71
Total operating costs (million dollars per year)**	286	188	—	37

*Assuming actual plant operation of 260 days per year.
†Includes neutralization chemicals, labor, utilities, maintenance, amortization charges (at 7 percent interest), insurance, taxes, and administrative expenses.
‡10-year straight line depreciation.
§Based on data from EPA Contract No. 68-01-0762 and EPA system variation analysis.
¶Total off site and on site, $863 million.
**With capital writeoff; total off site and on site, $511 million per year.

medium facilities a capacity of 1.62×10^5 tons (1.47×10^5 metric tons) per year. System variation studies indicate that the configuration combining least cost and adequate geographical distribution consists of 5 large- and 15 medium-size facilities. Therefore, large off-site treatment facilities will process approximately 6.5×10^6 tons (6.0×10^6 metric tons) per year and medium facilities will process approximately 2.5×10^6 tons (2.27×10^6 metric tons) per year.

(7) Current treatment technology does not allow complete neutralization/detoxification of all hazardous wastes. It is estimated that treatment residues constituting 2.5 percent of the incoming waste [225,000 tons (200,000 metric tons) per year] will still be hazardous.[1] Hazardous residues resulting from treatment facilities will be disposed of in secure land disposal sites. The most convenient location for secure land disposal sites is in association with the large treatment facilities. Therefore, five large secure disposal sites would initially be required. Hazardous wastes generated at other off-site treatment facilities would also be disposed of at these sites.

This information was then utilized to develop the configuration for the scenario of a hazardous waste management system cited in Section 4.

A more detailed comparative cost analysis that identifies and summarizes capacities, fixed capital, and operating costs associated specifically with treatment facilities has been developed in Table 17. These data were utilized in developing the cost aspects of the system scenario.

Appendix G

PROPOSED

Hazardous Waste Management Act of 1973

93d Congress, 1st Session

IN THE U.S. SENATE
Bill S. 1086
Introduced by Senator Baker
March 6, 1973
Referred to Committee on Public Works

IN THE U.S. HOUSE OF REPRESENTATIVES
Bill H.R. 4873
Introduced by Representative Staggers
for himself
and Representative Devine
February 27, 1973
Referred to Committee
on Interstate and Foreign Commerce

A BILL

To assure protection of public health and other living organisms from the adverse impact of the disposal of hazardous wastes, to authorize a research program with respect to hazardous waste disposal, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. This Act may be cited as the "Hazardous Waste Management Act of 1973".

FINDINGS AND PURPOSE

SEC. 2. (a) The Congress finds—

(1) that continuing technological progress, improvement in the methods of manufacture, and abate-

ment of air and water pollution has resulted in an ever-mounting increase of hazardous wastes;

(2) that improper land disposal and other management practices of solid, liquid, and semisolid hazardous wastes which are a part of interstate commerce are resulting in adverse impact on health and other living organisms;

(3) that the knowledge and technology necessary for alleviating adverse health, environmental, and esthetic impacts associated with current waste management and disposal practices are generally available at costs within the financial capacity of those who generate such wastes, even though this knowledge and technology are not widely utilized;

(4) that private industry has demonstrated its capacity and willingness to develop, finance, construct, and operate facilities and to perform other activities for the adequate disposal of hazardous and other waste materials;

(5) that while the collection and disposal of wastes should continue to be a responsibility of private individuals and organizations and the concern of State, regional, and local agencies, the problems of hazardous waste disposal as set forth above and as an intrinsic part of

interstate commerce have become a matter national in scope and in concern, and necessitate Federal action through regulation of the treatment and the disposal of the most hazardous of these wastes, and through technical and other assistance in the application of new and improved methods and processes to provide for proper waste disposal practices and reductions in the amount of waste and unsalvageable materials.

(b) The purposes of this Act therefore are—

(1) to protect public health and other living organisms through Federal regulation in the treatment and disposal of certain hazardous wastes;

(2) to provide for the promulgation of Federal guidelines for State regulation of the treatment and disposal of hazardous wastes not subject to Federal regulation;

(3) to provide technical and other assistance to public and private institutions in the application of efficient and effective waste management systems;

(4) to promote a national research program relating to the health and other effects of hazardous wastes and the prevention of adverse impacts relating to health and other living organisms.

DEFINITIONS

SEC. 3. When used in this Act:

(1) The term "Administrator" means the Administrator of the Environmental Protection Agency.

(2) The term "State" means a State, the District of Columbia, and the Commonwealth of Puerto Rico.

(3) The term "waste" means useless, unwanted, or discarded solid, semisolid or liquid materials.

(4) The term "hazardous waste" means any waste or combination of wastes which pose a substantial present or potential hazard to human health or living organisms because such wastes are nondegradable or persistent in nature or because they can be biologically magnified, or because they can be lethal, or because they may otherwise cause or tend to cause detrimental cumulative effects.

(5) The term "secondary material" means a material that is or can be utilized in place of a primary or raw material in manufacturing a product.

(6) The term "generation" means the act or process of producing waste materials.

(7) The term "storage" means the interim containment of waste after generation and prior to ultimate disposal. Containment for more than two years shall be considered disposal.

(8) The term "transport" means the movement of

wastes from the point of generation to any intermediate transfer points, and finally to the point of ultimate disposal.

(9) The term "treatment" means any activity or processing designed to change the physical form or chemical composition of waste so as to render such materials nonhazardous.

(10) The term "disposal of waste" means the discharge, deposit, or injection into subsurface strata or excavations or the ultimate disposition onto the land of any waste.

(11) The term "disposal site" means the location where any final deposition of waste materials occurs.

(12) The term "treatment facility" means a location at which waste is subjected to treatment and may include a facility where waste has been generated.

(13) The term "person" means any individual, partnership, copartnership, firm, company, corporation, association, joint stock company, trust, State, municipality, or any legal representative agent or assigns.

(14) The term "municipality" means a city, town, borough, county, parish, district, or other public body created by or pursuant to State law with responsibility for the planning or administration of waste management, or an Indian tribe or an authorized Indian tribal organization.

(15) The term "waste management" means the systematic control of the generation, storage, transport, treatment, recycling, recovery, or disposal of waste materials.

STANDARDS AND GUIDELINES FOR STATE REGULATION

SEC. 4. (a) Within eighteen months after the date of enactment of this Act, and from time to time thereafter, the Administrator pursuant to this section and after consultation with representatives of appropriate Federal agencies shall by regulation—

(1) identify hazardous wastes;

(2) establish standards for treatment and disposal of such wastes; and

(3) establish guidelines for State programs for implementing such standards.

(b) In identifying a waste as hazardous, pursuant to this section, the Administrator shall specify quantity, concentration, and the physical, chemical, or biological properties of such waste, taking into account means of disposal, disposal sites, and available disposal practices.

(c) The standards established under this section shall include minimum standards of performance required to protect human health and other living organisms and minimum acceptable criteria as to characteristics and conditions of disposal sites and operating methods, techniques, and practices of hazardous wastes disposal taking into account the nature of the hazardous waste to be disposed. Such standards shall include but not be limited to requirements that any person generating waste must (1) appropriately label all containers used for onsite storage or for transport of hazardous waste; (2) follow appropriate procedures for treating hazardous waste onsite; (3) transport all hazardous waste intended for offsite disposal to a hazardous waste disposal facility for which a permit has been issued. In establishing such standards the Administrator shall take into account the economic and social costs and benefits of achieving such standards.

(d) The guidelines established under paragraph (a) (3) of this section shall provide that—

(1) with respect to disposal sites for hazardous wastes, the State program requires that any person obtain from the State a permit to operate such site;

(2) such permits require compliance with the minimum standards of performance acceptable site criteria set by the guidelines;

(3) the State have such regulatory and other authorities as may be necessary to carry out the purpose of this Act, including, but not limited to, the authority to inspect disposal sites and records, and to judicially enforce compliance with the requirements of an approved program against any person.

(e) Within eighteen months of the promulgation of final regulations under this Act, each State shall submit to the Administrator evidence, in such form as he shall require, that the State has established a State program which meets the requirement of the guidelines of paragraph (a) (3) of this section. If a State fails to submit such evidence, in whole or in part, the Administrator shall publish notice of such failure in the Federal Register and provide such further notification, in such form as he considers appropriate, to inform the public in such State of such failure.

FEDERAL REGULATION

SEC. 5. (a) Within eighteen months after the date of enactment of this Act and from time to time thereafter, the Administrator after consultation with representatives of appropriate Federal agencies may with respect to those hazardous wastes identified pursuant to subsection (a) (1) of section 4 determine in regulations those of such wastes which because of their quantity or concentration, or because of their chemical characteristics, could if allowed to be dispersed into the environment result in, or contribute to, the loss of human life or substantial damage to human health or to other living organisms.

(b) The Administrator may promulgate regulations establishing Federal standards and procedures for the treatment and disposal of such wastes. Such Federal standards and procedures shall be designed to prevent damage to human health or living organisms from exposure to such wastes identified pursuant to subsection (a) and may include—

(1) with respect to hazardous waste disposal sites—

(A) minimum requirements as to the characteristics and conditions of such sites,

(B) minimum standards of performance for the operation and maintenance of such sites, and

(C) recommendations as to specific design and construction criteria for such sites; and

(2) with respect to hazardous waste treatment facilities—

(A) minimum standards of performance for the operation and maintenance, and

(B) recommendations based on available technology as to appropriate methods, techniques, or practices for the treatment of specific wastes.

(c) The Administrator may issue a permit for the operation of a hazardous waste disposal site or treatment facility if, after a review of the design, construction, and proposed operation of such site or facility, he determines that such operation will meet the requirements and standards promulgated pursuant to subsection (b).

(d) Within eighteen months after the date of enactment of this Act, the Administrator shall promulgate regulations establishing requirements for generators of hazardous wastes subject to regulation under this section to—

(1) maintain records indicating the quantities of hazardous waste generated and the disposition thereof;

(2) package hazardous waste in such a manner so as to protect human health and other living organisms, and label such packaging so as to identify accurately such wastes;

(3) treat or dispose of all hazardous waste at a hazardous waste disposal site or treatment facility for which a permit has been issued under this Act;

(4) handle and store all hazardous waste in such a manner so as not to pose a threat to human health or other living organisms;

(5) submit reports to the Administrator, at such times as the Administrator deems necessary, setting out—

(A) the quantities of hazardous waste subject to Federal regulation under this subsection that he has generated;

(B) the nature and quantity of any other waste which he has generated which he has reason to believe may have a substantial adverse effect on human health and other living organisms; and

(C) the disposition of all waste included in categories (A) and (B).

(e) The Administrator may prescribe regulations requiring any person who stores, treats, disposes of, or otherwise handles hazardous wastes subject to regulation under this section to maintain such records with respect to their operations as the Administrator determines are necessary for the effective enforcement of this Act.

(f) The Administrator is authorized to enter into cooperative agreements with States to delegate to any State which meets such minimum requirements as the Administrator may establish by regulation the authority to enforce this section against any person.

FEDERAL ENFORCEMENT

SEC. 6. (a) Whenever on the basis of any information the Administrator determines that any person is in violation of requirements under section 5 or of any standard under section 4(a)(2) under this Act, the Administrator may give notice to the violator of his failure to comply with such requirements or may request the Attorney General to commence a civil action in the appropriate United States district court for appropriate relief, including temporary or permanent injunctive relief. If such violation extends beyond the thirtieth day after the Administrator's notification, the Administrator may issue an order requiring compliance within a specified time period or the Administrator may request the Attorney General to commence a civil action in the United States district court in the district in which the violation occurred for appropriate relief, including a temporary or permanent injunction: *Provided*, That, in the case of a violation of any standard under section 4(a)(2) where such violation occurs in a State which has submitted the evidence required under section 4(e), the Administrator shall give notice to the State in which such violation has occurred thirty days prior to issuing an order or requesting the Attorney General to commence a civil action. If such violator fails to take corrective action within the time specified in the order, he shall be liable for a civil penalty of not more than $25,000 for each day of continued noncompliance. The Administrator may suspend or revoke any permit issued to the violator.

(b) Any order or any suspension or revocation of a permit shall become final unless, no later than 30 days after the order or notice of the suspension or revocation is served, the person or persons named therein request a public hearing. Upon such request the Administrator shall promptly conduct a public hearing. In connection with any proceeding under this section the Administrator may issue subpenas for the attendance and testimony of witnesses and the production of relevant papers, books, and documents, and may promulgate rules for discovery procedures.

(c) Any order issued under this section shall state with reasonable specificity the nature of the violation and specify a time for compliance and assess a penalty, if any, which the Administrator determines is a reasonable period and penalty taking into account the seriousness of the violation and any good faith efforts to comply with the applicable requirements.

(d) Any person who knowingly violates any requirement of this Act or commits any prohibited act shall, upon conviction, be subject to a fine of not more than $25,000 for each day of violation, or to imprisonment not to exceed one year, or both.

RESEARCH, DEVELOPMENT, INVESTIGATIONS, TECHNICAL ASSISTANCE AND OTHER ACTIVITIES

SEC. 7. (a) The Administrator shall conduct, encourage, cooperate with, and render financial and other assistance to appropriate public (whether Federal, State, interstate, or local) authorities, agencies, and institutions, private agencies and institutions, and individuals in the conduct of, and promote the coordination of, research, development, investigations, experiments, surveys, and studies relating to—

(1) any adverse health and welfare effects on the release into the environment of material present in waste, and methods to eliminate such effects;

(2) the operation or financing of waste management programs;

(3) the development and application of new and improved methods of collecting and disposing of waste and processing and recovering materials and energy from wastes; and

(4) the reduction of waste generation and the recovery of secondary materials and energy from solid, liquid, and semisolid wastes.

(b) In carrying out the provisions of the preceding subsection, the Administrator is authorized to—

(1) collect and make available, through publication and other appropriate means, the results of, and other information pertaining to, such research and other activities, including appropriate recommendations in connection therewith;

(2) cooperate with public and private agencies, institutions, and organizations, and with any industries involved, in the preparation and the conduct of such research and other activities; and

(3) make grants-in-aid to and contract with public

or private agencies and institutions and individuals for research, surveys, development, and public education. Contracts may be entered into without regard to sections 3648 and 3709 of the Revised Statutes (31 U.S.C. 529; 41 U.S.C. 5).

(c) The Interstate Commerce Commission, the Federal Maritime Commission, and the Office of Oil and Gas in the Department of the Interior, in consultation with the Environmental Protection Agency and with other Federal agencies as appropriate, shall conduct within twelve months of the date of enactment of this Act and submit to Congress, a thorough and complete study of rate setting practices with regard to the carriage of secondary materials by rail and ocean carriers. Such study shall include a comparison of such practices with rate setting practices with regard to other materials and shall examine the extent to which, if at all, there is discrimination against secondary materials.

INSPECTIONS

SEC. 8. (a) For the purpose of developing or assisting in the development of any regulation or enforcing the provisions of this Act, any person who stores, treats, transports, disposes of, or otherwise handles hazardous wastes shall, upon request of any officer or employee of the Environmental Protection Agency or of any State or political subdivision, duly designated by the Administrator, furnish or permit such person at all reasonable times to have access to, and to copy all records relating to such wastes.

(b) For the purposes of developing or assisting in the development of any regulation or enforcing the provisions of this Act, officers or employees duly designated by the Administrator are authorized—

(1) to enter at reasonable times any establishment or other place maintained by any person where hazardous wastes are stored, treated, or disposed of;

(2) to inspect and obtain samples from any person of any such wastes and samples of any containers or labeling for such wastes. Before undertaking such inspection, the officers or employees must present to the owner, operator, or agent in charge of the establishment or other place where hazardous wastes are stored, treated, or disposed of appropriate credentials and a written statement as to the reason for the inspection. Each such inspection shall be commenced and completed with reasonable promptness. If the officer or employee obtains any samples, prior to leaving the premises, he shall give to the owner, operator, or agent in charge a receipt describing the sample obtained and if requested a portion of each such sample equal in volume or weight

to the portion retained. If an analysis is made of such samples, a copy of the results of such analysis shall be furnished promptly to the owner, operator, or agent in charge.

(c) Any records, reports, or information obtained from any person under this subsection shall be available to the public, except that upon a showing satisfactory to the Administrator by any person that records, reports, or information, or particular part thereof, to which the Administrator has access under this section if made public, would divulge information entitled to protection under section 1905 of title 18 of the United States Code, the Administrator shall consider such information or particular portion thereof confidential in accordance within the purposes of that section.

ENCOURAGEMENT OF INTERSTATE AND INTERLOCAL COOPERATION

SEC. 9. The Administrator shall encourage cooperative activities by the States and local governments in connection with waste disposal programs, encourage, where practicable, interstate, interlocal, and regional planning for, and the conduct of, interstate, interlocal, and regional hazardous waste disposal programs; and encourage the enactment of improved and, so far as practicable, uniform State and local laws governing waste disposal.

IMMINENT HAZARD

SEC. 10. (a) An imminent hazard shall be considered to exist when the Administrator has reason to believe that handling or storage of a hazardous waste presents an imminent and substantial danger to human health or other living organisms the continued operation of a disposal site will result in such danger when a State or local authority has not acted to eliminate such risk.

(b) If an imminent hazard exists, the Administrator may request the Attorney General to petition the district court of the United States in the district where such hazard exists, to order any disposal site operator or other person having custody of such waste to take such action as is necessary to eliminate the imminent hazard, including, but not limited to, permanent or temporary cessation of operation of a disposal site, or such other remedial measures as the court deems appropriate.

PROHIBITED ACTS

SEC. 11. The following acts and the causing thereof are prohibited and shall be subject to enforcement in accordance with the provisions of subsection 6(d) of this Act:

(a) Operating any disposal site for hazardous waste identified pursuant to section 5 without having obtained an operating permit pursuant to such section.

(b) Disposing of hazardous waste identified pursuant to section 5 in a manner not in compliance with requirements under section 5.

(c) Failure to comply with the requirements of section 5 in labeling containers used for the storage, transport, or disposal of hazardous waste.

(d) Failure to comply with (1) the conditions of any Federal permit issued under this Act, (2) any regulation promulgated by the Administrator pursuant to section 4(a) (2) or section 5 of this Act, or (3) any order issued by the Administrator pursuant to this Act.

APPLICATION OF STANDARDS TO FEDERAL AGENCIES

SEC. 12. (a) Each department, agency, and instrumentality of the executive, legislative, and judicial branches of the Federal Government having jurisdiction over any property or facility, or engaged in any activity which generates, or which may generate, wastes shall insure compliance with such standards pursuant to subsections 4(a) (2), 5(a), and 5(c) as may be established by the Administrator for the treatment and disposal of such wastes.

(b) The President or his designee may exempt any facility or activity of any department, agency, or instrumentality in the executive branch from compliance with guidelines established under section 4 if he determines it to be in the paramount interest of the United States to do so. Any exemption shall be for a period not in excess of one year, but additional exemptions may be granted for periods of not to exceed one year upon the President's or his designee's making of a new determination. The Administrator shall ascertain the exemptions granted under this subsection and shall report each January to the Congress all exemptions from the requirements of this section granted during the preceding calendar year.

(c) Within eighteen months after enactment of this Act and from time to time thereafter, the Administrator, in consultation with other appropriate Federal agencies, shall identify products which can utilize significant quantities of secondary materials and shall issue guidelines with respect to the inclusion of such secondary materials to the maximum extent practicable in products procured by the Federal Government.

(d) In any proceeding initiated before the Interstate Commerce Commission or the Federal Maritime Commission after the enactment of this Act where a determination is made by such Commission as to any individual or joint rate, fare, or charge whatsoever demanded, charged, or collected by any common carrier or carriers, a specific finding by the Commission will be required that such rate, fare, or charge does not or will not cause discrimination against secondary materials.

CITIZEN SUITS

SEC. 13. (a) Except as provided in subsection (b) any person may commence a civil action for injunctive relief on his own behalf—

(1) against any person who is alleged to be in violation of any regulation promulgated or order issued under this Act;

(2) against the Administrator where there is alleged a failure of the Administrator to perform any act or duty under this Act which is not discretionary with the Administrator.

Any action under paragraph (a) (1) of this subsection shall be brought in the district court for the district in which the alleged violation occurred and any action brought under paragraph (a) (2) of this subsection shall be brought in the District Court of the District of Columbia. The district courts shall have jurisdiction, without regard to the amount in controversy or the citizenship of the parties, to enforce such regulation or order, or to order the Administrator to perform such act or duty as the case may be.

(b) No action may be commenced—

(1) under subsection (a) (1) of this section—

(A) prior to sixty days after the plaintiff has given notice of the violation (i) to the Administrator, (ii) to the State in which the alleged violation occurs, and (iii) to any alleged violator of the standard, limitation, or order, or

(B) if the Administrator or State has caused to be commenced and is diligently prosecuting a civil or criminal action in a court of the United States or a State to require compliance with requirements of this Act or order issued hereunder;

(2) under subsection (a) (2) prior to sixty days after plaintiff has given notice of such action to the Administrator.

Notice under this subsection shall be given in such manner as the Administrator shall prescribe by regulation.

(3) in such action under this section, if the United States is not a party, the Attorney General may intervene as a matter of right.

(d) The court, in issuing any final order in any action brought pursuant to this section, may award costs of litigation (including reasonable attorney and expert witness fees) to any party, whenever the court determines such award is appropriate.

(e) Nothing in this section shall restrict any right which any person (or class of persons) may have under any statute or common law to seek enforcement of any regulation or to seek any other relief (including relief against the Administrator or a State agency).

STATE AUTHORITY

SEC. 14. (a) If the Administrator has promulgated regulations under section 5 no State or municipality may without the approval of the Administrator impose more stringent requirements than those imposed under the provisions of section 5 on the transport, treatment, or disposal of hazardous wastes.

(b) No State or municipality shall impose, on wastes originating in other States or municipalities, requirements respecting the transport of such wastes into or disposal within its jurisdiction which are more stringent than those requirements applicable to wastes originating within such receiving States and municipalities.

AUTHORIZATION AND APPROPRIATION

SEC. 15. There is hereby authorized to be appropriated to the Environmental Protection Agency such sums as may be necessary for the purposes and administration of this Act.

JUDICIAL REVIEW

SEC. 16. (a) A petition for review of action of the Administrator in promulgating any regulation pursuant to sections 4 or 5 shall be filed in the United States Court of Appeals for the District of Columbia. Any person who will be adversely affected by a final order or other final determination issued under section 6 may file a petition with the United States Court of Appeals for the circuit wherein such person resides or has his principal place of business, for a judicial review of such order or determination. Any such petition shall be filed within thirty days from the date of such action or order, or after such date if such petition is based solely on grounds arising after such thirtieth day.

(b) Action of the Administrator with respect to which review could have been obtained under subsection (a) shall not be subject to judicial review in civil or criminal proceedings for enforcement.

(c) In any judicial proceeding in which review is sought of an action under this Act required to be made on the record after notice and opportunity for hearing, if any party applies to the court for leave to adduce additional evidence, and shows to the satisfaction of the court that such additional evidence is material and that there were reasonable grounds for the failure to adduce such evidence in the proceedings before the Administrator, the court may order such additional evidence (and evidence in rebuttal thereof) to be taken before the Administrator, in such manner and upon such terms and conditions as the court may deem proper. The Administrator may modify his findings as to the facts, or make new findings, by reason of the additional evidence so taken and he shall file such modified or new findings, and his recommendation, if any, for the modification or setting aside of his original determination, with the return of such additional evidence.

RELATIONSHIP TO OTHER LAWS

SEC. 17. (a) This Act shall not apply to—

(1) any source material, special nuclear material, or byproduct material subject to regulation or control pursuant to the Atomic Energy Act of 1954, as amended;

(2) lethal chemicals subject to regulation pursuant to title 50, United States Code, section 1511, and the following, as amended.

(b) This Act shall not be construed to relieve any person from any present or future requirement arising from any other Federal law.

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