PROJECTED OCEAN DUMPING RATES FOR MUNICIPAL AND INDUSTRIAL WASTES IN THE YEAR 2000

Prepared for

National Oceanic and Atmospheric Administration
National Marine Pollution Program Office
Rockville, Maryland
Mr. William Conner - Project Officer

Prepared by

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Waltham, Massachusetts 02154
Dr. Jerome Cura, Dr. Charles Menzie
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1. INTRODUCTION

1.1 OVERVIEW

The purpose of this report is to provide a range of estimated projections for the rates of ocean dumping of certain wastes in the year 2000. The projected rates are based on broad ranges developed as order-of-magnitude estimates to assist in evaluating research priorities. The wastes considered here are: coal ash, flue gas desulfurization sludge (FGD), sewage sludge, hazardous/industrial wastes, and seafood processing wastes. Dredge spoils are excluded from analysis. The estimates were made under three broad scenarios: 1) an extension of existing regulatory conditions to the year 2000; 2) a relaxed regulatory environment; and 3) cost considerations only. No judgments are made concerning the environmental acceptability of ocean dumping any of the wastes. This kind of analysis has been attempted in numerous other volumes (e.g., EG&G 1983). Rather, we have tried to put some boundaries on the potential magnitude of ocean dumping activity. The underlying assumption is that the environmental acceptability of ocean dumping of specific categories of wastes or waste components will ultimately be reflected in the regulatory environment.

Each section of this report addresses a separate category of waste or wastes. Section 1 reviews the current regulatory environment and describes the methodology used. Section 2 addresses ash and FGD sludge, Section 3 concerns sewage sludge, and Section 4 discusses hazardous/industrial waste. Section 5 concerns seafood processing waste, Section 6 is a summary, and the bibliography is presented in Section 7.

1.2 REGULATORY ENVIRONMENT

The Role of the Ocean in a Waste Management Strategy (NACOA, 1981) reviewed much of the thought concerning ocean dumping and publicly recognized that an integrated approach to waste management rather than a medium-by-medium approach is necessary to minimize risk to human health and the environment. Consistent with this recognition, NACOA recommended that the U.S. EPA reverse its policy that no ocean dumping permit be issued when any land-based alternative exists. In this report, NACOA also recognized that each region of the country has its own unique set of oceanographic, hydrologic, geologic, and atmospheric properties which must be considered when deciding upon a waste management strategy. NACOA also recommended that sewage sludge dumping and outfalls be allowed, under appropriate conditions and with adequate monitoring safeguards, in those areas where no unreasonable degradation of the environment exists. Also, ocean disposal of industrial wastes should continue at sites where evidence indicates no unreasonable degradation of the environment and when human health, environmental, and economic considerations indicate that this is the preferable option.

Amendments in 1977 and 1980 to the major legislation regarding ocean dumping, the Marine Protection, Research, and Sanctuaries Act of 1972, statutorily adopted a phaseout date of December 1981 for sewage sludge and industrial wastes, respectively. However, events subsequent to publication of the NACOA report gave further impetus to reconsideration of the role of the oceans in waste management strategy. On November 2, 1981, a Federal District Court Judge ruled that EPA had acted unreasonably in banning all sludge dumping after December 1981. He ordered EPA to revise its ocean dumping regulations to remove the conclusive presumption that materials which do not pass the agency's environmental criteria will "unreasonably degrade" the marine environment. The court also ruled that EPA must consider all relevant statutory factors before reaching a determination on whether a permit should be issued. These include:

- the need for the proposed dumping;
- the effect of such dumping on human health and welfare, including economic, aesthetic, and recreational values;
- the effect of such dumping on fisheries resources, plankton, fish, shellfish, wildlife, shorelines and beaches;
- the effect of such dumping on marine ecosystems, particularly with respect to (1) the transfer, concentration, and dispersion of such material and its byproducts through biological, physical, and chemical processes, (2) potential changes in marine ecosystem diversity, productivity, and stability, and (3) species and community population dynamics;
- the persistence and permanence of the effects of dumping;
- the effect of dumping particular volumes and concentrations of such materials;
- the appropriate locations and methods of disposal or recycling, including land-based alternatives and the probable impact of requiring use of such alternatives upon considerations affecting the public interest; and
- the effect on alternate uses of the oceans, such as scientific study, fishing, and other living resource exploitation, and nonliving resource exploitation.

EPA did not appeal the decision. They are presently revising the regulations in two phases. The first phase addresses incineration at sea. These proposed regulations have been published in the Federal Register (February 28, 1985). The second phase, which is a comprehensive revision of the ocean dumping regulations, will not be published at least until March 1986 (EPA, Marine Protection Branch).

In addition to the Marine Protection, Research, and Sanctuaries Act, the other major pieces of legislation affecting ocean dumping and the quantities of wastes that might be considered for ocean dumping are the Clean Water Act and the Resource Conservation and Recovery Act.

The Federal Water Pollution Control Act (Clean Water Act) specifies a National Pollutant Discharge Elimination System (NPDES) (Sec. 402) to control the discharge of pollutants from point sources. Discharges must comply with effluent guidelines, not violate applicable water quality standards and, in the case of ocean waters, must comply with Ocean Discharge Criteria (Sec. 403). Implementation of the physical control measures necessary to meet compliance with these programs have resulted in the generation of treatment sludges that could possibly be ocean dumped but are currently being disposed of in landfills, incinerated, or, in some cases, recycled and reclaimed.

Pretreatment is covered in Sec. 307 of the Clean Water Act. According to U.S. EPA regulations (40 CFR 403.5), municipalities operating Publicly Owned Treatment Works (POTW) must have had an approved pretreatment program in place by July 1, 1983. A municipality must require all industrial dischargers using its facility to control particular pollutants in their discharge to the facility. Pollutants of concern are those which pass through or interfere with the treatment process. National pretreatment standards currently in effect prohibit the discharge of pollutants that: 1) create a fire or explosion hazard; 2) cause corrosive structural damage to the POTW, and in no case have a pH less than 5 (unless the POTW is specifically designed to accommodate low pH waste); 3) are solid or viscous enough to obstruct sewer flow or otherwise interfere with POTW; 4) create a large oxygen demand and interfere with POTW operation; or 5) interfere with the biological treatment function of a POTW by addition of heat, and in no case create a temperature greater than 40°C (104°F) unless the POTW is designed to accommodate it.

Specific federal pretreatment standards for all priority industries are due to be phased in gradually on varying schedules over the next three years (EPA Region I, personal communication). These standards are principally designed to require removal of pollutants that would pass through a POTW essentially untreated.

The principal industrial sludges of interest that will be produced from pretreatment will be metal hydroxide sludges. The metals found in these sludges are generally prohibited from ocean dumping by the London Dumping Convention. No acids currently discharged to POTWs would comply with general pretreatment requirements. Increased amounts of acids and acid-neutralized sludges could be generated for potential ocean dumping as surveillance and enforcement programs succeed in eliminating these discharges.

Metal hydroxide sludges generated now by industries treating their waste to meet NPDES limitations, and generated in the future by pretreatment, could be retained for their metal value. Alternatively, these sludges, considered hazardous waste because of their metal content, could be solidified and dumped at sea. There have been recent proposals to stabilize hazardous waste by solidification and then landfill the solid material. Companies proposing such facilities have had a very difficult time siting them because, among other things, local communities do not want their towns to be the repositories for this material, stabilized or not. These materials may be suitable for disposal at sea.

Section 301(h) of the Federal Water Pollution Control Act can affect the amount of sludge generated by determining whether secondary or primary treatment is necessary. This section provides for a waiver from secondary treatment requirements for a POTW provided that, among other things, such a waiver will not violate water quality standards, will not require reductions from other point sources to attain water quality standards, and that there is a pretreatment program in place and sources of toxic pollutants are controlled. Secondary sludge is not generated if only primary treatment is required.

The waiver application approach has been revised to consider separately communities by size and type of population served, making it easier for smaller communities with only domestic waste to obtain waivers. The EPA would provide small coastal communities with technical assistance in obtaining waivers.

Ocean Discharge Criteria are promulgated by 40 CFR 125.121 and require that all discharges of pollutants from a point source into the territorial seas, the contiguous zone, and the oceans must not unreasonably degrade the marine environment. "Unreasonable degradation of the marine environment" means: 1) significant adverse changes in ecosystem diversity, productivity, and stability of the biological community within and surrounding the area of discharge; 2) threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms; or 3) loss of aesthetic recreational, scientific, or economic values that is unreasonable in relation to the benefit derived from the discharge. (As described above, Ocean Discharge Criteria do not materially affect, by themselves, the type or amount of ocean dumping that would be controlled by the MPRSA.)

At the federal level, the Resource Conservation and Recovery Act (RCRA) controls the generation, transport, treatment, storage, and disposal of material classified by regulation as hazardous. Material that was formerly disposed of as solid waste or discharged to waste treatment plants without regard to potential toxic effects is now controlled and can no longer be discarded in an uncontrolled manner. The effect of this law has been to identify increasing amounts of wastes that are hazardous and, because of the lack of suitable disposal sites, has resulted in pressure to have states try to identify proper hazardous waste disposal sites.

Siting acceptable hazardous waste disposal facilities has not been very successful. In Massachusetts, communities have successfully opposed siting such facilities within their borders. While publicly recognizing the need for proper facilities, communities have not been willing to accept them. Offshore disposal of solidified, detoxified hazardous waste may comply with ocean dumping regulations because the waste will no longer be toxic.

As state and local governments become increasingly aware of the problems associated with land disposal of solid and hazardous waste, more laws and ordinances are being enacted to control this activity. In many cases, this tightening of regulatory control at the state and local level is severely limiting disposal options for waste material, especially solid and hazardous waste. Tightening of control for land disposal, in combination with court rulings and proposed amendments to existing federal regulations that would encourage consideration of ocean disposal as a feasible alternative, tend to favor an increase in ocean disposal proposals for all types of solid waste. Some examples of these factors nationwide include:

- A ban on landfill disposal of sludge by the state of New Jersey.
- Sewage sludge from the City of New York can be considered for ocean dumping by EPA based on its actual effect on the marine environment (City of New York versus the U.S. EPA).
- States are being delegated federally mandated programs such as RCRA, NPDES, and Pretreatment. They are likely to be more strict.
- Zoning and Home Rule may keep hazardous waste disposal facilities from being located on land.

Considering the somewhat uncertain nature of the regulatory environment until the revised EPA ocean dumping regulations are published, three scenarios have been used in this report to estimate annual disposal rates of wastes likely to be ocean dumped in the year 2000.

1.3 METHODOLOGY

1.3.1 Existing Generation Rates

The existing generation rates of certain wastes having a high to moderate probability of being ocean dumped have been determined previously (EG&G, 1982). These include coal ash, FGD sludge, sewage sludge, industrial wastes, and seafood wastes. Dredged material is not included in this analysis. Data bases and previous estimates from industry and government were examined. We concentrated on coastal regions and coastal states, although in each case we tried to determine the national generation rates as well.

For coal ash and FGD sludge, a variety of groups were contacted. The data from individual states varied in quality and availability. Therefore, we relied upon major national organizations and federal agencies for data. These included: National Ash Association, Electric Power Research Institute, Edison Electric Institute, United Solid Waste Activities Group, DOE Office of Fossil Energy, DOE Office of Policy, Safety, and Environment, Argonne National Laboratories, and EPA Research Triangle Park.

For industrial/hazardous wastes, we utilized recent survey reports by EPA's Office of Solid Waste. In addition, we contacted each coastal state to obtain whatever reports were available on industrial waste generation and disposal. These reports include those developed as part of the RCRA manifest system. We also contacted individual companies engaged in ocean dumping as well as industry associations (e.g., Chemical Manufacturers Association).

Sewage sludge estimates were derived from Basta et al. (1982).

Accurate information on seafood processing wastes are not available for regional or nationwide planning purposes. Instead, the volume of wastes must be derived from data on landings of individual species or seafood categories. Such data were obtained from statistical reports issued by the National Marine Fisheries Service. Waste quantities were then derived using factors suggested in the literature including Murray (1981), Perry (1981), Brown (1981), and Pigott (1981).

1.3.2 Projections to the Year 2000

Projections of various wastes were derived from data supplied by the above industry groups or agencies. In some instances these projections were readily available as in the case of coal ash or FGD sludge. For some, however, estimates were difficult to obtain. This was particularly true of industrial wastes for a variety of reasons outlined in Section 4.

1.3.3 Development of Scenarios

Scenario I represents an extension of the current situation to the the year 2000. It assumes that only currently active permit holders will be dumping in the oceans in the year 2000. At present, ocean dumping of sewage sludge and industrial wastes is relatively limited. The City of New York continues to dump sludge at the 12-mile site. However, it is anticipated that future dumping will occur at the 106-mile site. In addition, Westchester County, New York, and six northern New Jersey Counties are also dumping at this site. At present, there are only three active industrial dumpers: DuPont-Grasselli of New Jersey, DuPont-Edge Moor in Delaware, and Allied Corporation of Elizabeth, New Jersey.

Scenario II represents a situation in the future where wastes are generated at the rates projected in this report. Regulations, although more relaxed, will conform to the factors laid down by the court and will adhere to the London Dumping Convention. In particular, it is assumed that dumping of sewage sludge, industrial wastes, and ash/FGD sludge would occur when evidence indicates no unreasonable environmental degradation and when human health, environmental and economic considerations indicate that this is the preferred option. Determining the preferred option under the constraints of finding the best alternative when considering human health, environmental and economic considerations requires local and geographic-specific knowledge as anticipated in the NACOA report.

Under these conditions, the nature and constituents of the waste, itself, will not be the only factors determining the preferred option. For example, in some instances, although disposal of a waste may not result in unreasonable environmental degradation if ocean dumped, the availability or unavailablity of suitable land or technology with their accompanying economic impacts may dictate disposal methods. This is particularly true for the disposal of coal ash, as will be explained in Section 2. The geographic region where a waste is generated can often dictate the method of disposal. In keeping with the spirit of the recommendations of the NACOA report, the following analyses consider that recycling and multimedia approaches will be followed wherever possible for all wastes.

Scenario III assumes the selection of a waste disposal alternative is based exclusively on economic considerations with no concern for environmental effects. We have considered only coastal EPA regions and, where possible, only the near-coast areas within these regions.

2. ASH AND FGD SLUDGE

2.1 EXISTING AND FORECASTED GENERATION RATES

This section concerns the projections of coal ash and flue gas desulfurization (FGD) sludge on a national and regional basis. Ash projections to the year 2000 for the United States are presented from a variety of sources. We have provided as detailed a breakdown of the areas of generation of these wastes for the coastal regions of the U.S. as is practical using existing data and current projections. Coal ash is a relatively high volume waste which derives from coal burning in electric utility and industry coal-fired boilers. The ash volumes generated in the processes are, to a large measure, a function of the source of the coal. The ash is characterized as either fly ash, a powdery particulate entrained in the flue gas exiting the boiler, or as bottom ash, a noncombustible material which is too dense to escape from the boiler in the flue gas stream. FGD sludges are also derived from coal burning in electric utility and industry boilers. The amounts of this waste are determined by initial sulfur content of the coal and the percent recovery of sulfur dictated by regulation. Both of these wastes are considered high volume wastes (USWAG, 1982). The major chemical constituents of coal ash, the salts of silicon, aluminum, potassium, and titanium (Table 2-1) do not present any major pollutant problems associated with ocean dumping. The minor constituents of coal ash and FGD sludge, trace metals (Table 2-2), may have potential ecological effects, as discussed in EG&G (1982). The major concerns of the discussion which follows center around the total amounts of coal ash and FGD sludge which may be potentially ocean dumped and the geographic source of these wastes.

Table 2-1. Range of major constituents by coal type (percent by weight of dry ash).

	Anthracite	Bituminous	Subbituminous	Lignite
SiO_2	48-68	7.0-68	17-58	6.0-40
Al_2O_3	25-44	4.0-39	4.0-39	4.0-26
Fe_2O_3	2.0-10	2.0-44	3.0-19	1.0-34
CaO	0.2-4.0	0.7-36	2.2-52	12.4-52
MgO	0.2-1.0	0.1-4.0	0.5-8.0	2.8-14
Na_2O	-	0.2-3.0	-	0.2-28
K_2O	-	0.2-4.0	-	0.1-1.3
TiO_2	1.0-2.0	0.5-4.0	0.6-2.0	0.0-0.8
SO_3	0.1-1.0	0.1-32	3.0-16	8.3-32

Sources: S.S. Ray and F.G. Parker. Characterization of Ash from Coal-Fired Power Plants. TVA. EPA-600/7-77-010. January 1977.

J.V. O'Gorman and P.L. Walker. Mineral Matter and Trace E.ements in U.S. Coals. Prepared by Coal Research Section, Pennsylvania State University for the Office of Coal Research, U.S. Department of Interior. R&D Report No. 61, 1972.

Table 2-2. Characteristics and constituents of fly ash and FGD sludge which may be ocean dumped (from EG&G, 1983).

General Characteristics	Fly Ash	FGD Sludge
% Solids	98-99	30-80
pH	3-12	2.8-12.8
Metals (ppm)		
Arsenic	3.2-74	4.0-12.0
Barium	700-15,000	20-4,400
Boron	179-1,040	42-211
Cadmium	0.39-5.3	0.4-25
Chromium	3.6-28.0	1.6-5.2
Copper	43-238	39-104
Lead	4.0-27	1.6-290
Manganese	157-374	56-340
Mercury		0.01-0.46
Molybdenum	5.9-12.0	8-81
Nickel	34-108	13-75
Selenium	1.7-16.4	2-4
Vanadium	<25-<100	50-100
Zinc	92-386	14-2,050

Present estimates of total ash and FGD sludge produced nationally illustrate the volumes of these wastes and provide ranges of values for these estimates. The estimates given below vary as a result of the method used to make them. Tobin (1982) estimated ash and FGD generation for the year 1981 by using stated generating capacity as listed in the Generating Unit Reference Files (GURF), and calculated waste production by assuming enough coal consumption to achieve the stated capacity, a given operating level, a given thermal efficiency, and an average ash content. In this manner, national production of ash in 1981 was calculated at 35,000,000 tons. This is a dry weight number, and reflects only ash. Estimates presented by USWAG (1982) for the year 1980 are considerably higher, 66,400,000 tons. This number is provided by the National Ash Association, and was extrapolated from questionnaire returns to utility operators. Differences in the numbers can be accounted for in part by the fact that the calculated numbers are dry weights while reported numbers will include water weight depending upon the disposal practice. In some cases, actual reported weights can contain only 50% solids. The range in values illustrates the dimensions of the problem in determining exact values. In either event, however, coal ash must be considered a high volume waste on the national level. Estimates of FGD sludge made by EPRI (1984) and Tobin (1982) are closer, 4,640,000 and 3,210,000 tons, respectively. DOE estimates of FGD sludge generation in 1981 are 4,300,000 tons with 978,725 tons contributed by the coastal states (DOE, personal communication).

Based on volume, it is clear that ash and FGD sludge from electric utility boilers present a considerable disposal problem. There is general agreement among government and industry sources that the generation of ash and FGD sludge will continue to grow over the next two decades. Table 2-3 presents forecasts of ash generation made by USWAG to the year 2000, and forecasts of FGD

Table 2-3. Forecasted electric utility ash generation in the United States, 1985-2000, in millions of tons (USWAG, 1982) and FGD sludge in millions of tons (DOE, personal communications).

Year	Total Ash	Fly Ash	Bottom Ash	FGD Sludge
1985	94.0	65.8	28.2	19.5
1986	98.0	68.6	29.4	
1987	103.0	72.1	30.9	
1988	107.0	74.9	32.1	
1989	111.5	78.1	33.4	
1990	116.5	81.6	34.9	29.7
1991	121.5	85.1	36.4	
1992	126.5	88.6	37.9	
1993	131.0	91.7	39.3	
1994	136.0	95.2	40.8	
1995	142.0	99.4	42.6	
1996	147.0	102.9	44.1	
1997	152.5	106.8	45.7	
1998	158.6	110.6	48.0	
1999	163.5	114.5	49.0	
2000	169.5	118.7	50.8	56.7
Totals	2,078.1	1,454.6	623.5	

sludge by DOE. According to these sources, by the year 2000, 169,500,000 tons of ash and 56,700,000 tons of FDG sludge will be generated annually in the U.S. Again, these are wet weight numbers extrapolated from historical trends and predicted coal consumption. The important point is that the yearly numbers presented in Table 2-3 are cumulative. Neither ash nor FGD sludge are degradable and disposal problems are compounded each year. Therefore, utilities and communities face the problem of finding new landfills. Studies concerning the utilization of ash and FGD sludge have been completed (e.g., EPRI, 1984; USWAG, 1982). USWAG (1982) estimates that recycling of ash will grow to 23,900,000 tons by 1990. The rate of utilization will slow thereafter, and 27,300,000 tons will be recycled in 2000. The level of effort that industry is putting into recycling possibilities is growing, but ash utilization is hampered by the variations in ash characteristics from batch to batch and between processes. This can make recycling difficult at times for industries such as construction, cement manufacture, and roofing grit. Even the most optimistic recycling scenarios leave a significant disposal problem.

National generation rates do not provide any insight on the amounts of these materials which might be considered for ocean dumping. To resolve this problem, we have examined generation rates on a regional basis. Two sources, Argonne National Laboratories (Tobin, 1982) and EPRI (1984), provide breakdowns on a regional basis. The same quantitative discrepancies referred to above apply to these two sets of regional numbers. Tables 2-4 and 2-5 present EPRI and Argonne Laboratory estimates of present (1980 and 1981) generation rates for primarily coastal regions; the Argonne estimates are by EPA region. It is obvious that the Pacific coast states are relatively minor producers of ash and FGD sludge at present. On the eastern seaboard, the New England states are also relatively minor producers. However, as will be

Table 2-4. Present (1980) rates of coal ash (tons/yr) and FGD sludge (tons/yr) in various coastal regions (adapted from EPRI, 1984).

Region	Ash	FGD Sludge
New England	130,000	0
Middle Atlantic (NY, PA, NJ)	8.9×10^6	960,000
South Atlantic (DL, MD, VA, WV, NC, SC, GA, FL)	12×10^6	160,000
East South Central (AL, LA, TN, KY)	8.38×10^6	820,000
West South Central (MS, TX, OK, AR)	6.69×10^6	410,000
Pacific (CA, OR, WA)	800,000	0
Totals	36.9×10^6	2.35×10^6

Table 2-5. Generating capacity (MW), ash generation (tons/yr), and FGD sludge generation (tons/yr) from existing utility boilers in coastal EPA regions (adapted from Tobin, 1982).

Region	Generating Capacity	Ash	FGD Sludge
I	2,500	250,000	0
II	5,000	750,000	0
III	32,500	5.5×10^6	800,000
IV	57,500	9.75×10^6	1,275,000
VI	7,500	1,000,000	0
IX	5,000	750,000	25,000
X	2,500	250,000	0
Totals	112,500	18,250,000	2,100,000

Map of EPA Regions

explained below, coal conversion may occur relatively rapidly in this region. In the middle Atlantic region, ash production is relatively high with the majority of ash and FGD sludge generated in the state of Pennsylvania. At present, the major source of coal ash in the coastal regions of the U.S. is the south Atlantic area. The states bordering the Gulf of Mexico are also major producers of coal ash and FGD sludge, although these numbers are somewhat inflated by the inclusion in both data sets of inland states such as Kentucky, Tennessee, New Mexico, Oklahoma, and Arkansas. According to the Argonne estimates, EPA regions III and IV generate approximately 83% of the ash produced in the coastal regions (approximatley 40% nationwide) and 98% of the FGD sludge. By EPRI estimates, the southern Atlantic and eastern Gulf coast states produce 55% of the ash from the coastal regions and 41% of the FGD sludge. (The differences reflect the inclusion of Pennsylvania in EPA Region III.) In general, the eastern seaboard from Pennsylvania to Florida and the Gulf states of Florida, Alabama, and Louisiana are major sources of coal ash and FGD sludge.

Argonne National Laboratories has made some regional projections of ash and FGD sludge to the year 2000 on the basis of a DOE/EPA acid rain mitigation study (see Tobin, 1982, for details of method). Table 2-6 presents the additional generating capacity, ash generation, and FGD sludge generation from proposed coal-fired boilers expected by EPA region for the year 2000. Only the coastal EPA region data is included. EPA Regions IV and VI (the southeastern and Gulf coast states) will experience the greatest rate of increase in generating capacity, ash generation, and FGD sludge production by the year 2000. Therefore, in the future as at present, the southeastern and Gulf states will be generating a high proportion of these wastes in the coastal regions. Even in the year 2000, the Pacific coast states will be generating relatively little coal ash and FGD sludge. In the

Table 2-6. Projected additional generating capacity (MW), ash (tons/yr), and FGD sludge (tons/yr) by the year 2000 from proposed coal-fired utility boilers (adapted from Tobin, 1982).

Region	Generating Capacity	Ash	FGD Sludge
I	7,500	1.5×10^6	2.5×10^6
II	12,500	2.5×10^6	3.5×10^6
III	32,500	8×10^6	8.5×10^6
IV	62,500	15.5×10^6	11×10^6
VI	62,500	16.5×10^6	5.5×10^6
IX	10,000	2.5×10^6	0.5×10^6
X	10,000	2×10^6	0.5×10^6
Totals	197,500	48.5×10^6	32×10^6

Map of EPA Regions

near term, however, the northeastern states will be converting existing plants to coal faster than the rest of the country (Table 2-7). Also as the table shows, most of the wastes will be disposed of off site. With land at a premium in the crowded northeast, alternative disposal methods will be welcomed by the electric utility industry (personal communication, Boston Edison). As an example of the northeast states' desire to use ocean dumping as an alternative, it is noted that ConEdison in New York has been attempting to gain permission to ocean dump mixed fly and bottom ash.

2.2 OCEAN DUMPING SCENARIOS

In the following subsections, estimates using the data of Tobin (1982) are made of ocean dumping of coal ash and FGD sludge under the scenarios described in Section 1. Estimates of generation rates in coastal areas were made on the basis of distribution maps prepared by Tobin. Figures 2-1 and 2-2 summarize the present generation rates, forecasted rates for entire EPA regions, and rates of ocean dumping under the three scenarios.

We have contacted the appropriate state agencies in all coastal states to determine the present regulatory environment dictating present disposal of coal ash and FGD sludge. This was particularly important in determining disposal under Scenario II. Disposal regulations were relatively constraining in the northeast and relatively relaxed in the southeast and Gulf states. A number of power companies in various regions were also contacted to determine their present disposal methods and their attitude toward ocean disposal. These companies included Central Maine Power Company, Boston Edison, New England Electric, Con Edison, United Illuminating, Pennsylvania Power & Light Company, Delmarva Power, and Georgia Power Company. In general, the northeastern companies were more favorably inclined to ocean disposal.

Table 2-7. Amount of ash (tons/yr) and FGD sludge (tons/yr) for conversion boilers projected during near-term (Phase I) coal conversion and percentage of offsite disposal by EPA region (adapted from Tobin, 1982).

Region	Ash	% Offsite Disposal	FGD Sludge	% Offsite Disposal
I	10^6	60	750,000	100
II	1.3×10^6	80	1.4×10^6	68
III	0.9×10^6	89	150,000	100
IV	150,000	66	0	N.A.
VI	150,000	100	0	N.A.

N.A. - Not Applicable

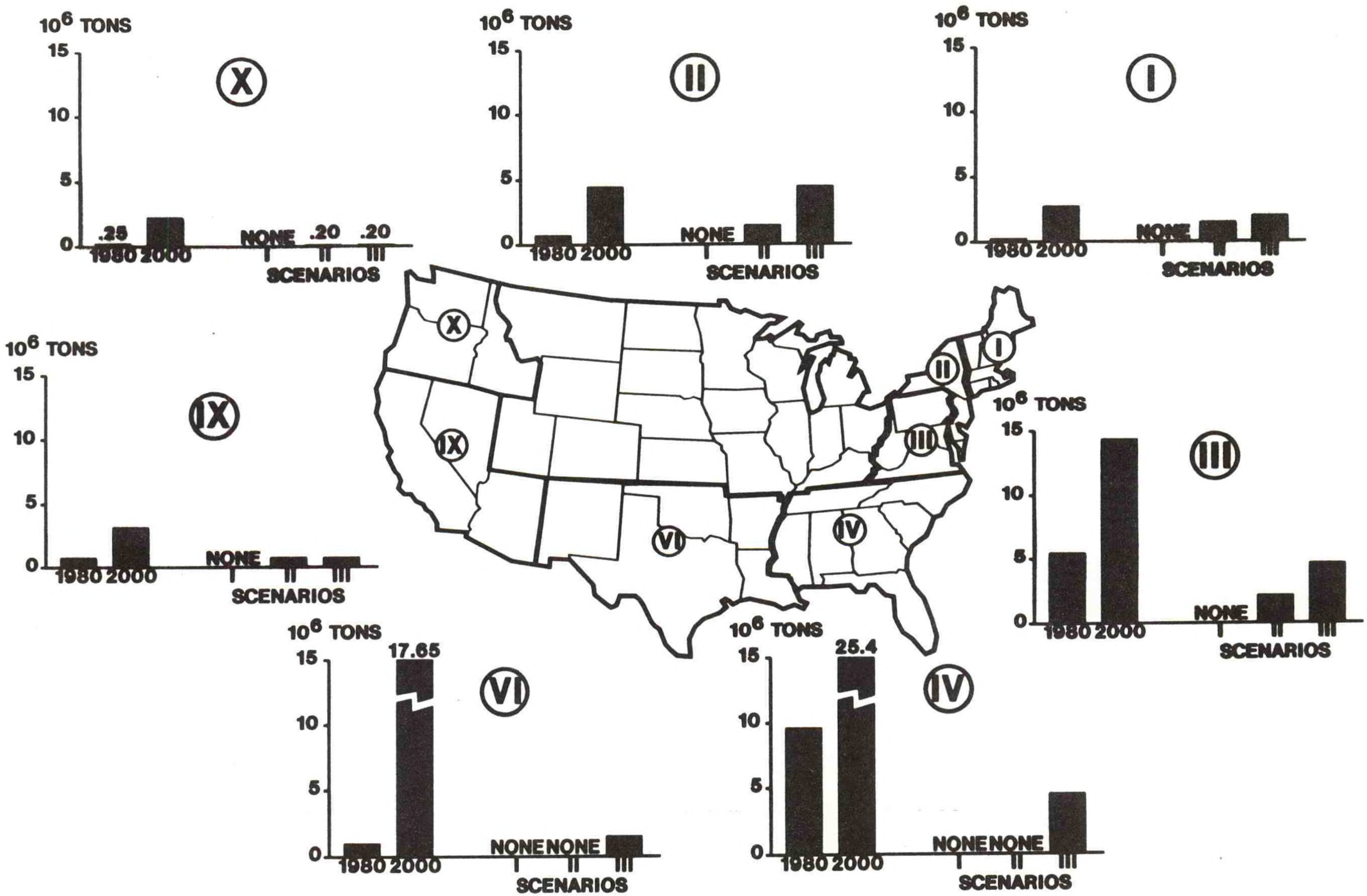


Figure 2-1. Present (1980) and projected (2000) generation rates (10^6 tons/year) for coal ash from utility boilers and ocean dumping rates (10^6 tons/year) under three scenarios by coastal EPA regions. Data for present and projected rates is from Tobin (1982).

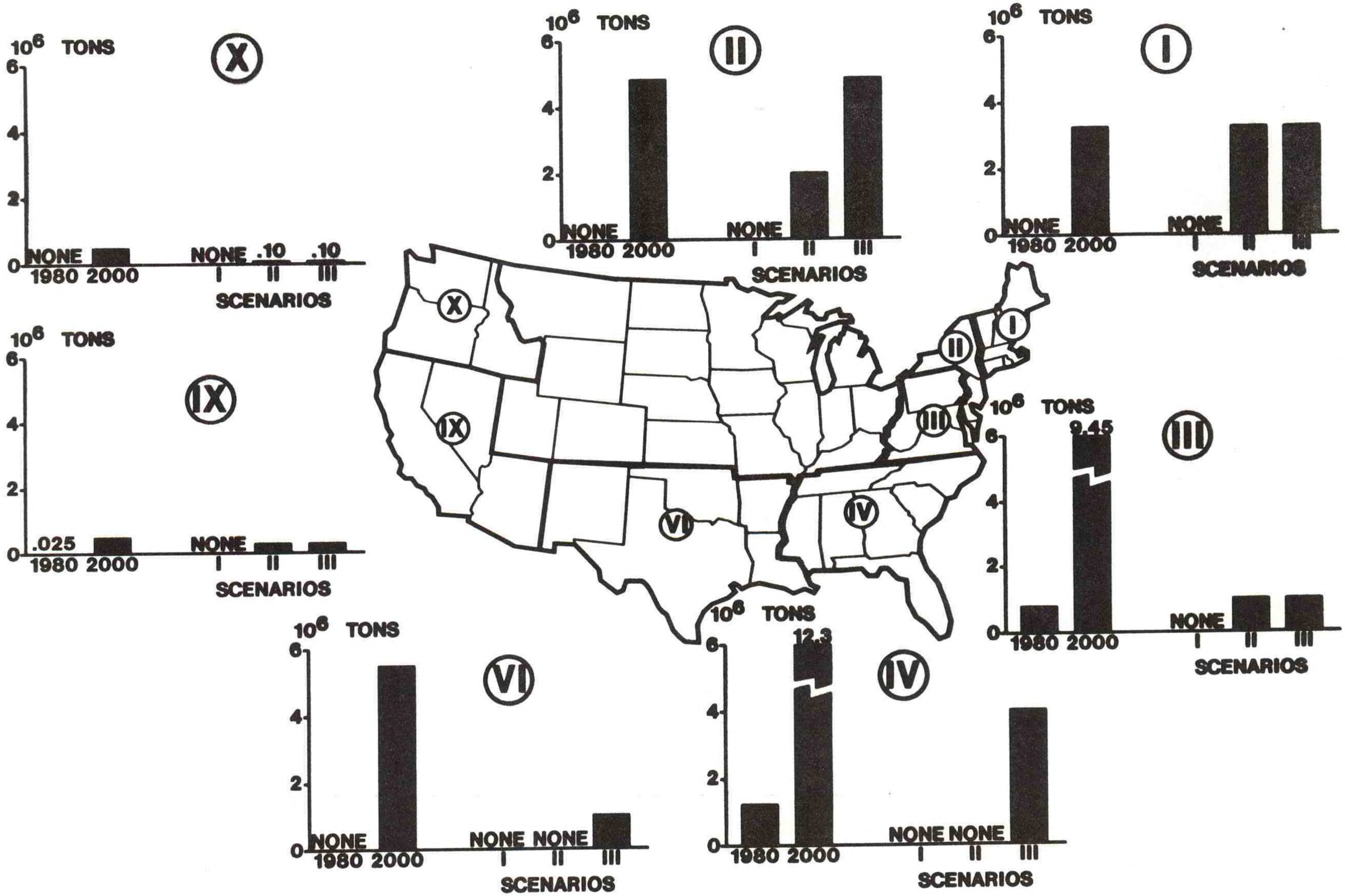


Figure 2-2. Present (1980) and projected (2000) generation rates (10^6 tons/year) of FGD sludge from utility boilers and ocean dumping rates (10^6 tons/year) under the three scenarios. Data for present and projected rates is from Tobin (1982).

The results of these telephone surveys of state agencies and power companies are incorporated below.

2.2.1 Scenario I: Ocean Disposal Under Existing Conditions

Under existing conditions in which only currently active permits are extended to the year 2000, there will be no ocean disposal of coal ash or FGD sludge.

2.2.2 Scenario II: Ocean Dumping of Ash and FGD Sludge Under Relaxed Regulations

In determining the amount of coal ash and FGD sludge available for ocean dumping, we have examined data from Tables 2-6 and 2-7 and from various figures in Tobin (1982). This data represents the amount of coal ash resulting from coal conversion burners projected for the near term (i.e., before the year 2000) and the amount of coal ash projected from proposed coal-fired utility boilers by the year 2000. These numbers are in addition to the amounts generated by existing coal-fired utility boilers (Table 2-5). As such, they present conservative estimates of generation rate for the year 2000. To arrive at a number that represents the amount of waste that may be ocean dumped, we utilized the figures in Tobin (1982) to estimate the proportion of waste generated in those counties near the coast. Both numbers, the near-term amounts due to coal conversion and the numbers due to proposed facilities, were factored by the estimates of offsite disposal presented in Table 2-7.

In the New England region, there will be an additional 1,000,000 tons per year of coal ash generated as a result of coal conversion during the next 16 years. Exactly when these conversions occur will be determined by state regulatory activities and industry construction schedules. Table 2-7 also indicates that approximately 60% of this additional waste generated will be disposed off site. When considering that land is at a premium in New England, and much of the available land in the coastal region is wetland and, therefore, unavailable for landfilling, it can be assumed that offsite disposal to an ocean dumpsite would be an attractive option in this region. Assuming that the entire 60% of additional near-term waste generated goes to an ocean dumpsite, then by the year 2000 the New England States might dispose of 600,000 tons of coal ash per year to the ocean. This amount could increase to 1,500,000 tons of coal ash per year if the additional coal waste from proposed coal-fired utility boilers for the year 2000 is considered (Table 2-6). However, considering the efforts being made by industry to find markets for coal ash, some amount in the range of 600,000 to 1,500,000 tons per year will probably be available for ocean disposal. Coal ash does not appear to provide any unreasonable environmental degradation when ocean dumped. Also, ocean disposal can be considered the preferred option in this region under relaxed regulation. Environmental considerations would be served since availability of a regionally limited resource, land (and wetland in particular), would be conserved. Most of the coal burning power plants in the region are located on the coastline or in estuaries. Ocean disposal of ash under these conditions would be compatible with economic and transportation considerations. As indicated above, an industry representative in Region I has expressed interest in an ocean disposal option.

The same arguments apply to the disposal of FGD sludge in the region. At present, no FGD sludge is generated in the region. However, it is projected that 2,500,000 tons per year will be generated by the year 2000. Table 2-7 indicates that in the near term, 100% of this will be disposed off site. Considering the additional FGD sludge from proposed facilities, there may as much as 3,250,000 tons per year disposed of at ocean disposal sites.

In EPA Region II, most of the ash generated by existing utility boilers is in inland counties (Tobin, 1982; Figure 4.4). However, near-term conversion of utility boilers to coal will occur for the most part in coastal counties (Tobin, 1982; Figure 4.14). Of the 1,300,000 tons of ash generated by conversion in the near term, 80% will be disposed off site (Table 2-7). This leaves 1,000,000 tons per year from near-term coal conversion available for ocean dumping. Since this represents only waste generated from coal conversion plants, it can be considered a minimum. Tobin predicts 2,500,000 tons of coal ash for proposed utility boilers in the region. Approximately 30%, or 750,000 tons, of additional waste will come from coastal or near-coastal counties (Tobin, 1982; Figure 4.10). Again assuming an 80% offsite disposal factor, this provides a maximum of approximately 1,600,000 tons of coal ash per year available for ocean disposal from coal conversion and proposed facilities.

In Region II, approximately 950,000 tons of FGD sludge will be available for offsite disposal from near-term conversion of coal burning facilities in the coastal areas. Approximately 1,000,000 tons may be available from proposed facilities. Therefore, there may be about 1,000,000-2,000,000 tons of FGD sludge available for ocean dumping by the year 2000.

In the northeast, Region III is projected to produce the largest share of ash and FGD sludge. However, the majority of these wastes are expected from inland areas such as western Pennsylvania and West Virginia (Tobin, 1982; Figures 4.10, 4.11, 4.14, and 4.15). A considerable amount of these wastes are projected to be disposed off site (Table 2-7). Approximately 580,000 tons of ash can be expected from coastal areas due to near-term conversion to coal. An additional 2,000,000 tons of ash are predicted from proposed near coast facilities. In this region, Pennsylvania and West Virginia are the major generators. Regulations in Pennsylvania for the disposal of ash and sludge are explicit, and the regulatory environment can be considered relatively strict (for a summary of regulations in this state see Kurgan et al., 1984). This environment may encourage generators to seek other alternatives such as ocean dumping if it becomes available. In West Virginia, the relatively relaxed regulatory environment and the land-locked nature of the area would probably not encourage ocean dumping even if it were an alternative. Considering the above, it is reasonable to assume that a relatively small proportion of the coal ash generated in Region III would be available for ocean dumping under relaxed ocean dumping regulations. The range can be considered to be approximately 600,000-2,200,000 tons of coal ash per year by the year 2000. FGD sludge will probably range from 100,000 to 1,000,000 tons per year by the year 2000, depending upon the pace of coal conversion and construction of proposed facilities.

In the near term, conversion to coal in Region IV will not contribute substantially to existing (Tables 2-4 and 2-5) or projected (Table 2-6) ash or FGD sludge generation rates. Near-term conversion to coal will result in only 150,000 tons of coal ash and no FGD sludge in the region. However, substantial contribution will be made due to generation from proposed coal-fired utilities. Approximately 6,000,000 tons of coal ash and 5,000,000 tons of FGD sludge are projected for proposed coastal and Mississippi River plants. Despite the relatively high amounts of ash and sludge generated in the region, ocean disposal is unlikely to be the preferred disposal option. Among the coastal states in the region, regulation is relatively relaxed, and most of the utilities have substantial land for onsite disposal. Communication with the appropriate state agencies and some of the power companies in the region revealed that, in most instances, the states are just begining to inventory solid wastes and design regulatory programs. In Georgia, most of the ash and sludge wastes are disposed on site and there appears to be no problem with continuing this practice (Georgia Power Co., personal communication). The Department of Air Quality in South

Carolina indicated that they do not at present keep data concerning onsite disposal of ash or sludge. The Water Division in Mississippi is just begining a program to regulate disposal of ash and FGD sludge. In Florida, the Florida Department of Environmental Regulation is charged with controlling solid wastes. Their regulations are geared toward regulating municipal solid waste, and guidelines for storage of materials such as ash and sludge are vague (Kurgan et al., 1984). It is unlikely that even under a relaxed regulatory environment that any substantial ocean dumping of coal ash or FGD sludge will occur in this region.

The regulatory environment and disposal practices in EPA Region VI are very similar to those in Region IV. The major ash-generating coastal states are Texas and Louisiana. Louisiana is presently developing a new notification program for coal ash generators (Louisiana Department of Solid Waste). In Texas, coal ash and scrubber sludge are considered Class II wastes. That is, no permit is required for onsite storage or disposal. There are management guidelines, but they are not enforceable as regulations. Some reuse of ash occurs in highway construction and stabilization projects (Kurgan et al., 1984). Although projected coal ash and FGD generation rates for Region VI are high (Figures 2-1 and 2-2), the relaxed regulatory environment and extensive onsite disposal indicate that under Scenario II, ocean disposal is an unlikely option in this region.

In EPA Region IX, the major coal burning coastal state is California. Projected generation rates of coal ash are a minimum of 300,000 tons per year and generation rates of FGD sludge in this state amount to approximately 300,000 tons per year (Tobin, 1982). Regulations controlling the disposal of coal ash in California are relatively constraining. The extraction procedure testing for metals from ash in California is more stringent than even the EPA extraction procedure (California Energy Commission). As a result, if ocean disposal of coal ash were permitted, California utilities would likely exercise that option. Under Scenario II, approximately 300,000 tons per year of coal ash and 300,000 tons of FGD sludge would be available for ocean disposal from EPA Region IX.

In EPA Region X, very little coal ash and FGD sludge will be generated in the coastal areas. Approximately 200,000 tons of coal ash and 100,000 tons of FGD sludge per year may be generated in the coastal areas of Washington and Oregon. Disposal regulations in the coastal areas are relatively constraining and the amounts may likely be ocean dumped under the conditions of Scenario II.

2.2.3 Scenario III: Ocean Disposal Under Only Economic Considerations

To determine the amount of coal ash and FGD sludge which may be available for ocean disposal under only economic constraints, we have examined the comparative cost of ocean disposal versus landfilling of these wastes. Recent analyses of the cost of ocean dumping of ash have been made by Con Edison of New York in conjunction with their attempts to gain an ocean dumping permit to dispose of fly ash at Deep Water Dumpsite 106. Their present estimate of $4.70/dry ton (1982 dollars) for ocean disposal compares favorably with their estimate of $16.44/dry ton (1982 dollars) for landfilling. The estimate for ocean disposal was calculated over an approximately 20-year plant life and includes tug boat and barge leasing, and monitoring costs and assumes at least 500,000 tons per year will be disposed. This estimate for landfilling falls within the range of national averages, $15-$20/dry ton (1980 dollars), presented by Fradkin et al. (1982).

We have developed Scenario III by assuming that coastal plants with access to a good harbor would use the most economically favorable alternative. Wastes generated at inland plants have been excluded from our estimates since ocean disposal options for these plants would have to consider development of extensive inland transportation infrastructure to ship the wastes to the coast.

As noted earlier, land is at a premium in Region I and therefore the industry would welcome the ocean disposal alternative. Transportation distances to the coast for all coastal states in the region are relatively short. As a result, nearly all coal ash and FGD sludge generated in the region in the year 2000 would be available for ocean disposal. The only exception would be a small plant in Bowe, New Hampshire, which continues to market all of its coal slag as blasting grit. Under Scenario III, approximately 2,000,000 tons per year of coal ash and 3,250,000 tons per year of FGD sludge would be available for ocean disposal in Region I.

In Region II, there is considerable interest in ocean disposal of ash and FGD sludge. Con Edison of New York has been attempting to gain a permit to dispose of ash at sea, and they view this as a very desirable option particularly for coal burning facilities in the northeast. Considering only economic factors, nearly all the coal ash and FGD sludge in Region II would be available for ocean disposal under Scenario III. This would amount to 4,550,000 tons of ash per year and 4,900,000 tons of FGD sludge per year in the year 2000.

In Regions III, IV, and VI all coastal coal burning facilities will probably utilize ocean disposal under Scenario III. We have utilized the data of Tobin (1982) to determine the approximate amounts of ash and FGD sludge projected to be generated in these coastal areas in the year 2000. The added cost of rail transportation and plant reconstruction in the inland areas would probably preclude the use of ocean disposal by noncoastal facilities. Under these assumptions, the following amounts of ash and FGD sludge will probably be available for ocean disposal in the year 2000: Region III - 4,700,000 tons of ash and 1,000,000 tons of FGD sludge; Region IV - 4,500,000 tons of ash and 4,000,000 tons of FGD sludge; Region VI - 1,500,000 tons of ash and 1,000,000 tons of FGD sludge.

In Regions IX and X, the amounts of ash and FGD sludge available for ocean disposal under Scenario III would be the same as under Scenario II. That is only the coastal plants would use this option.

3. SEWAGE SLUDGE

This section considers the disposal of sewage sludge generated by publicly owned treatment works (POTWs). Municipal officials are presently confronted with a broad array of constraints bearing on the various alternatives available for ultimate disposal of these sludges. These constraints are not easily reconciled and numerous metropolitan areas remain uncertain over a suitable course for meeting their long-range sludge disposal needs. The following sections are concerned with predicting the role of ocean disposal in resolving such problems under the three scenarios described in Section 1.

3.1 EXISTING AND FORECASTED SLUDGE GENERATION RATES

The 1980 generation rate of municipal sewage sludge for the nation as a whole was estimated at roughly 7,000,000 dry tons per year (EPA, 1980; EG&G, 1983). It is expected that this total will increase substantially by 1990 as the goal of providing secondary treatment for municipal wastewater discharges is uniformly achieved. The potential role of ocean sludge disposal will be limited to coastal municipalities. Therefore, for the purposes of the present study, only the fraction of the nation-wide generation total produced at treatment works located in the coastal zone are considered. Such an analysis has been performed by NOAA's Office of Ocean Resource Coordination and Assessment (ORCA) as part of a comprehensive optimization study (Basta et al., 1982). Annual sludge generation estimates are provided for the years 1980 and 2000 based on data developed from the 1980 EPA "Needs Survey" of 2,001 individual treatment plants located within 318 coastal counties. Sludge generation was estimated by means of empirical algorithms developed for a total of

20 different unit process trains representing the various plant designs encountered in the survey. Using measured and projected flows and wastewater characteristics as reported to EPA, the algorithms produce estimated sludge yields based on generally accepted relationships drawn from standard sanitary engineering design practice. This provides a convenient and well-documented estimation procedure; however, such nominal relationships are known to serve only as first approximations when considering the performance of individual plants. Better accuracy can be expected when consideration is given to the collective performance of a number of plants representing a state or region. As noted in the ORCA report, the objective of their analysis lies in furnishing a data base for strategic planning purposes, as opposed to detailed cost estimation, operational planning, or system design. Such a level of accuracy is presumed to be appropriate for the present study as well.

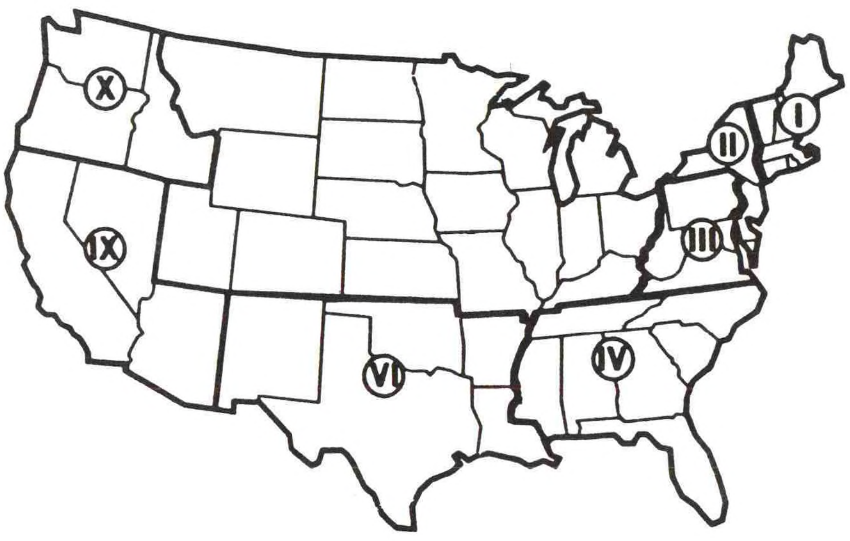
The accuracy of the forecasted generation rates for the year 2000 is primarily sensitive to the assumption that all of the facilities will be providing secondary treatment at that time, whereas primary treatment is the predominant treatment level reflected in the 1980 estimate. This assumption is the main reason for an overall increase of 130% predicted over the 20-year period within the nation's coastal zone as a whole. In 1980, it was reasonable for municipalities to anticipate a requirement to provide secondary treatment and to report upgrading plans in the Needs Survey questionnaires. Many had already made material progress toward that goal. More recently, the possibility of obtaining a waiver of secondary treatment requirements under Section 301(h) of the Clean Water Act has become an increasingly realistic possibility. In turn, the actual number of secondary plants which will be in operation by the year 2000 is becoming more difficult to predict. EPA must approve or disapprove of such waivers on a case-by-case basis and it is difficult to anticipate the outcomes without first-hand familiarity with the specific issues involved in each instance. However, it is clear that the decisions made in connection with the major urban centers will have a large impact on the quantity of sludge generated in the future. Upgrading a plant from primary to secondary treatment level can affect the sludge production rate by a factor of two or three. This clearly outweighs the effect of population growth or industrial/commercial development within urbanized sewerage systems.

Another important factor in predicting sludge generation is the selection of particular sludge processing systems within the overall treatment plant design. Conventional anaerobic digestion, for example, can provide net solids reductions of perhaps 70%, depending on the volatile solids fraction of the raw sludge (WPCF, 1977). The particular sludge processing system used is often dictated by the ultimate disposal method and the regulatory and economic constraints associated with that alternative. Thus, the generation rates cannot be considered strictly independent of the various disposal scenarios. In the ORCA estimates, it appears that either aerobic or anaerobic digestion, or some equivalent means of solids reduction, is uniformly assumed in specifying future unit process trains at the major treatment plants. It is thought that this is a reasonable assumption, consistent with the fact that most plants have digestion facilities in operation at the present time. The question of whether digestion is ultimately required for ocean disposal is likely to be decided on environmental grounds. The economics are related to wet tonnage which is not significantly affected by digestion.

Estimates of present and future generation rates summed for each EPA Region of interest are presented in Table 3-1 and summarized in Figure 3-1. These are directly based on the estimates for the individual states and for the major metropolitan areas in Basta et al. (1982; Tables 3 and 4, respectively).

Table 3-1. Summary of ocean disposal scenarios for sewage sludge (all quantities in thousands of dry tons per year).

Region	Sludge Generation		Disposal Scenarios		
	1980	2000	I	II	III
I	115	250	0	175	200
II	330	1,087	265	850	1,000
III	333	652	0	600	650
IV	151	490	0	100	250
VI	147	288	0	0	40
IX	648	1,142	117	600	800
X	124	348	0	0	40



Map of EPA Regions

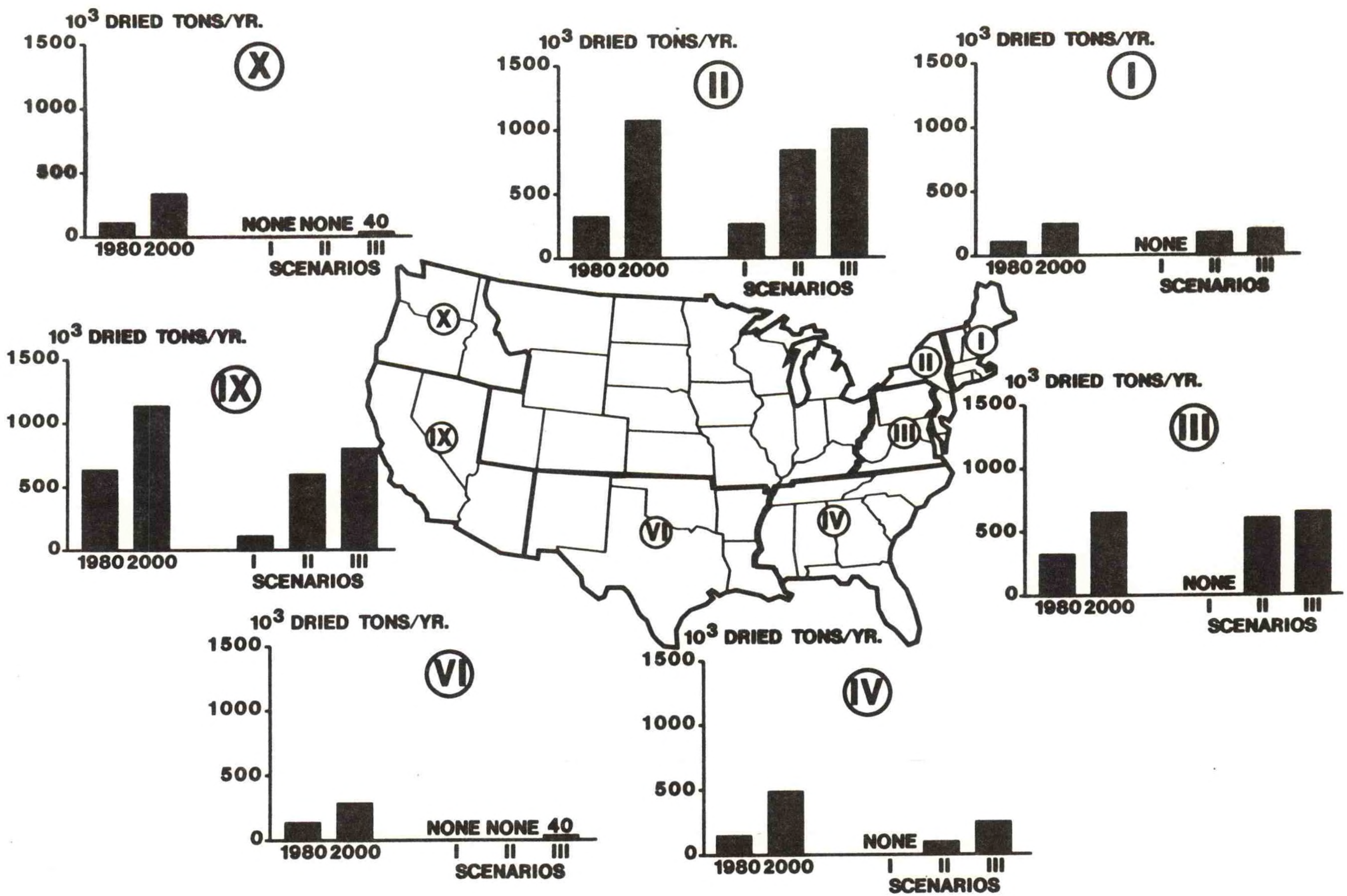


Figure 3-1. Present (1980) and projected (2000) generation rates (10^3 tons/year) for sewage sludge and ocean dumping rates (10^3 tons/year) under the three scenarios. Data for present and projected rates is from Basta et al. (1982).

Again, the sludge generation estimates only account for those plants in each region located within coastal counties.

3.2 OCEAN DISPOSAL SCENARIOS

The following sections provide estimates of the quantity of sewage sludge which may be expected to be ocean dumped under the three regulatory scenarios presented in Section 1. Table 3-1 and Figure 3-1 present a complete summary of the projections for each EPA Region.

3.2.1 Scenario I: Ocean Disposal under Existing Conditions

A strict interpretation of the present regulatory climate affecting ocean dumping would imply a projection of no ocean dumping of sewage sludge in the year 2000. As described in Section 1, the present regulations apply strict criteria to define waste materials presumed to "unreasonably degrade" the ocean environment. This had the effect of eliminating the possibility of obtaining a permit to dump sewage sludge at sea and resulted in plans to phase out all existing dumping operations. However, as of November 2, 1981, EPA is under court order to issue revised criteria which take into consideration a cross-media assessment of environmental and human health risks. This is anticipated to allow at least the present level of ocean dumping to continue. EPA intends to issue interim rules by 1985. Because there is a firm basis for expecting a relaxation of the previous regulations within the near future, it is considered realistic to base the projection under Scenario I on present levels of dumping as reflected in the ORCA data base.

Present ocean dumping practices are limited to New York and New Jersey which dispose of sludge at the 12-mile site and comparatively small quantities of digester clean-out residues at Deepwater Dumpsite 106. Recent EPA decisions, however, will require New York to dump at Deepwater Dumpsite 106 at least on an interim basis. According to data from EPA Region II files as reported by Temple, Barker and Sloan, Inc. (1982), the total quantity of sludge ocean dumped in 1981 was 225,000 dry tons. This agrees reasonably well with the ORCA estimate of 265,000 dry tons. Table 3 in Basta et al. (1982) also lists 40,000 dry tons as being ocean dumped by Philadelphia in 1980. Alternative land-based disposal methods have since been adopted and this quantity is not included in Table 3-1.

A further situation which deserves comment is Boston, which discharges between 60 and 70 dry tons per day of digested primary sludge by means of ocean outfalls. This translates to roughly 22,000 tons per year. ORCA does not list any sludge quantity under ocean disposal for Massachusetts, but lists 25,000 tons under a miscellaneous category. The outfalls terminate at points within Boston Harbor, therefore it is questionable whether this practice should be included under the category of ocean dumping. For the purposes of this report, Table 3-1 reflects the ORCA categorization and excludes Boston from Scenario I.

The final case of existing ocean disposal is the discharge of digested sludge by the City of Los Angeles from the Hyperion outfall which extends seven miles from the coast to a depth of 195 feet. The quantity of sludge is reported to be 164 tons per day (NACOA, 1981), or 60,000 tons per year. This compares with an ORCA estimate of 117,000 tons per year.

In summary, the ORCA estimate for New York and New Jersey is confirmed to be in good agreement with estimates from EPA Region II. For Boston and Los Angeles, certain discrepancies arise in comparison with independent estimates, but the quantities involved are small in comparison with the overall generation of sludge for the respective regions.

3.2.2 Scenario II: Ocean Disposal under Relaxed Regulation

Various scientific studies of the New York Bight and the coastal waters off southern California indicate that the dumping of sewage sludge provides a comparatively minor source of trace metals and other contaminants, and that the impacts on the marine food chain are, in many cases, less severe than previously thought (NACOA, 1981), although there are impacts. While it is not the objective of this study to review the environmental effects of ocean sludge disposal, such findings are cited because they raise the realistic possibility that the rate of ocean disposal could be substantially increased without necessarily degrading the receiving waters.

This possibility forms the basis of Scenario II in which it is assumed that the major urban centers, especially along the east coast, will find land-based disposal alternatives to be environmentally objectionable and/or a source of significant human health risks. Also, within areas of high population density, there is intense competition among development interests for the available land. Use of the land for the disposal of sewage sludge is likely to encounter controversy and public opposition whenever it must compete with more desirable alternatives. In many cases, states and counties have already enacted legal barriers to land-based disposal and even to the transshipment of sludge through their jurisdictions.

On the other hand, it is realistic to assume that smaller communities in areas devoted to more rural land use patterns where the competition is less intense will continue to have access to land-based disposal and will not resort to ocean dumping, even when there may be a moderate economic incentive to do so. In fact, this preference appears to be widespread as evident from the responses of municipal officials contacted during an earlier study (EG&G, 1983) and confirmed in a similar series of interviews performed by GAO (1983). There are numerous reasons for this attitude, but the essential point is that Scenario II appears to be based on a realistic presumption in this respect.

The following paragraphs briefly review the basis for the estimates provided in Table 3-1 for each EPA Region under Scenario II.

Region I - New England

A total of 175,000 tons is projected for New England by summing the ORCA estimates for Connecticut, Rhode Island and Massachusetts and assuming that 80% of this generation would come from metropolitan areas where the availabliity of land-based disposal options would be limited. There is no rigorous basis for this assumption and it is made simply for lack of more specific information; i.e., the ORCA data base does not include a further breakdown by metropolitan areas in Region I, even for the Boston metropolitan area. Separate estimates (U.S. EPA, 1980) of the sludge production for Boston are available for the year 1985 assuming upgrading to secondary treatment by means of trickling filtration. This estimate is equivalent to 50,000 tons per year. Population growth and industrial flow are expected to remain essentially static within the area, so that this generation rate may be extended through the year 2000 as a rough estimate. This compares to an ORCA estimate of 72,000 tons determined by prorating the total for Massachusetts based on a metropolitan area population of 2.0 million as compared to a total coastal population for the state of 2.9 million. This comparison indicates that the projected disposal of 175,000 tons may be a liberal estimate.

Boston has been denied a secondary treatment waiver. Therefore, its sludge disposal requirements will likely increase above the present levels of roughly 22,000 tons per year. Several other New England communities are also seeking waivers, therefore the sludge disposal projections in this region are quite speculative at the present time. By state law, Connecticut presently requires secondary treatment for all municipal discharges, thus, the estimates for this state are perhaps the least sensitive to future regulatory developments.

Region II - New York/New Jersey

The projected total for Region II of 850,000 tons is comprised of 620,000 tons for New York City and Essex County, New Jersey, as estimated by Basta et al. (1982). It also includes an additional 130,000 ton allowance for Nassau and Westchester Counties in New York and Bergen, Passaic, Union and Middlesex Counties in New Jersey. All of these communities are presently disposing of their sludge by ocean dumping. Consequently, the increase from Scenario I to Scenario II does not result from any additional communities engaging in ocean disposal; rather, it is attributable to the effect of population and industrial growth in New Jersey (where secondary treatment is widely in place) and to upgrading of the New York City facilities from primary to secondary treatment. As reflected in the ORCA data base, the effect of upgrading is dramatic, increasing from 103,000 to 525,000 tons from 1980 to 2000. At present, ocean dumping, which will continue for New York at Deepwater Dumpsite 106, is considered an interim solution.

Region III - Mid-Atlantic

Ocean dumping would appear to offer a convenient disposal alternative for most communities within this region given the extensive protected coastline provided by the Delaware and Chesapeake Bays and the resulting number of docking and loading facilities. Also, the major cities of Philadelphia, Baltimore and Washington are surrounded with sprawling suburban communities. Competition among various land uses is high throughout most of the region. This implies that the resort to ocean dumping would be widely justified under the assumptions of Scenario II. Consequently, the projection of 600,000 tons per year is a high percentage of the total regional generation of 652,000 tons. The projection figure consists of the sum of the generation estimates given by Basta et al. (1982) for Philadelphia, Baltimore, Washington, and Prince Georges County in Maryland plus 50% of the generation in Delaware, Virginia, and the remaining generation in Maryland.

In response to an informal survey (GAO, 1983), both Baltimore and Philadelphia expressed interest in ocean dumping as a future alternative to land-based disposal. Until recently, Philadelphia had relied on ocean dumping as its primary means of disposal.

<u>Region IV - Southeast</u>

The coastal region along the southeastern and Gulf coasts contrasts strongly with the northern states in terms of population and land use profiles. In general, the competition among land uses is not nearly as high and the metropolitan areas do not present the same concentrated magnitude of sludge generation. Port facilities suitable for ocean-going barge operations are also more widely distributed along the coastline, providing less convenient access to loading facilities for many communities.

The major exception to this general description is the south Florida area, comprised of Dade and Broward Counties. This area is also characterized by high groundwater conditions which discourage reliance on landfill disposal. Consequently, it is assumed that ocean disposal will only be justified in this particular area with the projection of 100,000 tons per year being equivalent to 85% of the total for Dade and Broward counties as given in Basta et al. (1982).

<u>Region VI - Texas/Louisiana</u>

The metropolitan areas of concern under Scenario II for this region include New Orleans and Houston. Since both areas have excellent port facilities, there are no practical limitations regarding barging operations. However, neither of these areas has relied on ocean dumping in the past and there was no indication in the literature that land-based disposal alternatives might become unavailable in the future. Consequently, the disposal requirement is set to zero for Scenario II.

Region IX - California

The Los Angeles metropolitan area is confronted with a situation which is similar in many respects to the one in New York. The city has historically relied on ocean disposal and still discharges digested sludge from the Hyperion outfall; however, it is presently committed to a phase-out of this practice and is attempting a conversion to land-based alternatives. This effort has met with considerable public opposition (NACOA, 1982), evidence of the highly competitive nature of land use in the area and the negative public perception of sewage sludge disposal operations. Under relaxed regulatory criteria, Los Angeles would certainly fall back on ocean disposal as the most desirable course to follow.

Both Los Angeles and Orange County presently have secondary treatment facilities in operation sufficient to treat less than half of the combined wastewater flow. While these facilities will remain in operation, it is possible that the majority of the wastewater will remain subject to primary treatment only should a 301(h) waiver be obtained.

The San Francisco Bay metropolitan area (Santa Clara and Alameda Counties) is excluded from Scenario II. San Francisco and Oakland both report satisfactory land-based alternatives (landfilling and composting, respectively) for the present, but foresee the possibility of ocean disposal becoming an attractive option in the future (GAO, 1983). In any event, the situation does not appear so pressing as in the case of Los Angeles, and the area is reserved for inclusion under Scenario III.

Region X - Northwest

The Puget Sound metropolitan area does not appear to have a pressing sludge disposal problem and will most likely not face the prospect of such a problem in the foreseeable future. In addition, there does not seem to be any interest in pursuing ocean disposal as an alternative. For example, Seattle reports that ocean disposal would be more expensive than current land-based alternatives. Tacoma has historically converted its sludge to a fertilizer product. The possibility exists that this may be restricted in the future due to concern over such contaminants as cadmium in connection with agricultural applications. Land-based alternatives will presumably tend to become less convenient toward the year 2000 and costs are likely to rise moderately as well. However, it is presumed that these alternatives will remain viable and publicly acceptable, so that the resort to ocean dumping will not become necessary within this time frame.

An important factor in the sludge disposal issue is the likelihood of primary treatment being allowed under provisions of 301(h) waivers. This will minimize the quantities of sludge generated and ease the demands on local landfills.

3.2.3 Scenario III: Ocean Disposal under Economic Constraints Only

The low cost of ocean disposal to coastal communities has historically been the most attractive feature of this alternative. Experience in the New York Bight, for example, indicates a cost of roughly $5 per wet ton in comparison with costs of perhaps an order of magnitude higher for land-based options. This is a clear situation where ocean disposal would automatically be the alternative of choice if the decision were to be based on economic criteria alone. As noted previously, however, Seattle has found the cost of ocean disposal to exceed that of the present landfilling operations, therefore, it does not follow that ocean disposal will always provide the most economic alternative. However, it is fair to assume that many metropolitan areas will find that their present disposal operations are no longer viable at some point prior to the year 2000. The increased costs of opening new landfills, providing new incinerator facilities, or initiating composting operations would then be unlikely to compare favorably with the costs for ocean disposal. Consequently, even with freedom from regulatory constraints, it is unlikely that most coastal cities would immediately resort to ocean dumping; but it is considered quite likely that a majority along the east and west coasts would do so eventually over the next 15 years.

The major economic disadvantage to ocean disposal probably lies with the transportation cost incurred when the treatment plant is removed from a suitable docking facility, or when the plant is not located on the coastline where an outfall could be economically constructed. These situations are most likely to occur in rural or lightly populated areas with small, decentralized treatment facilities. It is beyond the scope of this analysis to investigate the engineering economics involved in such cases; rather it is assumed that the intent of Scenario III is to provide an approximate upper bound on disposal estimates for the various regions. Consequently, it is sufficient to include an allowance for all the major metropolitan areas and a substantial percentage of the generation allocated to the surrounding rural areas. In almost all cases, generation outside of the urban centers is comparatively small, and it is unnecessary to devote attention to this aspect of the problem.

The following paragraphs provide details on the assumptions made in estimating the projected disposal requirements for each region. The estimates are summarized in Table 3-1 and Figure 3-1.

Region I - New England

The increment over Scenario II consists of the New Hampshire generation total of 13,000 tons plus 50% of the total for Maine, bringing the total ocean disposal amount to 200,000 tons or 80% of the total generation for the region as a whole. Maine and New Hampshire presumably have land-based alternatives available, but the costs of ocean disposal are considered likely to be cost competitive in nearly all cases where there is a significant population density.

Region II - New York/New Jersey

The assessment made in this case is that port facilities are not likely to be a limiting factor and the concentration of population is generally greater than in Region I. Consequently, a higher percentage of the generation could be economically ocean dumped, e.g., 90%. Essentially, this includes the entire coastal zone of the region with the exception of certain portions of the rural area of southern New Jersey.

Region III - Mid-Atlantic

The assessment in this region is essentially the same as in Region II; i.e., that upwards of 90% of the generation total could be economically ocean dumped.

Region IV - Southeast

Along the southeastern coastal zone, both the population density and distribution of docking facilities tend to decrease significantly in comparison with the regions to the north. The cost incurred in transporting the sludge to the docking facility must be weighed against the likelihood of having ample local landfill capacity conveniently at hand. The judgement in this region is that ocean disposal would prove economically attractive only in the major urban areas. The increment to Scenario II is then estimated to consist of the Tampa metropolitan area (Hillsborough and Pinellas Counties in Basta et al., 1982), and an additional allowance of 20,000 tons for the ports of Wilmington, Charleston, and Savannah. In the GAO survey, Jacksonville indicated it was satisfied with land-based alternatives.

Region VI - Texas/Louisiana

The assessment made in this region is similar to that in Region IV. Given the lack of any history of ocean disposal and the indicated adequacy of land-based alternatives, the judgement is made that ocean dumping would remain restricted; i.e., 15%.

Region IX - California

The increment to Scenario II consists of the San Francisco Bay area (Santa Clara and Alameda Counties) and the San Diego metropolitan area. Both areas could conceivably be included under the estimate given for Scenario II as well.

Region X - Northwest

As noted previously, Seattle has found the cost of ocean dumping to exceed those for available land-based alternatives. Whether this cost comparison will continue to remain unfavorable for ocean dumping by the year 2000 is somewhat speculative. However, it appears justified to assume that ocean dumping will not be the predominant means of disposal in the region, even on a purely economic basis. Consequently, the disposal amount is nominally estimated at 10% of the generation total for the region.

4. HAZARDOUS/INDUSTRIAL WASTES

4.1 EXISTING AND FORECASTED GENERATION RATES

Hazardous/industrial wastes are made up of thousands of waste streams, therefore this category is extremely complex. Data on the quantities of hazardous wastes generated in this country are emerging and it is acknowledged that the existing data base is soft. Manifest reports that states are required to submit to EPA will contribute greatly to regional estimates of the quantities of wastes that are disposed of off site. However, most states are presently (June 1984) in the process of preparing these reports and a central data base has yet to be established. Further, most of the available statistics are for large generators of hazardous waste (>1,000 kg per month); small generators have not been required to report quantities.

EPA has established a hazardous waste identification system which provides a useful framework for classifying wastes by characteristic. Characteristic hazardous wastes include those that are ignitable (D001*), corrosive (D002*), reactive (D003*) or EP (extraction procedure) toxic with respect to specific contaminants such as particular metals or organics (D004-D007*). In addition, there are several other general categories of wastes including generic solvents and sludges (F001-F012*), listed wastes from specific industries (K001-K106*), discarded commercial products, off specification products, and spill residues (P001-P122*) and toxic wastes including commercial chemical products and intermediates (U001-U247*). Individual states may supplement this list.

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*EPA Waste Codes

We reviewed these broad categories of hazardous wastes from the perspective of ocean disposal. While these are selected waste categories which might be considered for ocean disposal, one in particular deserves special attention. This is waste with corrosive characteristics. Of the various categories of wastes, corrosives (acids and alkalis) are the most likely candidates for ocean disposal. The ocean can provide a buffering medium for treatment of these wastes. In addition, Allied Chemical and DuPont are currently using the ocean as a diposal medium for corrosive wastes. Furthermore, corrosive wastes are generated in large quantities and are worth special consideration with regard to waste management. It should be noted that not all corrosive wastes are comprised of liquid acids and alkalis and new problems would have to be considered with regard to disposal of solid corrosive material.

Hazardous wastes contain a variety of chemicals. A partial list of these is given in Table 4-1 and additional data can be found in ICF (1984). Corrosive acids and alkalis listed under D002 may be considered hazardous strictly based on characteristic or may contain some metals and organics. The fate and effects of these contaminants must be considered for disposal options. The kinds and quantities of chemical contaminants will depend on the nature of the manufacturing or chemical process which generates the waste. Some acid or alkali wastes may be listed as EP toxic or as generic sludges because of high concentrations of metals, organics, or solids. The chemical contaminants in the three industrial wastes presently dumped at sea are given in Table 4-2.

The following sections describe the quantities of hazardous wastes and the amounts which are currently, and which in the future may be ocean dumped. Because of the potential importance of corrosive wastes from an ocean disposal perspective, these are given special attention.

Table 4-1. Constituents of concern in selected hazardous waste streams.

Treatment Sludge from Pesticide Production	Toxophene, Parathion, Chlordane, 1,2-Dichloroethane
Metal Sludges	Various metals (e.g., Hg, As, Pb, Cr, Cd)
Wastewater from Organic Chemical Production	Various organics including chlorinated and aromatic hydrocarbons
Ocean Dumped Acid and Other Industrial Waste	Certain metals, some organics
Solid Residues	Heavy metals
Cyanide Sludge	Cyanide, Arsenic, Phenols
Acid Solutions Containing Metals	Various metals (e.g., Cr, Pb)
Oily Wastes	Heavy metals and PAHs
Phenolic Wastes	Phenols, polynuclear aromatic hydrocarbons
Residues from Organic Chemical Production	Various organics including chlorinated and aromatic hydrocarbons
Other Concentrated Organics	Carbon tetrachloride, phenols, PCBs, 1,2-Dichloroethane
Spent Solvents	Various volatile organics (e.g., TCE, toluene)
Solvent/Metal Sludges	Methyl ethyl ketone, toluene, chromium, mercury, lead
Still Bottoms (Solvent Recovery)	Various volatile organics (e.g., TCE, toluene)
Mineral Wastes	Asbestos

Table 4-2. Chemical characteristics of industrial wastes currently disposed of in the ocean.

Constituent	Units	Allied Chemical	Dupont-Grasselli	Dupont-Edge Moor
Arsenic	µg/l	<2-<10	-	20
Cadmium	µg/l	<2-10	222	1,000
Chromium	µg/l	<20-400	128	200,000
Copper	µg/l	<10-200	276	8,000
Mercury	µg/l	<0.2-<20	4	100
Nickle	µg/l	<10-700	745	16,000
Lead	µg/l	<50-200	701	5,200
Zinc	µg/l	<5-580	275	110,000
Iron	µg/l	-	-	10-50
Total Solids	µg/l	-	113	240
Total Carbon	µg/l	-	4,765	690
COD	µg/l	-	9,780	10
Oil & Grease	µg/l	-	16	-
Petroleum Hydrocarbons	µg/l	-	12	-
Phenols	µg/l	-	2	-
pH	(S.U.)	0.1-1	11.2-13.3	0.01-1.0

Three main sources of information were used to assess how much hazardous waste is currently generated and disposed of in the United States. These sources include:

1) Individual state reports on either waste disposal needs assessments, generators, or the hazardous waste manifest system. These were obtained by EG&G for many of the coastal states. However, a number of states have not completed reports, and in a number of cases the quality of reporting is poor.
2) Booz-Allen & Hamilton, Inc., and Putnam, Hayes & Barlett, Inc. (Booz-Allen 1980). Hazardous waste generation and commercial hazardous waste management capacity, an assessment. U.S. EPA Office of Solid Waste. Publication No. SW-894.
3) Westat, Inc. 1984. National survey of hazardous waste generators and treatment, storage and diposal facilities regulated under RCRA in 1981. U.S. EPA Office of Solid Waste. 232 pp. plus appendices.

Available data obtained for coastal states are presented in Table 4-3. As noted above, there are a number of gaps in the information available on a state-by-state basis. These gaps can be filled over the next year as states complete their reporting to EPA. However, a few points are worth noting from this table: 1) where data are available on total generation of hazardous waste, the numbers range from approximately 100,000 metric tons/year (Virginia) to around 42,000,000 metric tons/year (Louisiana); 2) corrosive wastes often comprise a substantial portion of the total waste generated; 3) most of the waste is treated or disposed of on site; 4) for the states for which data were available, offsite disposal of corrosive wastes varies between 72 (Alaska) to over 600,000 (Mississippi, Pennsylvania) metric tons per year. The median quantity of corrosive wastes

Table 4-3. Data on the annual quantities (metric tons) of hazardous wastes and that portion designated as corrosive (D002) generated and/or disposed of off site for various coastal states. Data include most recent statistics available (generally 1981-1983 period).

States by EPA Region	Hazardous Waste Generated (MT)		Disposal of Offsite (MT) Manifested		
	Total	Corrosive	Total	Corrosive	
Region I					
Maine	NA	NA	11,254	590	
New Hampshire	NA	NA	10,883	4,219	
Massachusetts	NA	NA	NA	NA	
Rhode Island	NA	NA	13,484	697	
Connecticut	NA	NA	Not Estimated	10,409	(Est.)
Region II					
New York	10,759,920	10,134,278	149,585	46,152	
New Jersey	NA	NA	451,292	54,918	
Region III					
Pennsylvania	NA	NA	801,066	608,495	
Delaware		(236 Notifiers)			
Maryland	NA	NA	234,057	6,895	
Virginia	104,328	20,865	32,000	8,000	
Region IV					
North Carolina	2,792,182	785,720	NA	7,857	(Est.)
South Carolina	NA	NA	NA	NA	
Georgia	32,010,110	30,400,050	254,496	13,755	
Florida	2,399,725	2,308,626	42,905	933	
Alabama	NA	NA	NA	NA	
Mississippi	3,004,050	2,965,888	623,962	623,292	
Region VI					
Louisiana	42,214,928	4,744,749	553,367	8,323	
Texas	NA	NA	NA	NA	
Region IX					
California	NA	NA	NA	NA	
Region X					
Alaska	NA	NA	404	72	
Washington	467,969	117,344	66,305	NA	
Oregon	NA	NA	NA	NA	

NA = not available at time of report preparation.

generated within a coastal state for offsite disposal is approximately 8,000 metric tons/year.

Several estimates have been made on total hazardous waste generation in the country. Booz-Allen (1980) estimated that approximately 41,000,000-43,000,000 wet metric tons of hazardous wastes are generated (1980-1981) and that approximately 9,700,000 tons (23%) were disposed of off site. A more recent survey (Westat, 1984) has estimated that a much larger quantity of hazardous waste is generated (264,000,000 metric tons) and that only about 4% of this (~10,400,000 metric tons) was shipped off site for treatment and/or disposal. This recent survey is supported by the individual state reports examined by us inasmuch as the total quantity estimated by Booz-Allen could be accounted for by a single state, Louisiana, thus, the Booz-Allen estimate probably greatly underestimates the quantity generated. While the Booz-Allen and Westat estimates for total generation differ by a factor of six, their estimates for quantities disposed of off site are close (9,700,000-10,400,000 metric tons). Booz-Allen provides estimates of the quantities of hazardous wastes requiring offsite disposal or treatment for each of the EPA regions. Coastal EPA regions in which over an estimated 1,000,000 metric tons per year require offsite disposal include Regions II, IV, and VI. Of these, Region II has the smallest geographic area and conflicts for land use can be expected to be greatest.

Westat (1984) has estimated the quantity of corrosive wastes managed in the U.S. as approximately 123,000,000 metric tons, or almost half of the total waste generated. Again, most of the waste is handled by onsite treatment (e.g., neutralization, deep-well injection) as can be seen in the data obtained by us for Georgia, Florida, Mississippi, and Louisiana (Table 4-3). However, some portion of this waste will be disposed of off site. Based on the limited data available at this time, we estimate that offsite disposal of corrosive waste will be less than the

4% for total waste overall. Because acids and alkalis can often be handled by onsite neutralization programs (as is done with most of the corrosive waste generated in Florida and Louisiana), proportionally less corrosive waste will require offsite disposal. Using the information presented in Table 4-3, we estimate that the quantities of corrosive wastes requiring offsite disposal probably amount to 1-2% of the total corrosive waste generated. Still, this can represent a large quantity of wastes (thousands of metric tons per year) for particular states.

Using the data developed by Booz-Allen and Westat, Table 4-4 presents some first order estimates of the quantities of hazardous wastes generated by coastal EPA regions (including noncoastal states within a coastal region). Data obtained from individual states has helped with these estimates. The largest quantities of hazardous wastes generated and also requiring offsite disposal are generated in Regions IV and VI which include much of the southwest U.S. and all the Gulf Coast states. The largest quantities of corrosive wastes requiring offsite disposal occur in Regions III and IV and reflect the volumes of this kind of waste generated within Pennsylvania and Mississippi, respectively (Table 4-3).

Where data are available, the estimates for offsite disposal of corrosive wastes appear to be in the right range. For Region I, reports from four of the six states yield a quantity of 15,915 metric tons of corrosive waste (Table 4-3) which is within a factor of two of the estimates we derived from the Westat data and the Booz-Allen data for the same area. For Region II, the quantity of corrosive waste generated for offsite disposal is 101,070 metric tons (New Jersey and New York in Table 4-3) which is very close to the estimate for the region (Table 4-4).

In order to estimate how quantities of wastes generated and disposed off site might change in the future, i.e., preditions for the year 2000, we contacted industrial trade associations

Table 4-4. First order estimate of the quantities (metric tons) of hazardous wastes and that portion that is corrosive which are generated and/or disposed of off site for coastal EPA regions.

EPA Region	Wastes Generated (MT)		Disposed of Offsite (MT)	
	Total[a]	Corrosive[b]	Total[c]	Corrosive[d]
I (ME, NH, VT, MA, RI, CT)	6,624,000	3,047,000	580,000	30,470
II (NY, NJ, PR)	19,296,000	8,876,000	1,022,000	88,760
III (PA, MD, DE, WV,	27,042,000	12,439,000	922,000	623,390[e]
IV (KY, TN, NC, SC, GA, FL, MS)	64,182,000	36,460,204[f]	1,358,000	645,837[f]
VI (LA, TX, NM, OK, AR)	66,150,000	30,429,000	1,346,000	304,290
IX (CA, HI, NV, AZ)	17,550,000	8,073,000	896,000	80,730
X (AK, WA, OR, ID)	6,138,000	2,823,000	503,000	28,230

[a] Booz-Allen estimate for each region was multiplied by 6, the factor that their estimates differed from Westat's more accurate national estimate.

[b] Estimated as 46% of total (from Westat) or as indicated by state data.

[c] Taken directly from Booz-Allen; these numbers compared well with Westat on a national basis.

[d] Calculated as 1% of total corrosive wastes or modified based on individual state data.

[e] Includes 3 of 5 states.

[f] Includes 4 of 6 states.

(e.g., Chemical Manufacturers Association), individual companies (e.g., Allied Corporation), and reviewed the existing EPA reports. The concensus is that it is not possible to predict future generation of hazardous wastes with any reliability. The Chemical Manufacturers Association is developing a data base for assessing trends, but have not reached the point where they can estimate future generation rates.

The most recent EPA report on hazardous waste generation (Westat, 1984) included a discussion, presented here, of the factors which might affect future generation of hazardous waste.

The quantity of RCRA-regulated hazardous wastes generated at any point in time is essentially affected by two factors:

- the specific nature and scope of the RCRA hazardous waste regulatory program at that time; and
- the nature of the industrial and other activities that actually result in hazardous by-products.

Currently, Congress is considering a number of statutory changes to RCRA. Some of these changes, upon enactment, would have a considerable effect on the range of activities covered under the RCRA regulatory program and, therefore, upon the quantities of RCRA-regulated hazardous waste generated in the future. Important among the statutory changes under consideration are proposals to reduce the "small quantity generator" definition for generators of hazardous waste. While firm estimates of the numbers of small quantity generators that would be affected by such a change are not yet available, it is assumed that thousands of currently exempt firms would be brought into the RCRA-regulated community under these provisions. Furthermore, while information is also not yet available to estimate the additional quantities of hazardous waste that would be regulated under RCRA as a result of such a provision, it seems clear that an increase in the size of the RCRA-regulated population will serve to increase the quantities of regulated hazardous waste generated in the future.

Other changes currently under consideration by the Congress and at EPA involve the removal of exemptions for wastes burned as fuels, and removal of certain exemptions covering recycling activities. All of these changes to the RCRA regulatory program would be expected to result in greater quantities of wastes regulated under RCRA in the future.

Implementation of industrial pretreatment standards by EPA and states may also affect future hazardous waste generation. Currently, an unestimable quantity of otherwise hazardous wastes are exempted from regulation under RCRA because they legally pass through public sewer systems into Publicly Owned Treatment Works (POTWs). While the quantities of such wastes has not been estimated, information from various sources suggests that such quantities are indeed large. The Massachusetts Bureau of Solid Waste Disposal, for example, estimates that the quantity of hazardous waste generated annually in Massachusetts could increase by more than 50 percent with the implementation of pretreatment standards and the installation of industrial pretreatment processes by currently exempt generators. Similar experiences in other states would add considerably to the quantities of hazardous waste regulated under RCRA in future years.

Increased industrial output, prompted by improved economic conditions, could also increase hazardous waste generation in future years. It is generally believed that there exists a direct relationship between these two factors. Thus, hazardous waste generation would be expected to increase during periods of improved economic conditions.

EPA is currently proposing the listing of additional wastes as hazardous wastes. To the extent that such listings, now and in the future, are actually promulgated, the quantities of hazardous waste regulated under RCRA are expected to increase accordingly.

Finally, increased cleanup of abandoned or closed hazardous waste sites will generate additional quantities of hazardous waste that require proper disposal under RCRA. The survey observed some such quantities being generated during the 1981 calendar year. Implementation of the "Superfund" program by EPA and states has advanced since 1981 and is expected to continue to advance in coming years, with resulting increases in the quantities of hazardous waste to be managed.

While the factors stated above are among those expected to result in increases in hazardous waste generation in future years, a number of other factors are expected to contribute to decreases in future hazardous waste generation. Prominent among these are proposals in Congress and some states to adopt specific taxes on the generation and/or disposal of hazardous waste. These taxes are often intended, among other things, to provide economic disincentives toward the actual generation of hazardous waste. These and other existing or future economic factors are expected to encourage industries to engage in greater "source reduction" and "source separation" to eliminate or reduce their generation of hazardous waste.

Further regulatory actions by the Congress and EPA that may encourage or require reductions in hazardous waste generation include proposed bans on the land disposal and underground injection of certain hazardous wastes. As disposal options for hazardous waste become more limited and more costly, generators will be encouraged to reduce their hazardous waste generation.

Finally, one of the purposes behind the enactment of the Resource Conservation and Recovery Act was to encourage the conservation of natural resources through the use, reuse, recycling, and reclamation of materials contained in industrial and other waste streams. As the value of natural resources increases, economic incentives for such recycling activities are expected to increase, resulting in increased efforts by generators to turn their waste streams into useful, valuable commodities.

It is difficult, if not impossible, to draw any firm conclusions concerning future hazardous waste generation rates based upon data available from the survey. The interactions of the factors described above, together with countless other factors not mentioned or even currently anticipated, are difficult to predict. Furthermore, the uncertainties surrounding Westat's 1981 generation estimates will make the measurement of any short-term changes in hazardous waste generation rates even more difficult to evaluate. For the purpose of this report we have assumed that industrial/hazardous waste generation in the year 2000 will be the same as the estimate for existing generation.

4.2 OCEAN DISPOSAL SCENARIOS

4.2.1 Scenario I: Ocean Disposal under Existing Conditions

Ocean disposal of industrial wastes has been greatly reduced over the past decade both in terms of numbers of permittees engaged in ocean disposal and quantities of wastes (Figure 4-1). It is estimated that there were over 300 industrial facilities utilizing the ocean as a disposal medium prior to 1973. At present there are only three facilities.

All current ocean dumping occurs in areas regulated by EPA Region II, and waste generation occurs in Regions II and III. The three facilities include Allied Corporation's Elizabeth, New Jersey, fluorocarbon facility and two DuPont facilities in New Jersey and Delaware. A brief description of each of these three industrial facilities is given below.

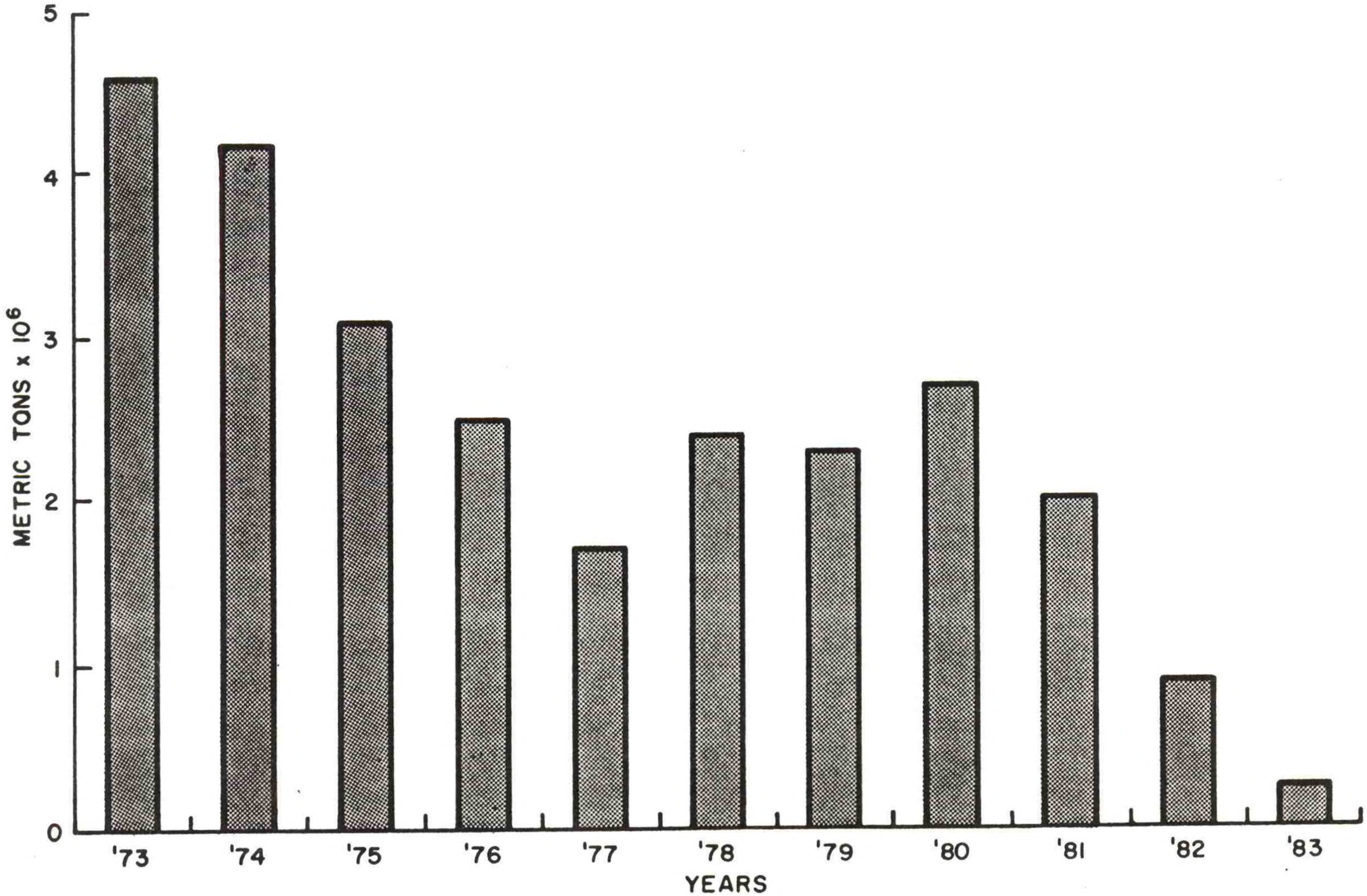

Figure 4-1. Quantities of industrial wastes which have been ocean dumped, by year since 1973.

Allied Corporation

Allied Corporation uses the ocean as a disposal medium for by-product hydrochloric acid (HCl) produced at its Elizabeth, New Jersey, plant. This plant is involved in the manufacture of fluorocarbon products and the quantities of by-product HCl have varied with product demand. The by-product HCl (equivalent 20^{o} Baume; 31 wt % HCl), containing about 2.0 wt % fluoride, is currently barged to the acid waste grounds in the New York Bight for disposal in accordance with conditions of an existing permit. A total of about 10,000,000 gallons of acid is dumped annually during 24 barge trips. Each load is disposed along a 40-mile path during a 7-8 hour period. Approximately 4,868 tons per year of spent caustic, containing 11.6 NaCl and 0.4% NaF, are transported to another Allied facility for fluoride removal and pH adjustment and final disposal in accordance with current permits.

As noted, the quantities of by-product HCl disposed of at sea have varied with fluorocarbon product demand. Quantities (metric tons) disposal during the past ten years are given below.

1973 - 60,000
1974 - 57,000
1975 - 49,000
1976 - 48,000
1977 - 29,000
1978 - 27,000
1979 - 30,000
1980 - 37,000
1981 - 33,000
1982 - 28,000
1983 - 35,000

DuPont-Edge Moor

Since 1968, DuPont-Edge Moor has disposed of acid-iron wastes (resulting from the manufacturing of titanium dioxide) at various ocean dumpsites.

Prior to enactment of the MPRSA, DuPont barged its wastes (sulfuric acid-iron sulfate wastes) to a disposal site located approximately 35 miles due east of the Maryland-Delaware border. In 1971, as a result of process changes, DuPont began barging hydrochloric acid-iron chloride wastes and pigment solids as well. In April 1973, EPA assumed regulatory responsibility for the ocean disposal permit program. The initial EPA permit was issued to DuPont on 23 April 1973. Permits issued to DuPont since that time have included schedules for cessation of the ocean dumping and implementation of a feasible alternative. Basically, the schedules required DuPont to develop and initiate a program for complete conversion to the chloride process; including recovery facilities for iron chloride, a marketing program for sale of iron chloride, and implementation of a hydrochloric acid recycling plant. As of 1980, DuPont had succeeded in developing a program of iron chloride recycling which reduced ocean disposal by 70 percent.

In March 1977, DuPont requested that their ocean dumping be moved to the 106-Mile Ocean Waste Dumpsite. Although DuPont's ocean disposal activities were scheduled to expire in 1980, an application for continued dumping was submitted on 30 April 1980.

DuPont cited shortages in demand for iron chloride as the underlying reason for its continued need for the ocean dumping alternative. However, EPA determined that the failure to cease ocean dumping and to implement the selected alternative by 1 November 1980 was a violation of the previously issued permit, and issued a Complaint (Docket No. MPRSA II-80-3) to this fact. Settlement of this Complaint resulted in a Consent Agreement containing a revised implementation schedule requiring the cessation of ocean dumping of the acid-iron wastes by 31 December 1983. In addition, provisions were made in the Agreement for collection of civil penalties in the event that a good faith effort was not made for development of the iron chloride marketing alternative.

Pursuant to the Consent Agreement, a Special Permit (II-DE-138-Special) was issued to DuPont on 1 February 1981, which included the revised schedule for cessation of ocean dumping by 31 December 1983.

Unexpected declines in market demands for iron chloride, among other reasons, caused DuPont to submit (4 May 1983) an application for renewal of its Special permit to transport and dump acid-iron wastes at the 106-mile site. DuPont maintains that in lieu of sales, ocean disposal of surplus iron chloride waste is the more environmentally acceptable disposal method. Comparison alternatives included sale of iron chloride, hydrochloric acid recycling, higher grade ore, and neutralization/landfill. Extensive discussion concerning the feasibility of these alternatives can be found in the permit application. In addition, information concerning the environmental impacts of disposal of the waste at the 106-mile site is included or referenced in the permit application.

In the past, DuPont has disposed of its industrial wastes at the former interim designated 106-mile site. This interim designation expired on 31 December 1982. On 20 December 1982, EPA proposed to designate the 106-Mile Ocean Waste Dumpsite as an approved ocean dumping site for authorized disposal of aqueous industrial wastes and municipal sludges. Based on review of all relative information and input from interested parties, EPA determined that use of the 106-mile site is consistent with the goals and criteria for site designation outlined by the MPRSA and regulations issued pursuant thereto. On 4 May 1984, EPA announced final designation of a Deepwater Industrial Waste Dumpsite for aqueous industrial wastes within the previously interim-designated 106-mile site. This final designation became effective on 3 June 1984.

The new special permit will have a term not to exceed 31 December 1986. The following volume limits will be imposed:

- Wastes ocean barged during 1984 will not exceed 115,000 wet tons.
- Wastes ocean barged during 1985 will not exceed 90,000 wet tons.
- Wastes ocean barged during 1986 will not exceed 50,000 wet tons.

DuPont is to aggressively implement a plan to meet this deadline for cessation of ocean dumping.

DuPont-Grasselli

Prior to 1968 the DuPont-Grasselli Plant discharged its alkaline sodium sulfate wastes into the Arthur Kill. As part of an area-wide cleanup of the Raritan Bay by the State of New Jersey, DuPont-Grasselli commenced ocean disposal of its wastewater in 1968. Between 1968 and 1974 the wastewater was dumped both at the New York Bight Acid Waste Site and the 106-Mile Ocean Waste Dumpsite. However, in 1974 DuPont began dumping its wastewater exclusively at the 106-mile site. DuPont has been the major contributor of waste to the 106-mile site over the years, releasing between 118,000 and 290,000 wet tons annually between 1973 and 1983. DuPont wastes result from the manufacture of DMHA (N-dimethylhydroxylamine) which is used as an intermediate in the production of agricultural chemicals at other DuPont plants. The waste material is an approximately 15% aqueous sodium sulfate solution, generally containing less than 1% organic compounds including sodium methyl sulfate, methyl alcohol, and methylamines.

In April 1973, EPA assumed responsibility for the strict regulation of ocean dumping under the MPRSA. On 23 April 1973, EPA issued the initial ocean dumping permit to DuPont-Grasselli. This Interim Permit was renewed roughly on an annual basis until 15 January 1978 when a Special Permit was issued. The initial

Interim Permit required DuPont to identify process changes to reduce pollutants. Subsequent permits required DuPont to assess the environmental and economic feasibility of alternative methods of disposal. In the past, DuPont has disposed of its industrial wastes at the interim designated 106-mile site. This interim designation expired on 31 December 1982. On 20 December 1982, EPA proposed to designate the 106-Mile Ocean Waste Dumpsite as an approved ocean dumping site for disposal of aqueous industrial wastes and municipal sludges. Based on review of all relevant information and input from interested parties, EPA determined that use of the 106-mile site is consistent with the goals and criteria for site designation outlined by the MPRSA and regulations issued pursuant thereto. As already noted, EPA has announced final designation of a Deepwater Industrial Waste Dumpsite for aqueous industrial wastes within the previously designated 106-mile site.

The term of the permit is not to exceed 31 December 1986. The implementation plan requires DuPont to continue to explore onsite and offsite treatment of its waste as an alternative to ocean dumping. Specifically, DuPont is to provide EPA with the following:

- Within six months of permit's effective date, a detailed evaluation of the practicability of onsite and offsite treatment alternatives. Offsite alternatives shall include use of the Linden Roselle Sewage Treatment Plant (LRSTP) and at least one other STP.
- Within 18 months of the permit's effective date, a detailed engineering report on the selection and design of one or more practicable alternatives.
- Within two months of the permit's effective date, apply for required regulatory permits for implementation of alternative(s).

Based on available information, it is anticipated that if current industrial permits remain in place and if DuPont-Edge Moor is phased out by 1986, there will be approximately 290,000 metric tons of industrial wastes barge dumped annually in the ocean. This includes the wastes from Allied Corporation's Elizabeth Facility and DuPont-Grasselli. All of this waste will be disposed of in areas regulated by Region II.

4.2.2 Scenario II: Ocean Disposal under Relaxed Regulation

An important aspect of Scenario II will be relaxation of the current policy toward ocean disposal. The policy has been and appears to be to phase out ocean dumping whenever possible. Opening up the ocean for increased disposal of industrial wastes would represent a reversal of past policy on the part of EPA. However, selected changes in policy may be consistent with management of waste from a multimedia perspective.

In estimating the quantities of wastes that could be dumped under a relaxation of regulations or change in policy, the London Dumping Convention (LDC) was considered to remain intact and it was assumed that the U.S. would comply with the convention. The LDC prohibits disposal of certain kinds of wastes (Table 4-5) but permits disposal of other wastes including industrial wastes (Table 4-6). Among the various categories of hazardous wastes that may be considered for ocean disposal, corrosive wastes are most likely to meet requirements of the LDC and there is continuing precedent for their disposal offshore. It is unlikely that many of the other hazardous waste categories (ignitable, reactive, EP toxic, generic solvents and sludges, toxics, hazards) would be permitted for ocean disposal even under a relaxation of regulations or policy. There may be certain exceptions to this, but these are impossible to quantify and would involve particular sets of circumstances which cannot be predicted in a comprehensive manner.

Table 4-5. Materials generally prohibited from ocean dumping[a,b] (Annex I of London Convention).

1. Organohalogen compounds and compounds that may form such substances in the marine environment, excluding those that are nontoxic, or that are rapidly converted in the sea into substances that are biologically harmless.

2. Organosilicon compounds and compounds that may form such substances in the marine environment, excluding those that are nontoxic, or that are rapidly converted in the sea into substances that are biologically harmless.

3. Substances that are likely to be carcinogenic under conditions of disposal.

4. Mercury and mercury compounds.

5. Cadmium and cadmium compounds.

6. Persistent plastics and other persistent synthetic materials that may float or may remain in suspension in the sea so as to interfere materially with fishing, navigation, or other legitimate uses of the sea.

7. Crude oil, fuel oil, heavy diesel oil, lubricating oils, hydraulic fluids, and any mixtures containing any of these, taken on board for the purpose of dumping.

8. High-level radioactive wastes or other high-level radioactive matter, defined on public health, biological, or other grounds, by the competent international body in this field, at present the International Atomic Energy Agency, as unsuitable for dumping at sea.

9. Materials in whatever form (e.g., solids, liquids, semiliquids, gases, or in a living state) produced for biological and chemical warfare.

[a]This table does not apply to substances that are rapidly rendered harmless by physical, chemical, or biological processes in the sea, provided they do not:

(i) make edible marine organisms unpalatable, or
(ii) endanger human health or that of domestic animals.

[b]This table does not apply to wastes or other materials (e.g., sewage sludges and dredged spoils) containing the matters referred to in Numbers 1-7 above as trace contaminants.

Table 4-6. Materials that require special care or permits for ocean dumping (Annex II of London Convention).

1. Wastes containing significant amounts of the matters listed below:

   arsenic)
   lead)
   copper) and their compounds
   zinc)
   organosilicon compunds
   cyanides
   fluorides
   pesticides and their by-products not covered in Annex I

2. In the issue of permits for the dumping of large quantities of acids and alkalis, consideration shall be given to the possible presence in such wastes of the substances listed in Number 1 and to the following additional substances.

   beryllium)
   chromium)
   nickel) and their compounds
   vanadium)

3. Containers, scrap metal, and other bulky wastes liable to sink to the sea bottom, which may present a serious obstacle to fishing or navigation.

4. Radioactive wastes or other radioactive matter not included in Annex I. In the issue of permits for the dumping of this matter, the recommendations of the competent agencies in this field should be considered.

5. Dredge spoils.

6. Substances that, though of a nontoxic nature, may become harmful due to the quantities in which they are dumped, or that are liable to seriously reduce amenities.

7. Titanium dioxide (specified by Council of European Communities).

The bulk (estimated at approximately 99%) of corrosive wastes is treated or disposed of on site primarily through neutralization and deep-well injection. Based on discussions with various state agencies this is likely to remain the case. However, if these onsite treatment and disposal options do reach capacity, then there could be considerable offsite disposal. (Approximately 46% of all hazardous waste is corrosive.) A substantial amount of corrosive wastes might also be considered for ocean disposal if the economics of barging the wastes are appreciably better than onsite treatment and disposal. This has not been examined in sufficient detail but merits further consideration.

Scenario II for hazardous/industrial wastes is considered to include ocean disposal of all corrosive wastes that are shipped off site for treatment or disposal. Most of this waste is currently handled by treatment and deep-well injection and a smaller portion by landfill. It is unlikely that all this "residual" corrosive waste would be designated for ocean disposal, but it does provide an upper bound for the quantity that might be dumped under one set of assumptions for Scenario II. The annual quantities (metric tons) of these wastes by EPA region are as follows: 30,470 (I), 378,760 (II), 623,350 (III), 645,837 (IV), 304,290 (VI), 80,730 (IX), and 28,230 (X).

The quantities of industrial wastes projected under Scenario II are substantially less than the total volume of industrial waste actually dumped during 1973 (4,598,000 metric tons). Therefore, under relaxed regulations and policies the quantities of industrial wastes could increase, but would probably be less than the quantities that were historically ocean dumped.

In order to evaluate the likelihood that particular industries would consider ocean disposal, we contacted representatives of several industries that have ocean dumped in the past. The intent was to assess the potential future attractiveness of ocean dumping to industries that have already developed land-based disposal. The three major industry groups surveyed were pulp and paper, chemical, and pharmaceutical companies.

Pulp and Paper

According to the National Council of the Paper Industry for Air and Stream Improvement, Inc. (NCASI), the main use of the ocean by the paper industry has occurred in the Pacific Northwest where proximity to deep water made ocean disposal of process effluents economically and environmentally attractive. In addition, some paper mills have used municipalities (~10% of the industry) or private contractors to barge solid and liquid wastes to sea. In these cases the barging was cost effective relative to concentrating and disposing of these wastes on land (James J. McKeown, NCASI, personal communication).

Although the paper industry has not extensively used the ocean to dispose of its wastes, there are cases where the ocean offers an economical and feasible alternative for disposal. Therefore, NCASI is interested in seeing research supported that will determine the impact and fate of various paper industry waste materials if ocean disposed. Large pulp and paper operations are able to burn much of their wastes for heat recovery, product recovery, or waste volume reduction. However, for small companies, the cost of a furnace is high and a small-scale furnace has poor heat balance.

One factor that has reduced interest in ocean dumping is many existing companies have already installed Best Practical Technology (BPT). A major determinant of the attractiveness of the ocean dumping option, therefore, will be which guidelines are in effect for new facilities.

Chemical

According to a representative of a major chemical company, it appears unlikely that wastes previously disposed of in the ocean and now land disposed would again be ocean dumped if this option were available. Most large companies have made substantial investments in incinerators, deep wells, and other land-based facilities to dispose of their wastes. Future applications for ocean disposal would depend on regulatory requirements and the results of evaluating alternatives for the disposal of specific wastes (R.F. Schwer, E.I. DuPont de Nemours & Company, personal communication). A representative of another major chemical company discussed the possibility that industrial wastes similar to those presently being ocean dumped (e.g., waste acids) would continue to be dumped and would perhaps increase in the future.

Other industry representatives surveyed specified heavy metal disposal as a major category of concern because of difficulty in heavy metal "detoxification." They expressed particular interest in research on the fate of heavy metals in the ocean.

Pharmaceutical

Most pharmaceutical companies have made large financial commitments to land-based disposal (e.g., onsite incineration, secondary waste treatment) in response to EPA regulations. Ocean dumping would only be an option for drug companies that do not yet have secondary treatment.

4.2.3 Scenario III: Disposal Based Strictly on Economic Considerations

The costs for various hazardous waste disposal options were evaluated by EG&G during 1982, and are given below:

Disposal Option	Cost per Ton (1982 $)
Ocean Dumping of Industrial Wastes	3-15
Land Disposal	20-500
Deep Well Injection	40-70
Chemical Fixation	50-100
Incineration	100-3,000

Ocean disposal is one of the cheapest alternatives for industrial waste disposal, although landfills and deep-well injection can be competitive. However, a key economic consideration is the fact that industries have invested and continue to invest in particular land-based waste disposal options. Thus, there would be a cost of closing down such facilities or in changing the procedures involved in utilizing alternative disposal options in favor of ocean dumping. In addition, many companies would not be willing to risk such a change even if the economics were favorable on paper. However, consideration of economics alone can provide an upper bound on the quantity of industrial waste that might be ocean dumped.

We have assumed that onsite treatment and disposal is less costly than offsite treatment and disposal, including ocean dumping. This is a critical assumption and, at present, we have insufficient data with which to evaluate it. However, onsite disposal options do not involve costs associated with transportation or commercial (profit making) disposal facilities. Because of the large quantity of hazardous industrial wastes managed on site (96% of total), we believe it is important to reexamine this assumption as data become available on the cost of onsite disposal.

For the purpose of this report and considering the comparatively low cost of ocean disposal, we consider Scenario III to include all hazardous industrial waste that is taken off site for treatment and disposal. Naturally, transportation costs from certain geographic areas will render the ocean disposal option more costly than other local options. However, in the absence of more detailed data and because the objective is to establish some upper bounds, the total waste taken off site is a reasonable first order estimate. The quantities (mt) of these wastes by

EPA region are as follows: 580,000 (I), 1,022,000 (II), 922,000 (III), 1,358,000 (IV), 1,346,000 (VI), 896,000 (IX), and 503,000 (X). Pretreatment regulations could be important in increasing the quantities of industrial sludge for disposal and this could increase the estimates of wastes disposed of off site.

There has been considerable attention given to the capacity of land-based hazardous waste disposal as this might be a factor in increasing pressure on the ocean disposal option. The unused capacity, as of January 1, 1982, for treating, storing, and disposing of hazardous waste is shown by region in Figure 4-2. Nationally, almost none of this unused capacity (less than 2%) was located at facilities that received more than half their hazardous waste from other firms. Therefore, it should be noted that even though substantial unused treatment, storage, and disposal capacity existed in 1981, very little of this capacity was available at commercial facilities and public facilities that service other hazardous waste generators.

Unused storage and disposal capacity was highly concentrated in certain regions. Over three-quarters of the nation's unused storage capacity was located in Regions II and VI, while nearly 60 percent of the nation's disposal capacity was located in Region IV. Another quarter of the total disposed capacity was also located in Region VI.

Westat (1984) concluded that hazardous waste generation levels during 1981 were easily accommodated by available treatment, storage, and disposal capacity across the U.S. In fact, the amount of unused capacity indicates that capacity was more than adequate on an aggregate basis.

If capacity becomes limited, small facilities could be more vulnerable to capacity constraints since they tended to have higher capacity utilization rates. Commercial facilities may be able to ease a tight capacity situation, but their quantities represent such a small part of the overall hazardous waste

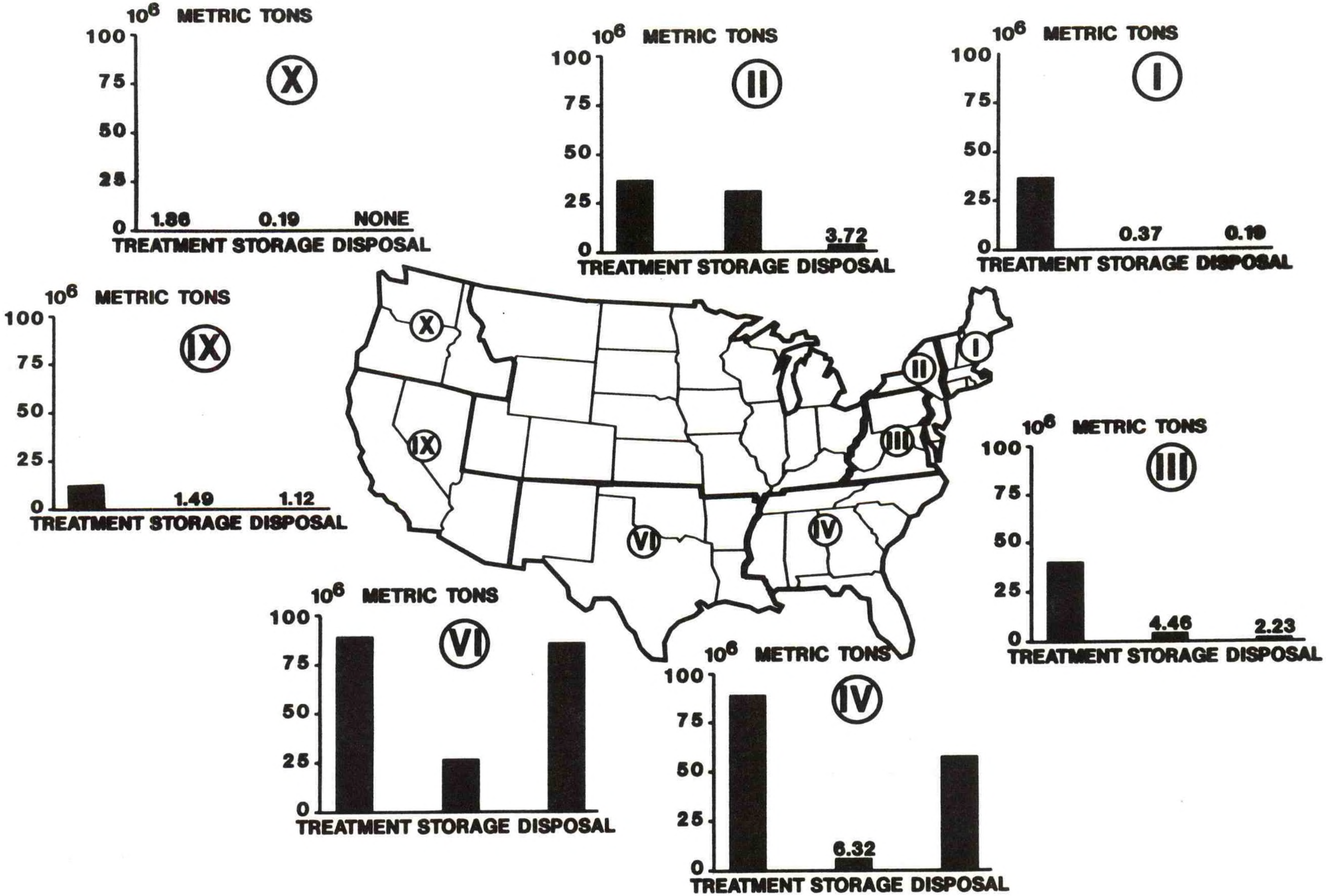

Figure 4-2. Unused capacity as of January 1, 1982, for treating, storing, and disposing of hazardous waste by EPA region.

management system that onsite facilities would have to accommodate most of the additional demands. From the 1981 Westat survey data, however, it appears unlikely that a capacity crisis is on the horizon. Still, it is clear that if there is a major shift from onsite to offsite treatment and disposal (especially for corrosive wastes), this could result in a substantial quantity of wastes which may potentially be considered for ocean disposal. Our present information indicates that this is not the case. However, a more complete analysis of this aspect of industrial waste management in the United States is warranted.

4.2.4 Summary of Hazardous Waste Generation and Ocean Disposal Scenario

Figure 4-3 summarizes the quantities of hazardous and corrosive wastes generated in the U.S. for the various EPA regions and the quantities that might potentially be ocean dumped under the three scenarios.

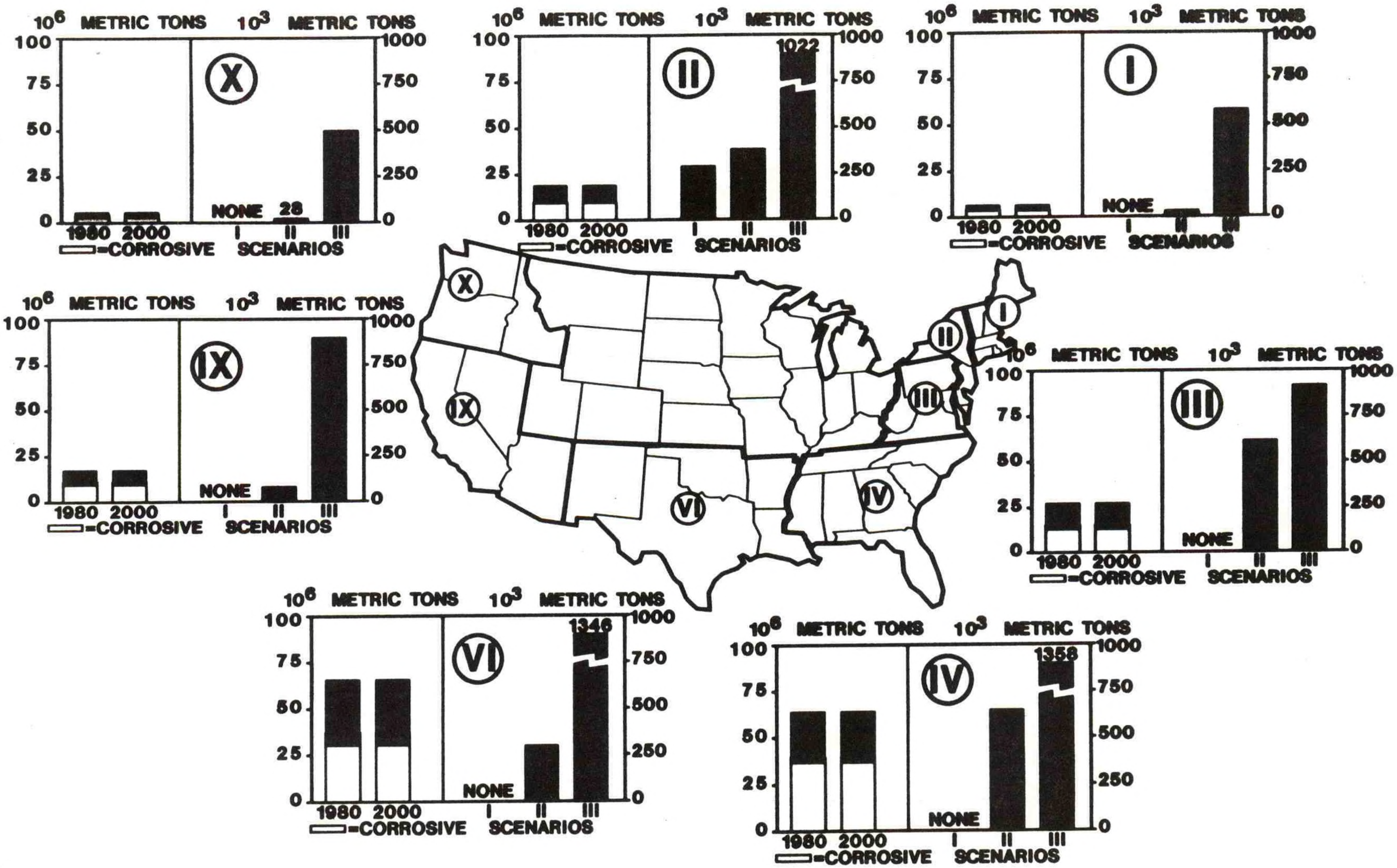

Figure 4-3. Present (1980) and projected (2000) generation rates (10^6 tons/year) for industrial/hazardous wastes and ocean dumping rates (10^3 tons/year) under the three scenarios by EPA region. NOTE: 1980 and 2000 corrosives are depicted as open histogram. Scenario I wastes are from present dumpers only. Scenario II represents only corrosive wastes taken off site and Scenario III represents all industrial hazardous wastes taken off site for disposal.

5. SEAFOOD PROCESSING WASTES

The U.S. seafood processing industry is a geographically and technologically diverse segment of the economy. With the exception of the large, year-round tuna and fish meal production facilities, most processing is performed by small, intermittent operations in response to the highly variable and seasonal nature of the raw supply of fish and shellfish. The industry has distinctly regional characteristics, reflecting the variety of the local fisheries and differences in marketing and distribution systems. Waste management practices within the industry reflect the decentralized nature of the processing operations and the specialized nature of the waste products.

5.1 EXISTING AND FORECASTED GENERATION RATES

The aggregate amount of seafood processing wastes produced in the U.S. during 1980 has been estimated at between 1,400,000 and 2,000,000 tons, with the majority resulting from the processing of finfish (EG&G, 1983). A substantial proportion of this is converted to marketable by-products (meal and fertilizer) or is otherwise considered useful; e.g., oyster shell which is returned to the beds as cultch. Thus, the waste volume which requires disposal of one form or another is some small fraction of the total waste figure.

Beyond such a statement, it appears genuinely questionable whether a more quantitative analysis of seafood waste disposal requirements can be made on any firm basis. There are a number of reasons for the ambiguity associated with this waste category, most important is the fact that data do not exist which reflect direct measures of waste volumes within particular segments of the processing industry. Instead, it is necessary to work with indirect estimates based on percentages of raw landings. The National Marine Fisheries Service (NMFS) through its Current Fisheries Statistics program (Wallace, 1979), has compiled extensive records describing landings and production levels of secondary seafood and industrial products. These data show large annual variations among landings for particular species and among various geographic regions. Table 5-1 is a state-by-state compilation of landings for the year 1975 grouped according to the various EPA Regions of interest. The data are primarily useful for comparison purposes among regions and between the fish and shellfish categories. The absolute quantities and dollar values are less meaningful because of the large annual variations which occur in the harvest and the volatility of exvessel prices and the effects of inflation. This is apparent in Table 5-2 which provides a comparison of the total catch and value for the top ten states between 1975 and 1979. Variations in landings of 50% or more over a period of several years are not unusual for certain fisheries.

The variability inherent in the raw landings translates directly to the volume of waste material generated by the processing industry. In addition, there is a large measure of uncertainty in defining the fraction of the reported catch that constitutes waste material. If the strict position is taken that waste accounts for the volume of raw product not processed directly in a form suitable for human consumption, then the annnual quantities fall somewhere in the range cited at the outset of this section. However, as previously noted, this is a rather arbitrary classification since extensive use is made of the "waste" as raw material in the reduction industry. In cases where this utilization appears to be based on stable market conditions, it is inappropriate to consider ocean disposal as a viable alternative. In a case where secondary utilization of the

Table 5-1. Quantity and value of U.S. seafood landings, 1975.

Region/State	Fish		Shellfish		Total	
	Million Pounds	Million Dollars	Million Pounds	Million Dollars	Million Pounds	Million Dollars
Region I						
Maine	101	7	38	41	138	48
New Hampshire	3	*	1	1	3	1
Massachusetts	250	53	23	30	274	83
Rhode Island	71	10	8	9	79	19
Connecticut	2	*	1	2	4	3
	427	71	72	83	498	154
Region II						
New York	20	5	18	23	37	28
New Jersey	99	9	44	11	144	20
	119	14	62	34	181	48
Region III						
Delaware	1	*	6	2	7	2
Maryland	15	2	49	21	64	23
Virginia	360	13	85	20	445	33
	376	15	140	43	516	58
Region IV						
North Carolina	221	12	18	8	238	20
South Carolina	4	1	16	12	20	13
Georgia	1	*	17	12	18	12
Florida	111	27	62	49	173	76
Alabama	15	2	16	19	32	21
Mississippi	299	10	6	5	306	14
	651	52	135	105	787	156
Region VI						
Louisiana	1,026	34	89	52	1,115	86
Texas	8	2	78	90	86	93
	1,034	36	167	142	1,201	179
Region IX						
California	829	125	46	9	875	135
Region X						
Alaska	196	74	248	56	444	130
Oregon	58	20	28	6	86	26
Washington	122	49	24	13	146	62
	376	143	300	75	676	218
Total	3,812	456	922	491	4,734	948

*Less than $500,000
Table may not add because of rounding. Total columns are correct.

Source: Bell, et al., 1978. Fishery Statistics of the United States 1975. National Marine Fisheries Service, Washington, D.C.

Table 5-2. Comparison of landings for 1975 and 1979.

	1975		1979[1]	
State	Million Pounds	Million Dollars	Million Pounds	Million Dollars
Alaska	444	130	899	597
California	875	135	728	227
Florida	173	76	163	124
Louisiana	1,115	86	1,529	199
Maine	138	48	232	80
Massachusetts	274	83	375	176
New Jersey	144	20	189	53
North Carolina	238	20	390	58
Oregon	86	26	128	65
Virginia	445	33	573	85
Washington	146	62	170	116

[1] Source: Otwell, W.S., 1981. Seafood Waste Management in Florida. In: Seafood Waste Management in the 1980's, Conference Proceedings, University of Florida, Sea Grant Report No. 40.

waste is marginally economic, or where possible future regulatory constraints threaten existing utilization practices, then the consideration of ocean disposal becomes a realistic option.

In an attempt to discern some of the specific waste disposal requirements of the seafood processing industry and its present and future reliance on ocean dumping practices, the industry must be examined on a regional basis as provided below.

New England

The waters offshore of the New England states support several productive and varied fisheries. For the most part, processing operations do not result in contaminated waste products; for example, many finfish species are headed and dressed at sea and are shipped without further processing to wholesalers and distribution/storage centers. The major exception to this is the Maine sardine (herring) industry which consists of 15 canneries distributed among the numerous bays, inlets and estuaries along the Gulf of Maine coast. According to the EPA, between 40% and 60% of the raw sardine product is canned as a final product. A substantial portion of the waste fraction is captured by in-plant management techniques, screening and oil separation units and sold to reduction facilities for conversion into fish meal and oil. The high protein content of the waste products and the relatively stable quantities generated by this industry imply that the reduction option is likely to remain an economically viable means of waste disposal for the foreseeable future. There is a possibility that dissolved air flotation (DAF) systems may be required at certain processing plants where the present practice of screening and oil separation is not seen as sufficient to protect the local receiving waters. The sludge generated by this treatment system will contain chemical coagulants necessary to provide efficient operation of the unit. The Federal Drug Administration has not approved such sludge for use in animal feed supplements or fertilizer products, therefore, this waste stream presumably must be landfilled. The option of ocean dumping of DAF sludge would not be a preferred option in comparison with landfilling, for both economic and operational reasons. The resort to ocean dumping would depend on regulatory or other factors which would eliminate the landfill option.

Mid-Atlantic States

Seafood landings in the Mid-Atlantic states are mainly concentrated in the Chesapeake area, including Virginia and Maryland. Menahaden is, by far, the largest single species in terms of gross catch. For example, menhaden normally account for roughly 80% to 85% of the total commercial landings in Virginia. The fish is used exclusively in reduction plants producing fish meal and oil, and the waste management problems are similar to those described previously for the Maine sardine industry. This industry has implemented comparatively sophisticated in-plant management and waste recycle/reuse methods since 1975 in response to early regulatory requirements imposed by the EPA. This successful implementation was significantly encouraged by the value of the waste streams and the ease of recycling through the primary reduction process. At the present time this industry segment does not appear to be a possible source of significant solid waste generation of interest to the present study.

The blue crab industry is a smaller but still economically significant fishery comprised mainly of widely dispersed, low-volume processing facilities. Virginia and Maryland together produced an annual total of 50,000,000 pounds of hard scrap on average from 1960 to 1978. During the 1970's, this waste was reduced to crab meal and sold as a protein supplement for use in animal feed. However, this option has become uneconomic due to the lower cost of grain-based alternatives (mainly soybean and corn) and the variable quality and seasonal nature of the supply of waste material. As a result, local processors are faced with the problem of finding alternative means of disposal. As a practical matter, this means land-based alternatives, primarily municipal landfills. However, in many cases this is not anticipated to be a viable long-term solution. A large body of research and pilot plant work has been performed, largely under Sea Grant funding, to investigate the production of chitin/chitosan from shellfish wastes. A number of prospective markets have been identified for this material and practical methods of production have been developed; however, the economic viability of a chitin/chitosan industry appears to be a remote prospect at the present time. It does not appear likely to eliminate the need for finding more immediate methods of disposal.

Despite the present lack of acceptable land-based solutions, ocean dumping at sites beyond the 3-mile limit does not present an attractive alternative. The majority of the processors could not financially support an ocean-going barge operation. Further logistical problems arise given the weather-related dependency of the operation, the highly degradable nature of the waste material, and the consequent problems involved in transporting and storing the waste in a central facility.

The remaining seafood industries in this region, including oysters, clams, and finfish, also do not present any existing or foreseeable solid waste disposal problems which could be addressed by the ocean dumping option.

South Atlantic

The various fisheries along the coasts of North and South Carolina and Georgia, consist primarily of small, seasonal processors. The predominant landings are shellfish: shrimp and blue crabs. North and South Carolina produce roughly 6,000,000 pounds of shrimp wastes, primarily heads and shells, per year. Nearly all the shrimp landings in Georgia are headed at sea, considerably reducing the waste volume in this state.

An additional 4,000,000 pounds of hard crab waste is generated in the region as well. In South Carolina, one plant processes 55-65% of the state-wide crab production and converts the waste to crab meal by means of an onsite facility. However, the remainder of the industry throughout this region is too small and widely dispersed to allow similar onsite reduction facilities or even a centralized plant to be economic. Disposal is accomplished primarily by landfilling and by limited barged disposal within the 3-mile limit under NPDES permits. Land-based disposal alternatives are not desirable for the long term, but the labor and time intensive aspects of ocean dumping, together with the weather dependent nature of the operation, does not make this an attractive option for the preponderance of low-volume processors.

Nearly all finfish landings are either shipped whole or dressed/gutted at sea so that this segment of the industry is not a significant generator of solid waste.

Gulf Coast

The gulf fisheries are dominated by shrimp and menhaden landings. As in the previous cases, finfish are not a problem due to the availability of reduction plants which will readily accept the raw processing wastes for reduction to fish meal and oil. The shrimp wastes pose a problem similar to that being experienced along the Mid- and Southern Atlantic states. The problem is further aggravated in this region by the presence of a high ground water table and, consequently, the relative scarcity of landfill capacity. Coastal waters are also poorly flushed due to the low tidal range. The imposition of DAF requirements on the shrimp processing industry will compound the problem. The waste quantity involved is determined to a large extent by the proportion of the catch which is headed and immediately disposed at sea. This proportion is highly variable from state to state. For example, in Texas nearly all of the catch is headed prior to landing, while relatively small amounts are headed in Louisiana. This approach is the best waste management method now available, but it will require the development of mechanical equipment suitable for use on small shrimp boats before it becomes feasible on a widespread basis. In the meantime, the prospect for ocean dumping is similar to that described for the Atlantic states, in that the processors would not be able to support a large-scale dumping operation at remote sites far removed offshore. Local dumping permits are being granted and will continue to be the only feasible solution for the immediate future.

California

California ranks third in tonnage of seafood landings and second in gross value. The largest segment of the industry is represented by the large tuna processing plants located in the Los Angeles area. These plants are presently equipped with DAF units, screens and separators, and discharge to the municipal sewerage system. DAF sludge is landfilled and uncontaminated wastes are sold to reduction plants. There is no current need to resort to ocean dumping, but this is contingent upon the continued availability of landfill capacity to the industry. In the event that this availability is curtailed in the future, ocean disposal may become an attractive option. The situation is clouded by the uncertain economic future surrounding the continued operation of the processing plants in southern California where several companies have recently announced plant closings in favor of relocating overseas.

Alaska

Alaska ranks second in tonnage and first in gross dollar value of the annual catch. Several fisheries are significant in the Alaskan industry including, especially, salmon and (king) crab. Current regulations segregate the processors according to a classification system of either remote or nonremote locations. Remote locations are exempt from many treatment and disposal requirements, in recognition of the special difficulties involved with mechanically sophisticated treatment systems and landfill operations. These plants screen their wastewater discharges and grind the solids prior to discharge to local receiving waters. Nonremote plants are required to employ screening and to barge or landfill the solids. Reduction plants process a minor portion of the total annual waste volume, estimated at roughly 90,000,000 pounds of finfish waste and 130,000,000 pounds of shellfish waste. The distribution of the waste among the various disposal alternatives is unknown and variable from year to year.

5.2 OCEAN DUMPING REQUIREMENTS

The preceding review of the seafood industry reveals two possible waste sources which could justify consideration of ocean disposal. The first stems from the use of dissolved air flotation (DAF) systems for the primary treatment of process wastewaters. DAF systems are currently in operation at the large tuna processing facilities in southern California and at many fish meal reduction plants on the east coast. The technology is presently under consideration by the EPA as a possible future requirement under BCT effluent regulations for large portions of the industry. DAF systems generally require the use of coagulants which contaminate the sludge so that it is no longer exempt from ocean dumping regulations, as is the case for uncontaminated seafood wastes.

At present this sludge is generated in small quantities and is disposed in landfills. If the EPA adopts an industry-wide requirement for this technology under BCT regulations, the generation would obviously increase substantially, but the amount would still remain small in comparison to the quantities estimated for the waste categories examined in previous sections of this report. Based on the data of Carawan and Thomas (1981), wastewater-suspended solids are generated at a rate of 1-2 pounds (dry weight) per thousand pounds of raw fish processed. Assuming that 2,000,000 tons of fish are processed per year, an order of magnitude estimate for the annual volume of DAF sludge generated would then be 2,000 tons. This assumes industry-wide application of the treatment technology, and should be considered a liberal upper bound on the actual generation for the foreseeable future.

In comparison with previous estimates, this amount of waste material is essentially negligible. In addition, there is no reason to expect that this waste would be classified as toxic or hazardous. In fact, it has been argued that the discharge of such waste is beneficial to the marine environment due to bio-enhancement effects. Although this is a controversial topic, it is clear that DAF sludge is a comparatively benign waste material and would not be generated in sufficient quantities to constitute an environmental management problem of national significance.

The other category of seafood wastes which may become a disposal problem is shellfish wastes, specifically crab and shrimp wastes generated outside the Pacific Northwest (Region X). The problem is largely concentrated in the Gulf Coast area and Chesapeake Bay (Maryland and Virginia). The annual volume of crab and shrimp waste produced in these two areas is perhaps in the vicinity of 100,000,000 pounds. Projections of the waste volume produced in the future are entirely speculative. In the past this material had been used in centralized reduction facilities; however, it now appears that such reduction facilities will only be feasible as an integral part of large processing plants or where shellfish wastes are incidental to a larger and more stable source of raw material from other sources. Unless local landfills will accept the waste on a long-term basis, small processing operations are left without a practical means of disposal.

Ocean disposal at sites beyond the 3-mile limit is not considered economically or operationally feasible for these processors. South Carolina has granted NPDES permits to dump shellfish wastes within the 3-mile limit on a case-by-case basis, but even this limited barging operation is not seen by the industry as a widely applicable solution to the problem. Because this waste is largely uncontaminated, it could be ocean dumped if the processors could afford the expense of ocean-going barge operations. In this sense, the problem is not an especially critical one within the regulatory perspective of the present study.

6. SUMMARY

Due to the action of the court, ocean dumping regulations are currently undergoing reevaluation. Recent examinations of the ocean disposal option (NACOA, 1981; GAO, 1981, 1983) support a multimedia approach to waste management in which ocean disposal is a considered alternative. In this report, we have examined the present and projected generation rates for coal ash, FGD sludge, sewage sludge, industrial waste, and seafood processing waste. All but the latter are high-volume wastes on a national scale. We have examined the potential for ocean disposal of these wastes from coastal EPA Regions under three scenarios. Each scenario assumes a different regulatory or economic environment. Scenario I assumes that only currently active permit holders will continue to ocean dump in the year 2000. Under Scenario II, it is assumed that ocean dumping regulation is somewhat relaxed. Scenario III considers only the economics of ocean dumping.

Tables 6-1 through 6-4 summarize the projected annual ocean dumping rates of fly ash, FGD sludge, sewage sludge, and industrial wastes for the year 2000 under each scenario. On a national level, coal ash and FGD sludge are projected to be the most voluminous waste dumped at sea under any level of regulatory relaxation. Although under present regulations, no fly ash or FGD sludge is ocean dumped (Scenario I), fulfillment of the assumptions under Scenarios II or III will result in high rates of ocean dumping for these wastes. Under Scenario II, 5,800,000 tons/year of fly ash and 6,650,000 tons/year of FGD sludge will be ocean dumped. Under Scenario III, these figures increase to 19,300,000 and 14,550,000 tons/year, respectively. Ocean dumping

Table 6-1. Projected ocean dumping rates (thousands of tons/year) of coal ash by EPA region under each scenario.

EPA Region	Disposal Scenario I	II	III
I	0	1,500	2,000
II	0	1,600	4,600
III	0	2,200	4,700
IV	0	0	4,500
VI	0	0	1,500
IX	o	300	300
X	0	200	200
National Total	0	5,800	19,300

Table 6-2. Projected ocean dumping rates (thousands of tons/year) of FGD sludge by EPA region under each scenario.

EPA Region	Disposal Scenario I	Disposal Scenario II	Disposal Scenario III
I	0	3,250	3,250
II	0	2,000	4,900
III	0	1,000	1,000
IV	0	0	4,000
VI	0	0	100
IX	0	300	300
X	0	100	100
National Total	0	6,650	14,550

Table 6-3. Projected ocean dumping rates (thousands of tons/year) of sewage sludge by EPA region under each scenario.

EPA Region	Disposal Scenario I	Disposal Scenario II	Disposal Scenario III
I	0	175	200
II	265	850	1,000
III	0	600	650
IV	0	100	250
VI	0	0	40
IX	117	600	800
X	0	0	40
National Total	382	2,325	2,980

Table 6-4. Projected ocean dumping rates (thousands of metric tons/year) of industrial waste by EPA region under each scenario.

	Disposal Scenario		
EPA Region	I	II	III
I	0	30.5	580
II	290	379	1,022
III	0	623	922
IV	0	646	1,358
VI	0	304	1,346
IX	0	81	896
X	0	28	503
National Total	290	1,500	6,627

of these wastes is most likely to occur from the east coast. Under Scenario II, over 90 percent of the coal ash and FGD sludge projected for ocean dumping nationwide will come from Regions I, II, and III. Even under the "worst case" conditions of Scenario III, 58 percent of coal ash and 63 percent of FGD sludge dumped at sea will be generated in Regions I, II, and III. Most of the remainder of the national total would be generated in Region IV. Therefore, the ocean dumping of these wastes is clearly a major consideration on the east coast, particularly the northeast.

The major factors influencing sewage sludge generation are increases in secondary treatment and the selection of sludge processing systems. Currently ocean dumping is utilized by New York and New Jersey. Boston and Los Angeles discharge sludge through harbor and ocean outfalls, respectively. Under Scenario I, these will be the only areas to continue this practice in 2000. Under relaxed regulation of Scenario II (Table 6-3), Region I would use an ocean dumping alternative, but the extent would be influenced by the success of 301(h) waiver applications in metropolitan areas. Similarly, Region II would continue to use ocean dumping. Region III will provide a considerable source of sewage sludge under this scenario. Philadelphia has used ocean disposal in the past, and this city and Baltimore have expressed interest in the ocean dumping alternative. In Region IV, the most likely area to use ocean dumping is Florida's Dade and Broward Counties. Ocean dumping would be unlikely in Region VI. On the west coast, Los Angeles would use ocean disposal. Under the conditions of Scenario III, ocean disposal of sewage sludge is the most attractive option. Considerable increases in ocean dumping over scenarios I and II would occur especially in EPA Regions I, II, III, and the urban areas of Regions IV, VI, and IX. Region X is less likely to use ocean dumping even under Scenario III.

The complex nature of industrial wastes makes projection of future volumes difficult. Predictions are sensitive to industrial changes, RCRA regulations, and to disposal through POTWs. Ocean Dumping has decreased steadily since 1973. Most industrial waste (96%) is disposed on site. Of the 4% disposed off site, a considerable portion is corrosive waste. Corrosives (acids and alkalis) are currently ocean dumped in Region II. Ocean disposal of corrosive wastes conforms to the London Dumping Convention and are likely candidates for future ocean disposal. Under Scenario I, only EPA Region II will experience ocean disposal of industrial waste in 2000. Under Scenario II, all corrosive wastes currently shipped off site might be ocean dumped. Even under these conditions, the total ocean dumping of industrial waste would be less than it was in 1973. Industry representatives have indicated that ocean dumping would be an alternative depending upon future regulation and the future extent of investment in BPT, land disposal, and detoxification. In particular, ocean dumping of metal wastes may be considered because detoxification of these wastes is difficult. Considering these investment factors in other alternatives, many companies may not use ocean dumping even under only the economic constraints of Senario III. The projections for Scenario III, therefore, provide a conservative "worst case" estimate.

Although there is a significant volume of seafood wastes which are disposed of at sea, especially in Alaskan waters, the material is uncontaminated and therefore exempted from ocean dumping regulations. The disposal of contaminated wastes at sea, which is of direct concern in this study, is presently limited to a single instance offshore American Samoa. In the future, there may be a need for ocean disposal by certain of the larger processors with regard to DAF sludge. The quantities involved are difficult to estimate accurately, but are negligible in comparison with the other categories which have been considered.

There are certain limitations to the data bases used in this report. In the case of ash and FGD sludge, existing data reports were used to review and synthesize existing and projected conditions. These sources were adequate for the present task, but it should be recognized that these data bases were not collected specifically to address coastal problems. The data base used in the section on sewage sludge provides the best example of a data source and report with objectives entirely congruent with those of the present work. The industrial waste data base provides the most concern as to accuracy. At present, this data base is subject to the greatest variation in estimates of even present rates. As the individual states begin to implement RCRA over the next few years, inventory of industrial wastes and present methods of disposal will become clearer.

There also remains the question of whether the industries concerned will actually use the ocean dumping option. The projections of ocean dumping rates for industrial waste is complicated by the fact that, at present, ocean dumping is not a viable option. Therefore, industrial planners are not considering it as an alternative waste management strategy. It is difficult to speculate upon how their plans may change under a more relaxed regulatory environment. However, industry has used ocean dumping in the past. In Region II, there are active dumpers who have made efforts to maintain or extend their present permits. This indicates that at least some segment of industry will use the option. The historical trend, however, has been to move away from ocean dumping of industrial waste. On the other hand, there is a clear interest in using ocean disposal of ash, particularly in the northeast. Use of the option for ash is more questionable on the southern and Gulf coasts where there are not as many regulatory and logistical constraints to land disposal. Ocean dumping of sewage sludge is also more likely to be used in the

Mid-Atlantic and northeastern states. These areas presently dump sewage sludge or have done so in the recent past.

Another unknown affecting the ocean dumping projections is the level of local opposition likely to be encountered. In states where fishing on the continental shelf is a major industry, there has been a recent history of opposition to any activity perceived as a disturbing influence. For example, OCS oil and gas lease sales have been delayed, and even cancelled off Alaska and New England, as a result of local opposition. Some resistance to ocean dumping is very likely to be encountered from citizen groups or state and local agencies.

Further studies can mitigate some of the above limitations. A clearer definition of the actual extent of ocean dumping suggested by the projections in this report should be evaluated on a region-by-region basis. The general magnitude of the problem has been defined herein. Once ocean dumping regulations have been promulgated, a series of regional-specific studies should be initiated. These should include contacting the appropriate industry representatives to determine their view of the ocean dumping alternative. It should be stressed that this report defines the regions where ocean dumping of various wastes is likely to occur. Further definition of the magnitude of the problem should, therefore, await promulgation of regulations. It is not too early, however, to begin evaluating alternative dumpsites for each waste type, particularly in the northeast and east where the most immediate pressures for dumpsites are likely to occur.

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