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THE EFFECTS OF AIR AND WATER POLLUTION CONTROLS ON SOLID WASTE GENERATION, 1971–1985
Executive Summary

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Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

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Executive Summary

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FOREWORD

Man and his environment must be protected from the adverse effects of pesticides, radiation, noise and other forms of pollution, and the unwise management of solid waste. Efforts to protect the environment require a focus that recognizes the interplay between the components of our physical environment--air, water, and land. The National Environmental Research Centers provide this multidisciplinary focus through programs engaged in

- studies on the effects of environmental contaminants on man and the biosphere, and
- a search for ways to prevent contamination and to recycle valuable resources.

Recognizing the interplay among the components of our physical environment, this study presents quantitative estimates of the effects of air and water pollution controls on the generation of wastes destined for land disposal.

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ABSTRACT

The effects of air and water pollution controls on solid waste generation were evaluated. The solid wastes from pollution control were identified for individual industrial sectors, by their original air or water pollutant constituents, and the treatment process applied. The wastes were categorized by type and by location (rural or urban). Total solid wastes from pollution control activities were estimated for 1971 and projected for 1985. Particulates and sulfur oxides were identified as the major air pollutants capable of generating solid wastes when treated; suspended solids and biological oxygen demand were identified as the principle means of estimating the impact of water pollution control on solid wastes. Important sectors generating solid wastes included power plants (SIC 491), paper and pulp (SIC 26), chemicals (SIC 28), cement and clay (SIC 324-326), steel furnaces (SIC 331), nonferrous smelting and refining (SIC 333, 334), sewerage systems (SIC 4952), and hazardous wastes from uranium mining (SIC 10). Mine tailing ponds were estimated to be a greater source than all the above sources but were not seen to be a landfill disposal problem.

The report is submitted in fulfillment of Contract 68-03-0244 by Ralph Stone and Company, Inc. under the sponsorship of the United States Environmental Protection Agency. Work was completed August, 1974.

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ACKNOWLEDGMENTS

Sincere appreciation is expressed for the able direction and assistance given for this project by the Environmental Protection Agency's Project Officer, Ronald J. Talley. We also wish to express our thanks to all firms and individuals contacted during the industrial pollution control telephone survey; these sources provided much information not otherwise available in the literature.

This publication is a summary of the more extensive report, Forecasts of the Effects of Air and Water Pollution Controls on Solid Waste Generation, submitted by Ralph Stone and Company, Inc. to the U.S. Environmental Protection Agency in fulfillment of Contract No. 68-03-0244. That report is available from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, Virginia 22151. Mr. Ralph Stone served as Project Director and Mr. David E. Brown served as Project Coordinator. Ralph Stone and Company staff who participated in this project were Messrs. Cecil Owusu, O. B. Kaplan, Timothy Zimmerlin, Edward J. Daley, Tuan Huynh, Herbert A. Smallwood, Albert Herson, Howard Smith, and John East. Valuable secretarial assistance was provided by Mrs. Martha Lieberman and Miss Greta Wallin. This Executive Summary report was written by Messrs. Ralph Stone, John East and Albert Herson.

SUMMARY

This study contains the major conclusions concerning the effects of air and water pollution controls on solid waste generation. These conclusions were drawn from the final report of an EPA-sponsored project (Contract No. 68-03-0244) entitled "Forecasts of the Effects of Air and Water Pollution Controls on Solid Waste Generation."

The main focus of this report is the change in pollution control residues between 1971 and 1985 and the major SIC code sources of those residues. Sections I, II and III present the main conclusions and recommendations of the study and provide an introduction to the topic. Section IV considers the legislative basis (the Clean Air and Clean Water Acts of 1970 as amended) of increased pollution control requirements. Section V considers the effects of these laws on specific industries, discussing specific pollution control processes applied and forecast quantities of residues remaining (after reuse) for ultimate disposal. Section VI further characterizes the solid waste residues, comparing the quantity of residues resulting from pollution control with the National solid waste total (for 1971 and 1985). The biodegradability and destination of the residues from pollution control are also discussed. The Section concludes with a discussion of the relative contributions of the various treatment processes to residue generation. A Glossary and References are also included.

SECTION I

FINDINGS

Sources of Pollution that Generate Solid Waste Residues.

1. Of the major air pollutants, those that generate solid waste residues when controlled nationwide are particulates and sulfur oxides. Control of carbon monoxide generates no solid waste residues, and control of nitrogen oxides generates relatively insignificant amounts. Hydrocarbons in particulate form generate solid residues when controlled by filter-type devices; however, when they are incinerated, they produce little solid residue. The control of gaseous hydrocarbons creates little solid waste residue. Other miscellaneous air pollution control activities, principally fluoride and hydrogen sulfide control, create solid residues, but their contribution to the total of solid residues resulting from air pollution control is negligible due to their relatively small total discharges when compared to the total particulate and sulfur oxide discharges. Table VI-4 presents, for 1971 and 1985, estimates of solid waste residues from air and water pollution control broken down by type of pollutant controlled and industry source.

2. The major water pollutants capable of generating solid waste residues when controlled are suspended solids, dissolved solids, and biological oxygen demand (typically measured as BOD_5). Certain commonly-used wet process air pollution treatments, such as limestone scrubbing, generate suspended solids which add to the total water pollutant load. Acids in wastewater generate solid wastes when inert salts are formed by their neutralization or precipitation.

3. A relatively small number of industrial sources generate the majority of those air and water pollutants whose control can create solid waste residues. The main industrial solid waste residues and their sources are: Feedlots (SIC 02), Meat and Dairy Products (201,202), Canned and Preserved Fruits and Vegetables (203), and Sewerage Systems (4952)--suspended solids and BOD_5; Mining (10-12,14)--suspended solids and acidity; Grain Mills (204), Cement and Clay Products (324-326), Blast Furnaces and Basic Steel Production (331), Iron Foundries (332), and Solid Waste Incineration (4953)--particulates; Paper and Allied Products (26)--suspended solids, particulates, and BOD_5; Chemicals (28)--suspended solids and SO_x; Petroleum Products (13,29)--suspended solids, BOD_5, particulates, and SO_x; Nonferrous Smelting and Refining (333,334)--suspended solids, particulates, and SO_x; and Steam Electric Power Plants (491)--particulates and SO_x.

4. Of the major industrial sources, power plants, steel production, cement and clay production, and nonferrous metallurgy are the largest contributors to air pollution; they generated 63 percent of all uncontrolled particulates and 77 percent of all uncontrolled sulfur oxides in 1971. The largest contributors to water pollution (excluding mining) are sewerage systems, paper products, steel products, and feedlots; they generated 69 percent of all uncontrolled suspended solids and 75 percent of all uncontrolled BOD_5 in 1971. Mining operations generated suspended solids in quantities large enough

to make the other industrial contributions insignificant; however, these solids are largely generated and disposed of in the immediate vicinity of the mine, posing no significant urban treatment and disposal problems.

5. Excluding mining pollution control, in 1971, the control of particulates accounted for 62 percent of total solid residues from pollution controls, with sulfur oxide and other air pollutant controls accounting together for only one percent of the total residues. Control of all water pollutants accounted for the remaining 37 percent of total solid residues. By 1985, these respective contributions to total solid waste residues are forecast to change as follows: particulate control--40 percent, sulfur oxide control--39 percent, other air pollutant controls--0.2 percent, and water pollution control, the remaining 21 percent. Figure VI-1 presents this information graphically.

6. Urban storm drain runoff, conventionally considered as a "background" for other substances causing water pollution, is actually a significant pollution source caused by man's activities. Although waste contributions from storm drainage to water pollution are unquantifiable due to limited investigations, future increased treatment of the runoff by pollution abatement systems could result in considerable additional solid waste generation.

Pollutant Abatement Measures and Their Impacts on Residues.

1. Principal pollutant abatement alternatives are waste treatment processes and plant process modifications designed to eliminate uncontrolled industrial pollution discharges. The end products of pollution treatment processes are typically solid or liquid residues ("solid waste residues") which must be disposed, most often to land, if they are not reused or recycled. The effect of reuse and recycling, relative to the disposition of these residues, is to reduce the amounts that must be disposed. The effect of plant industrial waste-reducing process modifications is to lower the total pollutant load that ordinarily must undergo treatment, thus reducing potential pollution control residues.

2. Common air pollution treatment processes may be classified as wet versus dry and physical versus chemical. Dry processes generally produce solid waste residues directly, while wet processes (e.g., scrubbers) create residues suspended in water which must be removed by water treatments. Physical (filtration) processes (e.g., baghouses, scrubbers) generally are employed for particulate control and create solid residues approximately equal to the weight of the pollutant removed. Chemical treatment processes (e.g., limestone scrubbers), often used for sulfur oxide control, usually add reacting chemicals to the original pollutants and create solid residues greater in weight than the original pollutant. Limestone scrubber residues are over twice the weight of the SO_x removed from the stack gases.

3. Common water pollution treatment processes may be classified as primary, secondary, and tertiary. Primary (physical) treatments (e.g., screening, sedimentation, flotation) generally remove suspended and flotable solids, creating solid waste residues equal in weight to the original pollutant removed. Secondary treatments, which are either biological or chemical, can result in either less (via biological decomposition) or more (via chemical addition) solid residue weight than that of the original pollutant, depending on the specific treatment(s) involved. Efficient biological treatment residues from the treatment of organic wastes may range from as low as 25 percent of the BOD_5 removed (after anaerobic digestion) to 50 percent

of the BOD_5 (after activated sludge aerobic digestion). Where the pollutants do not decompose easily, these ratios may be considerably higher. Estimates for 1971 of solid waste residues generated by specific air and water pollution controls for key polluting sectors are presented in Table VI-5 . Corresponding forecasts for 1985 are presented in Table VI-6.

Tertiary treatments of organic waste streams, due to extensive solids removal by primary and secondary treatments, usually contribute only small amounts of solid residues, but may generate extensive salt residues when demineralization is employed for inorganic waste streams.

4. It is estimated that in 1971, solid waste residues from pollution control were due largely to physical wet air treatments (accounting for 49 percent of all solid residues) and primary water treatments (accounting for 20 percent). By 1985, 40 percent of all residues are expected to be produced from chemical wet air treatments (e.g., limestone scrubbing), 32 percent are forecast to be produced from physical wet air treatments, and only 12 percent are forecast to be produced from primary wastewater treatment processes. This information is summarized in Figure VI-2 .

Impacts of Federal Pollution Control Legislation on Solid Waste Generation.

1. The major Federal legislative measures that affect the type and quantities of solid wastes generated from air and water pollution control are the Federal Water Pollution Control Amendments of 1972; the Marine Protection, Research, and Sanctuaries Act of 1972; and the Clean Air Act of 1970. In general, the effect of this Federal legislation is to increase the quantities of solid waste residues from air and water pollution control by banning or reducing pollutants discharged to the air and water.

2. The Clean Air Act of 1970 will have differential impacts on particulate and sulfur oxide emissions. Particulate emissions, which are currently (1974) partially controlled, will be further controlled in the future. Sulfur oxide emissions, currently (1974) largely uncontrolled on a National basis, should be greatly reduced in the future. Air pollutant control levels should increase removal to at least 90-95 percent of the untreated emissions by 1977 as a result of the Clean Air Act, although no nationwide deadline is specified in the Act. No specific legislation for the anticipated increased treatment requirements beyond 1977 has yet been promulgated.

3. Current water pollution control legislation requires that secondary treatment and, to a limited extent, tertiary treatment should be employed for most wastestreams by 1977. By 1983, discharges to water are required to be further reduced, in part by additional secondary and tertiary treatment beyond the 1977 levels and restricted ocean dumpings.

4. Air and water pollution control enforcement will increase the quantities of solid waste residues to the extent that they require or otherwise result in increased application of pollution treatment processes; this study assumes that increased application of treatment controls will probably be industry's short-term (i.e., pre-1985) answer to strict emissions re-

quirements. If long-term economic considerations dictate increased plant process modifications and/or increased recycling and reuse by industry as a result of strict emissions requirements, then the increased solid waste residues resulting from Federal legislation will in turn be reduced.

Estimates of Pollution Control Residues.

1. Total post-consumer and industrial solid wastes were forecast to increase from 214 million metric tons in 1971 to 370 million metric tons in 1985. Of these, solid waste residues from air and water pollution controls were estimated at 61 million metric tons for 1971 (29 percent) and forecast to increase to 244 million metric tons by 1985 (66 percent). Mineral and agricultural wastes are excluded from the above figures (see Table VI-3 for estimates) because they normally are generated in relatively isolated rural locations and present relatively minor handling and disposal problems. Non-point sources are also excluded; these include natural sources (e.g., volcanoes, forest runoff) and runoff from urban, agricultural, and landfill areas.

2. The largest weight of solid residues from pollution control activities is contributed by the mining industry. However, the solid residues produced are not a problem for urban solid waste management, as they are generally non-hazardous and disposed in the immediate vicinity of the mining operations, usually in rural areas.

3. The organic solid waste residues from pollution control in feedlots, meat and dairy products, canned and preserved fruits and vegetables, grain mills, paper products, and sewerage systems are readily decomposed. These residues may also contain some toxic constituents.

4. The solid waste residues from pollution control in cement and clay products, blast furnaces and basic steel production, iron foundries, and fossil fuel plants, although not in general highly toxic, are largely inert and do not biologically decompose.

5. Radioactive solid residues from pollution control activities in nuclear power plants and fuel reprocessing plants are not nearly so great in magnitude as radioactive residues that are concentrated and handled as solid residues; these wastes from pollution control generally have both shorter half-lives and lower levels of radioactivity than solid or liquid wastes from nuclear reprocessing plants.

6. Radioactive solid residues from mine tailings are the largest source of radioactive wastes from air and water pollution control. These wastes, although having a low level of radioactivity, contain many long-lived isotopes and the resulting tailing piles remain hazards to the environment for many years.

7. Residues from air and water pollution control form a significant portion of the total National solid waste production from the following sources: post-consumer, industrial, and mineral. Wastes from pollution control in agricultural activities form an insignificant proportion of the total National agricultural solid waste production.

SECTION II

RECOMMENDATIONS

Two sets of conclusions resulted from this study. The first set, although not strictly dealing with forecasting residues from pollution control, does result directly from the forecasts presented in the full report. This first set of recommendations suggests alternative strategies (or policies) for reducing the solid waste impact of pollution control activities. The second set of recommendations deals with areas requiring further research, data, or methodologies if the solid waste implications of pollution control are to be more fully assessed.

Alternatives for Reducing Impact on Solid Waste Management.

1. Reuse of residues from pollution control should be encouraged, since it would reduce the adverse impact of control activities on solid waste management. Such reuse could be encouraged in several ways, including incentive taxes, subsidies, further research, and direct legislation.

2. To minimize the impact on solid wastes, consideration should be given to modifying the organization of industrial production instead of simply adding additional controls. For example, the current (1974) requirement for use of available low sulfur fuels is effective in reducing the potential solid wastes from sulfur oxide control.

3. Reuse, recycling, and process modifications should be emphasized, where practical, since they can reduce solid waste residues from pollution control. Pollution controls create solid residues both directly (from trapped emissions) and indirectly (from manufacture and operation of control equipment and the energy requirements for these activities).

Further Research Needed.

1. Future effluent guidelines and other detailed studies of industrial pollution control should require a mass balance analysis. The mass balance allows an analysis of the intermedia effects of specific pollution controls.

2. A National survey of the potential for recycling solid residues from air and water pollution controls should be taken since the available literature is inadequate.

3. Methods of stimulating the reuse of solid waste residues from fossil fuel power plant pollution controls should be developed to reduce their environmental impact.

4. A detailed National assessment of solid residues from air and water pollution control of hazardous pollutants should be made.

5. A National survey of the sulfur content of available fossil fuel reserves should be made to more accurately estimate solid wastes produced from sulfur oxide control in fossil fuel power plants.

6. Environmental impact reports should be required to include evaluations of the solid waste impact of proposed developments.

7. Improved methods are needed for segregating solid wastes by type and characteristic to allow for optimum disposal and reuse. Combustible solid wastes could be reclaimed for power generation; toxic wastes should be segregated and neutralized before entering the environment.

8. Further analysis of the pollutants contained in urban, agricultural, and sanitary landfill runoffs and the potential solid waste residues from their control should be made. These pollutants, conventionally considered as natural or non-point source pollution are, in reality, a by-product of society's activities. Natural pollution does occur (e.g., from volcanoes, forest and field runoff) and must as well be quantified.

SECTION III

INTRODUCTION

The Problem of Pollution-Control Generated Solid Waste: An Overview.

Two pollution control laws enacted by the U. S. Congress will have a major impact on National solid waste generation: the Clean Air Act of 1970 and the Federal Water Pollution Control Act Amendments of 1972 (the Clean Water Act). Their primary objective is the reduction of environmental degradation caused by air and water pollutants. Many impediments to the achievement of the objective exist, however. For example, two key problems encountered to date are: (1) who will pay for an improved environment, and (2) what specific form should the implementation requirements (such as monitoring, interim emission standards, permits, and enforcement) take.

An effect of these laws (which has received little attention) is the increased solid waste residues requiring disposal which will result from application of pollution control devices. Although the intent of the Clean Air and Clean Water Acts is to improve the air and water environment, the steps taken by industries and municipalities to comply with specific requirements may create new, unanticipated environmental problems. The negative effects of environmental protection measures, a familiar occurrence to professionals in the environmental field, usually are called secondary or time-related impacts. Examples include consumption of scarce resources for construction and operation of additional water pollution control facilities and increased unplanned residential development resulting from sewering previously undeveloped suburban land.

An increase in the pollution-control generated solid wastes destined for land disposal is a probable, secondary impact of air and water pollution legislation. The specific quantity and composition of this increment to solid wastes will be determined by industrial and municipal responses to increased pollution control requirements. Figure III-1 summarizes the relationship between increased pollution control and solid waste generation. Increased pollution control requirements present dischargers with three alternatives: greater recycling of materials, plant process-modifications (e.g., low-sulfur coal in power plants) which reduce discharges, or additional pollution control devices. The final alternative (additional pollution control devices) so far appears to be the main short-term response of industry to the more stringent Federal emission requirements. Pollution control devices capture pollutants before they can be released to the environment. The captured pollutants, whether in solid or concentrated sludge form, require ultimate disposal.

Materials derived from pollution control which are destined for disposal rather than reuse are defined in this report as solid waste residues. Such "solid wastes" may be solid, sludge, or aqueous - the criteria being that they are destined for final disposal. The solid waste residues from air and water pollution control impact adversely on the environment.

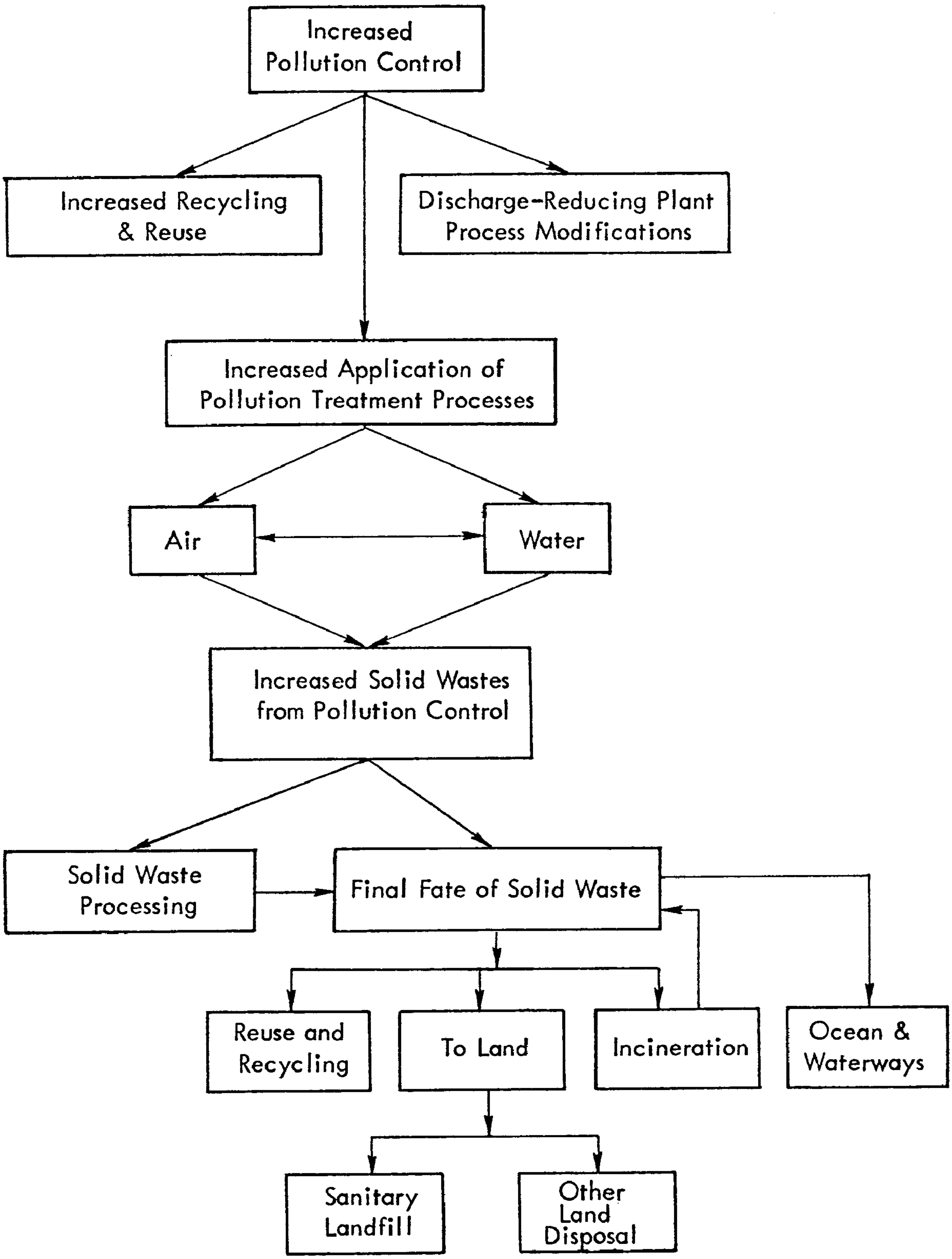


FIGURE III-1
THE SOLID WASTE IMPLICATIONS
OF INCREASED POLLUTION
CONTROL

Disposal alternatives for various solid wastes are incineration, land disposal and ocean or waterway dumping. Current trends in solid waste management favor land disposal. Current air pollution control legislation places strict limits on conventional incineration (although less polluting techniques such as pyrolysis and improved incineration are being developed), and current marine protection and water pollution control legislation severely limit the dumping of wastes into oceans and fresh water.

The need to predict the sources, quantities, composition, and ultimate fate of solid waste residues derived from air and water pollution control is clear. Implementation of higher air and water pollution control standards is scheduled by law for the mid-1970's (air) and the mid-1980's (water). Annual increases in solid waste residues generated are predicted due to greater application of pollution abatement techniques and industrial growth. Accurate forecasts of the quantity and composition of solid waste residues will enable environmental planners and decision-makers to devise and implement comprehensive strategies for minimizing the adverse effects of these wastes on the total environment by anticipating ultimate disposal needs.

Objectives and Scope of Study.

The study objectives as set forth in the authorized work program were:

1. Review the available literature from published EPA reports, "The Intermedia Aspects of Air and Water Pollution Control"[2] and supplemental data sources. Evaluate available predictions concerning economic growth and the trends in industrial production methodology.

2. Identify the major air and water pollutants capable of creating solid wastes and the SIC code sources of these pollutants.

3. Identify the pollution abatement measures, their costs, and their impact upon solid waste generation.

4. Review Federal pollution control laws as they affect the degree and type of waste treatments that may be required through 1985.

5. Forecast the effects of pollution control measures on solid waste generation through 1985. Establish both the quantities and characteristics of these latter solid waste residues.

The study objective was to predict the degree that control of air and water pollution will increase the quantities of solid wastes destined for land disposal. To accomplish the study objective, it was necessary to first provide an inventory of all SIC code[3] industrial air and water pollution discharges before treatment, predict the waste treatment processes that will be applied, then establish the resulting solid waste residues and the probable disposal techniques for these solid residues. The extent to which these residues will be recovered for useful purposes was an important component in the analysis.

This study was not concerned with solid wastes normally resulting from residential, commercial, and industrial process steps per se, but rather with those solid wastes resulting from air and water pollution control activities. More specifically, the study investigated possible increases during the 1971 and 1985 period of solid waste residues attributable to air and water pollution control activities. The study's scope was National, encompassing all solid wastes generated from air and water pollution control activities by all the private industrial and public sectors in the 50 States of the Union.

Method of Analysis.

Individual SIC code industries generating large quantities of solid waste residues were evaluated separately. This was necessary because each industrial sector has different, unique requirements for pollution treatment processes and industry-specific characteristics for residue reuse and disposal. Lesser industries (in terms of the quantity and impact of residues)were evaluated jointly in a separate section of the report. A standardized analytical format was developed and applied to each sector. First, air and water pollutant unit discharge rates (before pollution treatments) for various industrial processes were estimated; economic growth was forecast for each of these processes for the selected years 1971, 1975, 1980, and 1985 to arrive at estimated uncontrolled pollutant discharges. Next, the probable waste treatment processes, their efficiencies, and the solid waste residues they create were identified for each air and water pollutant discharged by the contributing industrial sector. The amount of reuse or recycling of residues from pollution control activities was then forecast, as was the percentage of pollutant discharges by particular processes for the years 1971 through 1985. These analytical steps led to a final estimate of the total solid waste residues generated from pollution control activities for each industrial sector.

In mathematical form, the process used to derive these final estimates of solid waste residues may be reduced to the following equations:

$$R_{ixy} = p(r \cdot E \cdot Z) \qquad \text{(III-1)}$$

where:

R_{ixy} = total residues from a particular treatment process i in industry x (units = kg) generating pollutant y

p = percent of a particular pollutant y treated by process i (no units)

r = solid residues that would be produced by process i assuming it were 100 percent efficient (units = kg)

E = the actual efficiency of process i in trapping pollutant y (no units)

Z = the percent of the residues provided from process i that are not forecast to be reused

The total solid residue estimate, R_x, provided by industry x was obtained by summing over residues produced by all treatment processes for all pollutants, as in Equation 2:

$$(\text{III-2}) \qquad R_x = \sum_i \sum_y R_{ixy}$$

Pollutants, Treatment Processes, and Solid Waste Management: An Overview.

Pollution Sources Considered in this Report. It is estimated that the SIC code sources covered in the report account for approximately 95 percent of the air and water point source pollutant emissions in the United States which when controlled could impact on solid waste generation. Certain major polluting sectors were omitted either because their control would not produce significant solid waste residues, or because no control program is forecast to be implemented by 1985. For example, no consideration was given to the automobile (or other) transportation sector, although it generates large amounts of air pollutants, simply because the control of those emissions does not have a significant solid waste impact. As another example, the impact of storm drainage was not evaluated because there is no National plan for controlling these presently largely uncontrolled wastes, although future Federal legislated water quality requirements may require treatment. Treatment of storm-drain waters, in addition to being extremely expensive, would generate large quantities of solid waste residues. These water pollutants and other non-point pollution sources, such as landfills, forests and fields, will require extensive study in the future.

Hazardous Solid Residues from Air and Water Pollution Control. A preliminary analysis was made of hazardous waste streams resulting from air and water pollution control. This analysis was much more qualitative than other sections of this report, because available information was limited. Some preliminary estimates were made, but they are admittedly limited. The major sources of hazardous wastestreams considered were: pesticides, munition plants, radioactive wastes (mainly from nuclear power generation), chemicals manufacturing, and metals mining, smelting and refining. Radioactive wastes were considered together with steam electric power plants.

Pollutant Treatments and Intermedia Transfers. Preliminary analyses based on inter-industry comparison concluded that particulates and sulfur oxides are the major air pollutants whose treatment generates solid waste residues. The control of hydrogen sulfides and fluorides also produces solid waste residues, but those pollutants are generated in relatively small amounts and only by a few industries. Control of carbon monoxide and gaseous hydrocarbons will most likely have minimal impact on solid waste residues through 1985, largely because controls for these pollutants result in gaseous products released to the air. Particulates are normally controlled by physical filtration, using either dry (e.g., precipitators, baghouses) or wet (e.g., wet scrubbing) processes. (Pollution treatment processes are evaluated more completely in the following Section.) Sulfur oxides, if not reclaimed for sulfuric acid or elemental sulfur reuse, are normally controlled by chemical neutralization with reactants such as limestone (either dry or wet methods are used) or dolomite. Reactions with limestone create calcium sulfates and sulfites weighing approximately twice as much as the sulfur oxides removed. All wet treatment methodologies result in transfer of suspended and dissolved solids to water, where final residues may be created by further processing.

Determination of solid residues from water pollution control is made more complex by the diverse physiochemical nature of solids in water and the use of a wide variety of alternative physical, chemical, and biological treatment methods both within and between industries. On an inter-industry basis, BOD_5 and suspended solids removal are reasonable indicators of solid residues created from biological treatments, although knowledge of organic content of solids in water and the ratio of total dissolved to suspended solids (generally unavailable) would enable more accurate prediction. The weight of residues from a variety of preliminary waste treatments is normally equal to the weight of suspended solids removed, usually 60 to 80 percent of the suspended solids in the treated influent. Activated sludge treatment is estimated to create sludge solids equal to half of the BOD_5 load in the influent following preliminary treatments.[4] Trickling filters normally produce approximately 90 percent of the residues created by an activated sludge plant for a similar influent stream. Lagoon treatment produces even less residue, since most organic suspended solids are stabilized. Lagoon treatment produces a total residue of about 0.25 times the influent BOD_5. Thus, total weight of organic residues may be estimated from influent suspended solids and BOD_5; other inert pollutants in the influent can determine the specific nature of the solid waste residues created.

Overview of Pollution Treatment Processes. This section briefly describes the most commonly used pollution control devices; most of these descriptions were modified from information appearing in the 1973 Environmental Wastes Control Manual.[5] Air pollution control methods can generally be categorized as filtration, scrubbing, cycloning, electrostatic precipitation, incineration, oxidation, or adsorption. Common types of filtering devices employed for air pollution control are baghouse filters; these can be very efficient in particulate collection. Baghouses use fabric filters (with openings usually around 100 μ) to separate particles from their gas medium. The filters are contained by structures known as baghouses. The filters are usually cleaned by mechanically shaking the bags to remove trapped particles; reverse air cleaning is sometimes used.

Wet scrubbers are useful for removing particulates, acids, fumes, and gases; their use in the control of sulfur oxides emissions is expected to increase. Scrubbers operate by causing surface contact between a liquid medium (usually water) and air pollutants. The scrub water often has additives such as detergents or caustics (lime or limestone) to increase removal efficiencies. Scrubbers may operate by water spraying against baffles or in packed towers. In venturi scrubbers, the air and water media are injected into a venturi tube.

Cyclones are used for dry particulate control and operate on the principle of centrifugal force. Particulates are removed by contact with the walls of the collector and subsequently settle in the cone of the separator. Electrostatic precipitators, which are also used for particulate control, ionize gases with a high voltage corona discharge. The charged gas ions then charge particulates; these then migrate to a collecting electrode where they are neutralized by an opposite charge. Fine particulates and colloidal particles may largely escape the aforementioned air pollution equipment.

Incineration is generally used to burn combustible fumes at high temperatures. Combustibles may also be stabilized by catalytic oxidation. Gases are preheated and passed over a catalyst (usually a nickel alloy) to achieve oxidation at lower temperatures than possible with simple incineration.

Adsorbers selectively remove air pollutants from the gas stream. Activated carbon adsorption, the most common adsorption method, is used to adsorb organic gases and odors. Silica gel (to remove organic and inorganic gases) and alumina and bauxite (to achieve dehydration) media are less common adsorption media.

Water pollution control devices can be classified as primary, secondary, and tertiary or advanced waste treatment methods. Primary treatment involves physical removal of suspended pollutants through the use of screening, settling and flotation processes. Screens employed may be either coarse or fine, and are generally used to remove the less dense suspended solids. Denser suspended pollutants, such as cinders and metal fillings, are removed through grit collection, in which the velocity of the effluent is slowed to allow differential settlement of the heavier solids. The lighter solids are often removed by clarification in settling tanks; flotation, flocculation, and sludge-thickening methods are often included as a clarification process.

Secondary treatment includes several treatment processes; the EPA has defined secondary treatment as those processes producing the following effluent quality: BOD_5 and SS at a maximum monthly average of 30 mg/l, fecal coliform at a maximum monthly average of 200/100 ml, and pH equivalent to 6 to 9. The main secondary treatment processes are activated sludge, oxidation ponds, and trickling filters. In conventional activated sludge processes, the effluent, following settling, is aerated for 6-8 hours. Aeration may also be accomplished in oxidation ponds. Aeration and sludge recirculation biologically stabilize the dissolved solids in the effluent. Biological stabilization by trickling filters involves passing effluent over rock or other media where attached microorganisms grow.

Advanced wastewater treatment processes can remove residual solids, dissolved organics, and pathogens still present in the effluent following secondary treatment. A wide variety of treatment processes are available for this further treatment. These include electrodialysis for demineralization, reverse osmosis to remove suspended and dissolved solids, lime or alum coagulation to remove phosphates, dual media filtration to remove suspended solids, activated carbon beds for organics removal, coagulant addition (principally aluminum sulfate, ferric chloride, ferric sulfate, and ferrous sulfate) to remove a variety of pollutants, etc.

SECTION IV
EFFECTS ON SOLID WASTE MANAGEMENT OF FEDERAL LEGISLATION REQUIRING POLLUTION CONTROL

To estimate the future degree of pollution treatment in the various industries, it was necessary to first review the relevant Federal legislation. Recent relevant Federal environmental protection legislation includes the Federal Water Pollution Control Act Amendments of 1972; the Marine Protection, Research, and Sanctuaries Act of 1972; and the Clean Air Act of 1970. The following is a summary of major provisions of the three laws. The implementation of these laws will have a substantial National impact on the distribution within the environment of solid wastes. The first part of this Section presents a summary of the three laws; the final part discusses the implications of this legislation for solid waste management.

Federal Water Pollution Control Act Amendments of 1972. The goals of this law are to achieve, by July 1983 wherever possible, water clean enough for both human body contact and the continued existence of fish, shellfish, and wildlife; these goals further specify the elimination of the discharge of municipal and industrial point source pollutants into the Nation's waterways by July 1985. Pollutants to be controlled under the Act include, but are not limited to: dredged soil, solid waste, incinerator residue, sewage, sewage sludge, garbage, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, dirt, and industrial, municipal, and agricultural wastes discharged to water.

Industrial Pollution Treatment. The EPA has or will establish effluent limitations and performance standards for categories of stationary industrial pollution sources which include the following sectors: industrial pulp and paper mills; paperboard, builder's paper, and board mills; meat product and rendering processing; dairy product processing; grain mills; canned/preserved fruits and vegetables processing; canned/preserved seafood processing; sugar processing; textile mills; cement manufacturing; fertilizer manufacturing; petroleum refining; iron/steel manufacturing; phosphate manufacturing; steam electric power plants; ferroalloy manufacturing; leather tanning and finishing; glass/asbestos manufacturing; rubber processing; timber products processing; etc.

The EPA, in accordance with the FWPCA goals, has issued development documents for effluent limitation guidelines listing the "best practicable" and "best available" technologies for the treatment of waste prior to discharge to receiving waters; these reports identify pollution control methods for the complete elimination of industrial dischargers to receiving waters. Existing stationary industrial sources discharging pollutants to the Nation's waters must use the "best practicable" control technology by July 1977, and the "best available" by July 1983. New industrial sources of pollution must use the "best available demonstrated control technology" by May 1974. Where practicable, new industrial facilities may be prohibited from discharging any pollutants to the Nation's waters. For all industrial wastes discharged to a municipal treatment plant, pretreatment will be required by July 1974 for new industrial facilities, and by July 1976 for existing industrial facilities.

Municipal Pollution Treatment. The Federal Water Pollution Control Act Amendments of 1972 require that new treatment plants approved before July 1974 must at least provide secondary treatment to qualify for Federal construction grants; after that date, "best practicable" treatment must be used. By July 1977, all sewage treatment plants in operation must provide "secondary treatment" and must also comply with any additional effluent limitation established by either the EPA or the State. By July 1983, all publicly-owned waste treatment plants in operation must use "best practicable" treatment methods. The EPA will encourage waste management which provides for recycling of pollutants, confined or contained disposal where not recycled, wastewater reclamation, nonhazardous final sludge disposal, integrated sewage, and industrial or other municipal waste treatment and recycling facilities.

Water Quality Standards. The discharge to navigable waters of any radioactive, chemical or biological warfare agent, and of any high-level radioactive waste, is prohibited by these amendments. In addition, the EPA is to identify substances which in any quantity present an imminent and substantial danger to the public health or welfare, whose discharge is also to be prohibited. Federal standards of performance for marine sanitation devices will be established by the EPA and Coast Guard.

The EPA is to publish criteria relating to the following: chemical, physical, and biological integrity of water; the protection and propagation of fish, shellfish, and wildlife; recreational use; measurement and classification of water quality; maximum daily load requirements; best practicable control technology to achieve effluent reduction; pretreatment guidelines; and pollution discharge source categories. States must adopt intrastate water quality standards subject to EPA approval, and the EPA will establish such standards in the event a State fails to do so. If the "best practicable" or "best available" controls are inadequate to meet water quality standards, the State is required to impose stricter controls. To this end, the State must establish daily maximum total load standards. The Corps of Engineers may issue permits for the discharge of dredges or fill material; these permits are subject to EPA prohibition if the effects on municipal water supplies, fish, wildlife, or recreational areas would be unacceptable.

The NPDES Permit System. Under the 1972 law, it is illegal to discharge any pollutant to National waterways without an NPDES (National Pollutant Discharge Elimination System) permit. Point sources requiring a permit for water pollutant discharges include municipal wastewater treatment facilities, all industrial sectors, and all other service, wholesale, retail, and commercial establishments. The NPDES permit system is to assure that effluent limitations and performance standards are met, that necessary anti-pollution technology is applied, and that all other sections of the amendments are met.

The NPDES permit system is the main implementation mechanism for the 1972 law. The permits specify the types and concentrations of pollutants which are allowed to be discharged by each point source; they are fixed for a period of time not exceeding five years. If immediate compliance with these standards is not possible, the permits set target dates for progressive steps towards compliance. If the conditions of the permit are violated, or if a point source is found to be illegally discharging without a permit, the discharger faces the prospect of penal action, fines, and sometimes imprisonment. State permit programs are subject to the 1972 Federal Water Pollution Control Act Amendments; State permit programs must be approved by the EPA, and the EPA is responsible for issuing permits if State permit programs are not deemed acceptable.

Marine Protection, Research, and Sanctuaries Act of 1972. This Act restricts the transport or dumping of any radiological, chemical or biological agent, or high-level radioactive waste, within the 12-mile territorial limit. The EPA is authorized to issue permits for the transport and dumping of waste materials when such disposal would not unreasonably endanger human health and welfare or the marine environment, and to designate sites where transport and dumping are permitted. The Corps of Engineers is authorized to issue permits for the transport and dumping of dredged or fill materials. The restrictions on ocean dumping will necessitate alternative methods for disposal of these wastes.

Clean Air Act of 1970. This Act is intended to control two types of air pollutants: those which endanger public health or welfare (i.e., pollutants having an adverse effect on the environment or public health) and those considered "hazardous" (i.e., pollutants which may cause or contribute to increased mortality or irreversible and incapacitating illness).

Ambient Air Quality Standards. The EPA is authorized to establish primary (public health) and secondary (welfare) ambient air standards for each pollutant from stationary or mobile sources judged to endanger public health or welfare. No ambient air standard, however, is applicable to hazardous air pollutants. Each State is required to develop plans subject to EPA approval which include: emission limitations; timetables; land-use and transportation controls; and appropriate devices, systems, and monitoring requirements. The EPA is authorized to act if States fail to provide for the implementation of Federal ambient standards or the enforcement of National emission standards and requirements. No industry-wide deadlines exist for implementation of EPA-required emission standards. However, most sources will be required to improve controls over present levels by 1976. The Economics of Clean Air[6] lists forecast control levels for emissions in major polluting industries for 1977; no data are available for controls to be established beyond 1977.

Stationary Sources. The EPA will maintain a list of categories of stationary sources which may contribute significantly to air pollution, establish National standards of performance for new sources within each category, and issue information on related pollution control techniques. State plans may include standards and requirements for pollutant emissions from existing stationary sources for which no Federal standards have been issued, and may implement the Federal standards for existing or new stationary sources.

The EPA will publish a list of hazardous air pollutants, issue information on control techniques, and establish emission standards. No new source or modification of an existing facility may violate standards for any hazardous pollutant. The EPA may, however, grant waivers of up to two years for existing sources.

Mobile Sources. It was required by the Clean Air Act, by 1975, that carbon monoxide and hydrocarbon emissions from light-duty automotive vehicles and engines must be reduced a minimum of 90 percent based on model-year 1970 averages; by 1976, oxides of nitrogen emissions must be reduced a minimum of 90 percent based on model-year 1971 averages. The EPA may control the sale or commercial use of automotive fuel or additives which either endanger the public health or impair the emission control system or device. Subsequent rulings by the EPA in 1973[8,9], however, have resulted in the delay of full-scale implementation of these requirements.

Effects of Federal Legislation on the Disposition of Solid Waste Residues. The effect of these three laws, and particularly the FWPCA Amendments of 1972 and the Clean Air Act of 1972, will generally be to increase the quantity of solid waste residues disposed to land. The goal of these laws is the reduction and eventual elimination of pollutant discharges to air and water media. There are, in general, two ways of reducing discharges: treatment and capture of pollutants is one; the other is process modifications designed to reduce or eliminate the generation of pollutants. Abatement through treatment methods will increase solid waste residues for land disposal. The response of industrial and municipal dischargers to Federal air and water pollution control legislation is likely, at least in the short-term, to be preference toward installing pollution control devices, rather than switching to production methods which are less polluting.

Current trends in pollution abatement measures dictated that increased application of pollutant treatment methods will comprise the bulk of industry's short term (pre-1985) response to the goals and requirements of Federal air and water pollution control legislation. If long-term economic considerations or technological breakthroughs result in increased use of more non-polluting processes or increased amounts of reuse and recycling of wastes, the amount of solid waste residues destined for land will correspondingly be reduced. The possibility exists that future Federal legislation or economic incentives will require or stimulate the incorporation of more non-polluting processes or increased reuse and recycling of wastes, thus mitigating the solid waste impacts of existing legislation.

SECTION VI
INDUSTRY-BY-INDUSTRY
BREAKDOWN OF SOLID RESIDUES

Feedlots (SIC 02).

Pollutants generated by housing animals in feedlots are mainly dry solids, BOD_5, ash, and nitrogenous wastes; these pollutants are either directly discharged into the water medium or removed via mechanical means. The main sources of water pollutants in this sector are: milk rooms (for dairy cattle) and housing (barns, yards, etc. for all other animals), and storm drainage runoff. Total untreated solids generated from dirt lots were forecast to increase from 20,000 million kg in 1971 to 25,466 million kg in 1985; total untreated solids generated from solid and slotted floors were forecast to increase from 28,665 million kg to 30,264 million kg during the same period.

Common waste-removal methods are mainly mechanical (e.g., scraping) and water flushing. Mechanical removal creates solid residues which are usually reclaimed; flushed wastes, along with drainage runoff, must undergo effluent treatment. These wastewater treatments, which all produce some solid waste residues, are mainly lagooning, oxidation ditches, activated sludge, and evaporation. Of the various alternative disposal methods, composting, soil conditioning,and other utilizations provide complete reuse, feed recycling involves 80 percent reuse,dehydration 43 percent reuse, oxidation ditch provides 25 percent solids, and incineration little. Total solid residues from pollution control in feedlots were forecast to increase from 920 million to 1,150 million kilograms between 1971 and 1985. Additional solids from feedlots are generated from dry processes; these were forecast to decrease from 5,540 to 4,560 million kg between 1971 and 1985. This forecast reduction is a consequence of the forecasted increase in feedlot solid waste reuse, and a corresponding decrease in landfill disposal, between 1971 and 1985. Raw solid waste residues from feedlots were estimated to be composed of about 84 percent water. Of the dry residue, approximately seventy percent is biodegradable, thirty percent ash, seventeen percent potassium, three percent phosphorus, and one percent magnesium.

Mining (SIC 10-12, 14). Particulate emissions in mining and milling operations are very large. Total emissions before treatment were forecast to increase from 8,000 million kg in 1971 to 13,100 million kg in 1985. Huge amounts of suspended solids are discharged before treatment. Tailing ponds have been in common use long enough so that partial suspended solids control is an accepted practice in the industry. Suspended solids before treatment were forecast to increase from 8×10^{11} kg in 1971 to 13×10^{11} kg in 1985. Both process water and drainage water contribute to this pollutant load.

Cyclones and baghouses are the most common air pollution control devices, although wet scrubbers are utilized in some milling operations. Sedimentation in tailing ponds removes the overwhelming portion of suspended solids discharged by mines, and neutralization followed by sedimentation is used to treat acid mine drainage. Passive controls entail the sealing of "dead" mines to prevent the discharge of drainage waters. The degree of reuse of solid residues from air and water pollution control is a function of mine type, product quality, etc. Metal mines typically do not recycle residues, while coal cleaning produces both usable and solid waste residues. Normally, dust collected from non-metal mining can be reused. Figure V-1 is a schematic of pollution control generation of solid waste residues.

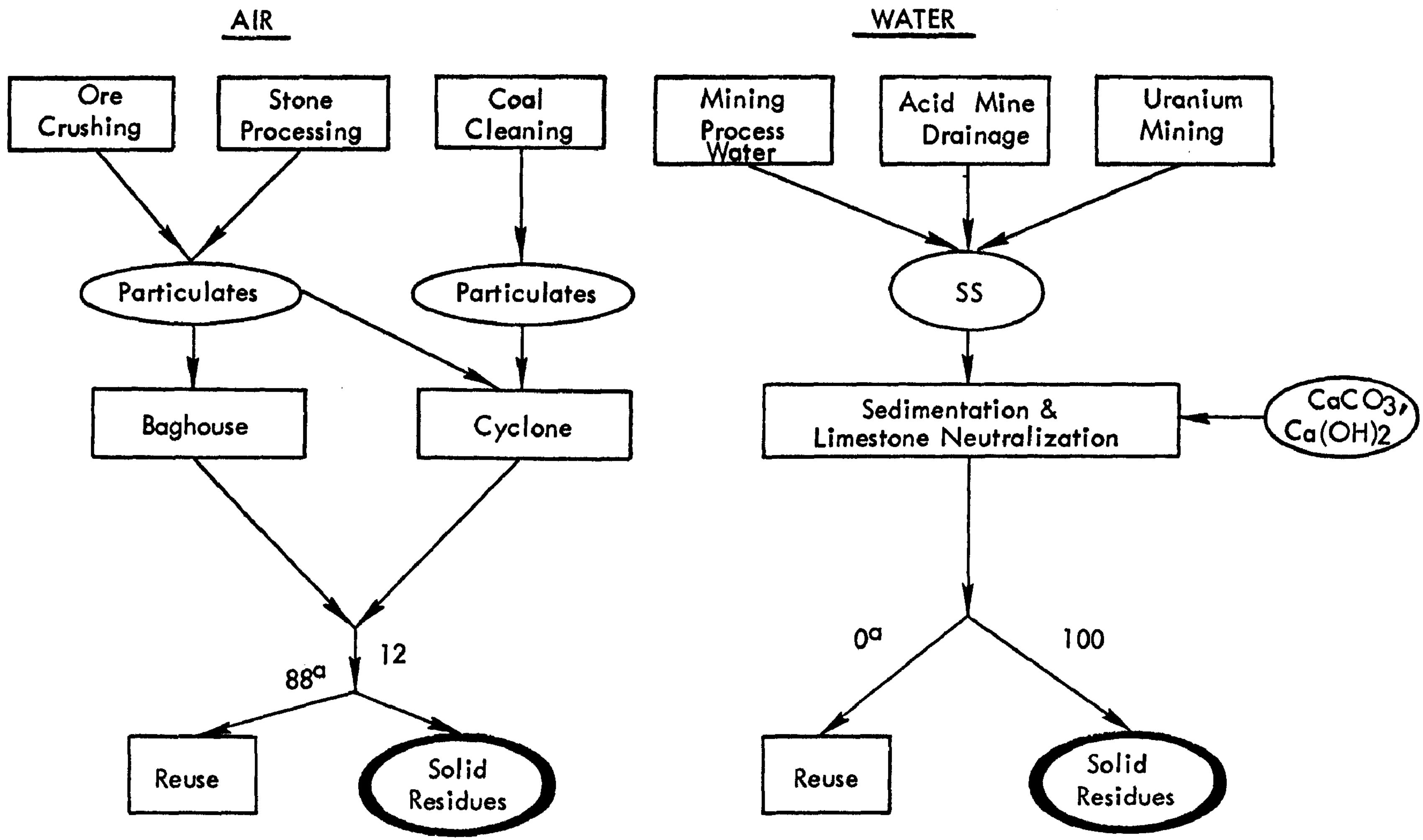
Table V-1 presents forecasts for the years 1971 and 1985 of solid waste residues generated by pollution control activities. Total solid residues from air and water pollution control in mines and ore milling operations were forecast to increase from 8 x 10^{11} kg in 1971 to 13 x 10^{11} kg in 1985, mostly from tailing ponds. This tends to obscure the very significant quantities of solid waste residues from air pollution control and drainage from dead mines; waste residues from air pollution control were forecast to increase from 460 million kg in 1971 to 1,410 million kg in 1985. The impact of total solid wastes is not as important as it seems from the quantities involved, since the mines from which they originally came are near at hand and are natural disposal sites. The cost of reclaiming strip mined land is significant, however, and so the solid wastes have an economic impact even though they do not directly create a residue which cannot be handled locally. The heavy metal content of solid wastes from air and water pollution controls in mines causes these residues to have toxicity problems, particularly when water leaches through disposal sites.

There are two distinct types of solid waste residues, commonly termed sludges and silicates. Sludges result from limestone neutralization. Silicates are the non-organic soils and rocks tailings usually excavated with the ore. Sludges contain high concentrations of metallic oxides, calcium sulfate, and silicates. Sludges are subject to leaching and require isolation. Most tailings and air pollution residues not reused are "silicates" and are largely inert and relatively insoluble.

Meat and Dairy Products (SIC 201, 202).

The majority of pollutants generated by this industry are derived from slaughtering and by-product handling and are released to water. Air pollutants from the industry are relatively insignificant. Untreated BOD_5 discharges were forecast to increase from 700 to 890 million kg between 1971 and 1985; total suspended solids discharges during the same period were forecast to increase from 590 to 710 million kg. Meat products account for the majority of these untreated BOD_5 and SS discharges. This sector, in addition, was forecast to generate significant amounts of untreated dissolved pollutants (e.g., phosphorus, chlorides); dissolved pollutant generation is forecast to increase from 257 to 334 million kg between 1971 and 1985.

Primary in-plant controls (e.g., screening, settling) are common in the meat products industry, and produce significant quantities of solid waste residues. Common wastewater treatments for meat and dairy product effluents are biological treatments, spray irrigation, ultrafiltration, reverse osmosis, dissolved air flotation, coagulation, lagooning, aeration, trickling filtration, and ion exchange. Ion exchange is used generally for dissolved pollutants only, and the remaining treatments are used for suspended solids and other flotables. From the latter advanced wastewater treatments, solid wastes are generated mostly from



[a] Estimated reuse percentage for 1985.

FIGURE V-1
GENERATION OF SOLID RESIDUES:
MINING

TABLE V-1

SOLID WASTE RESIDUES FROM POLLUTION CONTROLS IN MINING

SIC 10-12, 14

Pollutant Method	Treatment Process	1971 Residues Before Reuse (10^6 kg)	1971 Reuse (%)	1971 Solid Waste Residues (10^6 kg)	1985 Residues Before Reuse (10^6 kg)	1985 Reuse (%)	1985 Solid Waste Residues (10^6 kg)
AIR POLLUTANTS							
Particulates							
Milling	Cyclones, bag-houses	3,390	86	460	11,280	88	1,410
Total Residues Directly from Air Pollution Control		3,390	86	460	11,280	88	1,410
WATER POLLUTANTS							
Acid Mine Drainage							
Active mines	Limestone	270	0	270	2,990	0	2,990
Process Water[a]							
All mines	Sedimentation	8×10^5	0	8×10^5	1.3×10^6	0	1.3×10^6
Radioactive Tailings							
All mines	Sedimentation/ limestone	990	0	990	29,700	0	29,700
Total Residues from Water Pollution Control		8×10^5		8×10^5	1.3×10^6		1.3×10^6
Total Residues from Air and Water Pollution Control		8×10^5		8×10^5	1.3×10^6		1.3×10^6

TABLE V-1 (Cont.)

SOLID WASTE RESIDUES FROM POLLUTION CONTROLS IN MINING

SIC 10-12, 14

Pollutant Method	Treatment Process	1971			1985		
		Residues Before Reuse (10^6 kg)	Reuse (%)	Solid Waste Residues (10^6 kg)	Residues Before Reuse (10^6 kg)	Reuse (%)	Solid Waste Residues (10^6 kg)
Total Residues from Air and Water Pollution Control Excluding Process Water		4,650		1,720	43,970		34,100

[a] Specific pollutants depend on the type of ore being mined.

aerobic lagooning followed by trickling filtration, dissolved air flotation followed by inorganic coagulation, and ion exchange. The main instances of reuse in these industries are use of integument as food supplements for animals, and similar by-product reclamation of the grease produced from dissolved air flotation.

Total solid residues from water pollution control in these sectors were forecast to increase from 60 to 220 million kilograms between 1971 and 1985. The vast majority of the solid waste residues produced will likely be from meat products, which are also forecast to be responsible for the majority of untreated discharges. The small 1971 contribution of the dairy products sector, 16 million kg, was forecast to decline to 6 million kg by 1985.

Canned and Preserved Fruits and Vegetables (SIC 203).

This sector generates few air pollutants but a substantial quantity of water pollutants. Total BOD_5 discharges before treatment were forecast to increase from 350 million kilograms in 1971 to 600 million kilograms in 1985; total suspended solids discharges were forecast to show a similar increase from 390 to 670 million kg during the same period. Most plants currently employ primary treatment processes such as screening, sedimentation, and flotation. Secondary controls will be required by 1977 and further improvements by 1983.

Although large amounts of solid waste are generated in this sector (both during processing and as a result of pollution control), their reuse potential is high (mostly for animal feed). Approximately 80 percent of the residues generated from pollution control were forecast to be reused. For 1971 and 1985, final solid waste residues for land disposal were forecast to be only 50 million kg and 140 million kg, respectively. The waste residues are mainly organic and may be used as a soil conditioner or for spray irrigation. Because of their organic content, solids disposal in landfills presents no major problems.

Grain Mills (SIC 204).

Grain mills generate air pollutants (largely particulates) almost exclusively; these particulate emissions are normally controlled by dry methods. The cyclone is currently the predominate treatment method; fabric bag filters are more efficient and are likely to be the major treatment method by 1985. Total uncontrolled particulate pretreated discharges (before treatment) were forecast to increase from 4.8 billion kg in 1971 to 7.8 billion kg by 1985.

Treatment generated an estimated 500 million kg of solid waste residues in 1971, a weight forecast to increase to 2,700 million kg in 1985. These figures assume a fairly high degree of reuse. As more fines are captured with more stringent emission control equipment, the degree of reuse will decline slightly.

Papers and Allied Products (SIC 26).

The recycling process is the major source of water pollutants. Significant quantities of air pollutants, sulfur oxides, particulates, and hydrogen sulfide are also emitted. Most air pollution control is currently accomplished with wet scrubbers, although electrostatic precipitators may be used more frequently in the future. Primary and secondary treatments are applied to the effluent stream to control suspended solids and BOD_5, while carbon absorption and lime coagulation are used to control the discharge of color (lignins).

The total solid waste residues from air and water pollution control were forecast to increase over the period 1971 to 1985 from 6,910 to 15,350 million kg. Table V-2 summarizes the solid waste residues resulting from air and water pollution control. Although currently (1974) most wastes are incinerated or landfilled, the use of recovered fibers in the building materials industry, of dried activated sludge as a fuel, and of processed activated sludge as a commercial soil conditioner holds promise for future recycling (see Figure V-2).

Chemicals and Allied Products (SIC 28).

This sector generates substantial quantities of both air and water pollutants. Particulates are discharged from the production of carbon black, plastics, nitrate and phosphate fertilizer, and phosphoric acid. Sulfur oxides and hydrogen sulfides are discharged from sulfuric acid and carbon black, respectively. The untreated discharges of particulates and sulfur oxides were forecast to increase from 6,370 million kg in 1971 to 10,390 million kg in 1985. Untreated water pollution discharges in the form of suspended and dissolved solids generated by the manufacture of inorganic chemicals amounted to 14.9 billion kg in 1971 and were projected to increase to 20.9 billion kg in 1985. Untreated sludge from the production of plastics and synthetics and untreated BOD_5 load from the manufacture of organic chemicals were forecast to increase from 93 million kg and 3,647 million kg in 1971, respectively, to 324 million kg and 8,336 million kg in 1985.

Air pollution treatments applied in the chemical manufacturing industry are primarily bag filters, cyclones, electrostatic precipitators, wet and dry scrubbers, and incinerators. The reuse of the residues generated by pollution treatment is fairly common in the industry. Water pollutants are typically subjected to settling and clarification to remove settleable solids in the effluent prior to being neutralized, evaporated, or lagooned. Figure V-3 is a schematic of the generation of solid waste residues by pollution control.

Table V-3 presents, for 1971 and 1985, estimates of total solid waste residues resulting from air and water pollution controls in the chemical sector. Solid wastes were projected to reach 17,400 million kg in 1985, a considerable increase of 80 percent over the 1971 level of 9,680 million kg. Residues derived from air pollution control are mainly attributable to fertilizer, carbon black, and sulfuric acid manufacture; those derived from water pollution control are mainly attributable to inorganic chemicals and plastics, and synthetics manufacture. Required advance water pollution treatments alone will create 820 million kg of solid waste in 1985, as compared with a zero level of solid waste residues in 1971.

Petroleum Extraction, Refining and Transportation (SIC 13, 291).

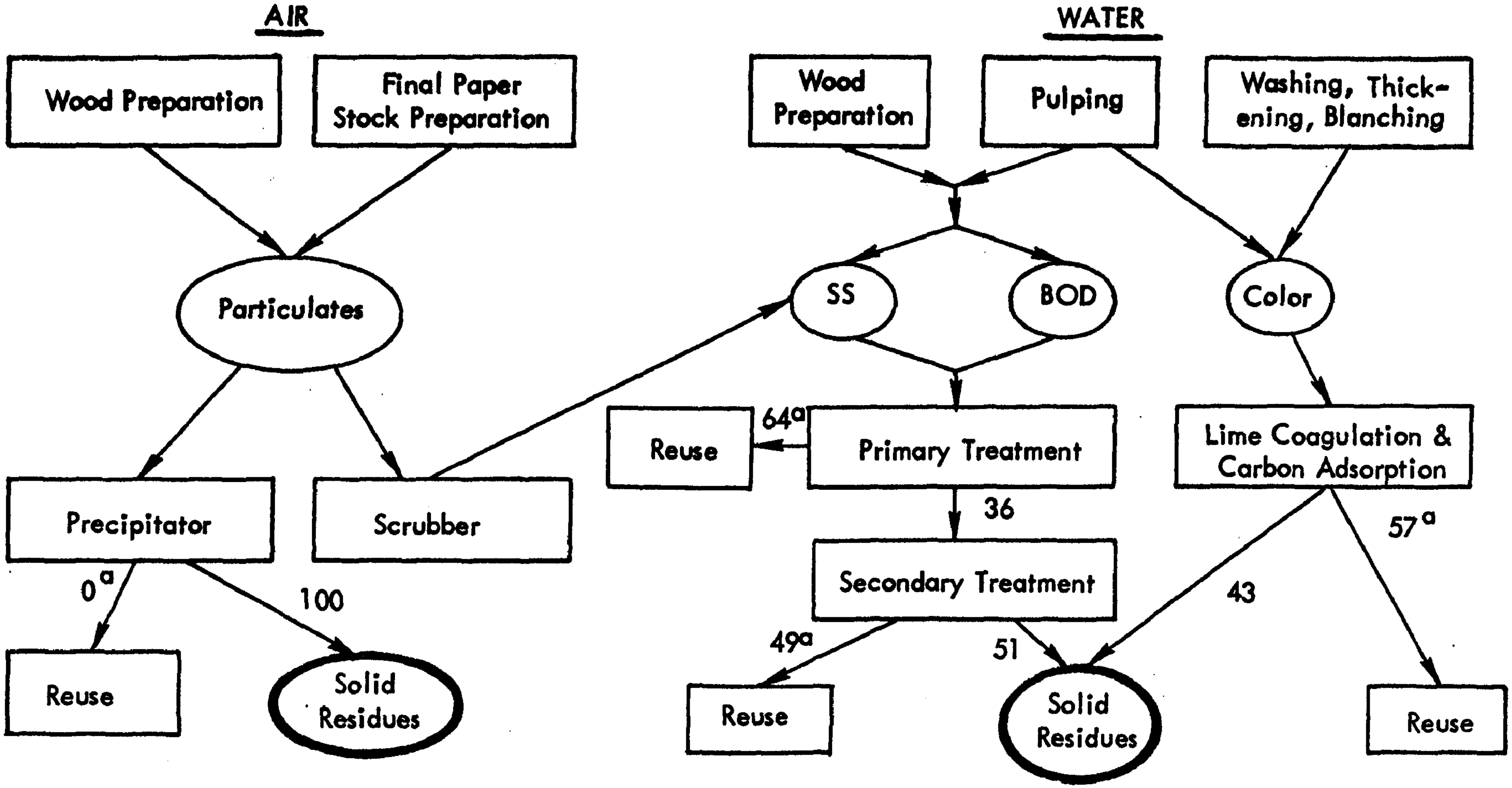
Oil extraction and transportation primarily generate water pollutants; refining generates both air and water pollutants. Total uncontrolled particulate emissions from this industry were

TABLE V-2

SOLID WASTE RESIDUES FROM POLLUTION CONTROLS IN PAPER

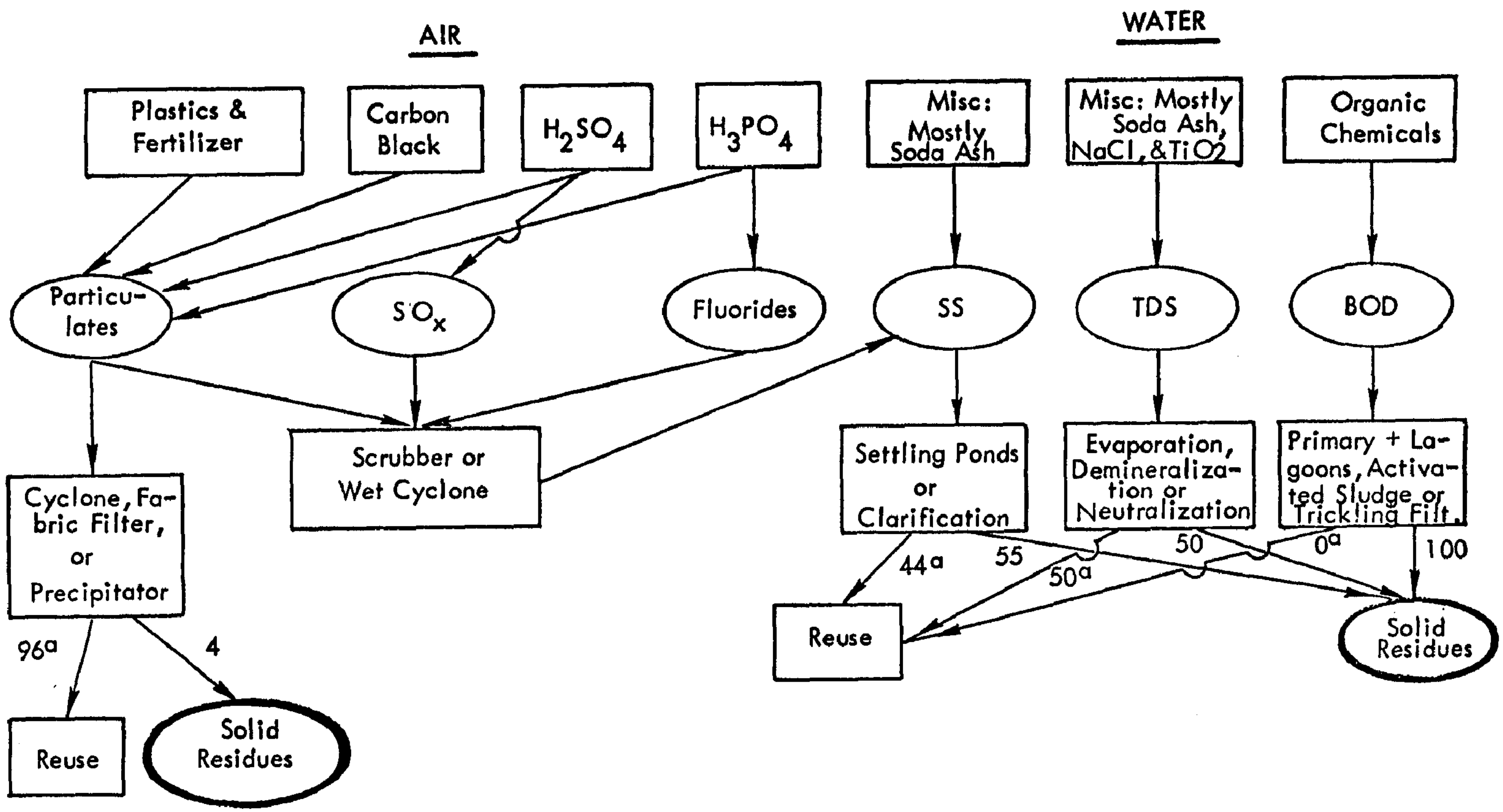
SIC 26

Pollutant Method	Treatment Process	1971 Residues Before Reuse (10^6 kg)	1971 Reuse (%)	1971 Solid Waste Residues (10^6 kg)	1985 Residues Before Reuse (10^6 kg)	1985 Reuse (%)	1985 Solid Waste Residues (10^6 kg)
AIR POLLUTANTS							
Particulates							
All	Precipitator	1,450	0	1,450	4,900	0	4,900
	Wet scrubber	2,634	transferred to water		2,540	transferred to water	
Total Residues Directly from Air Pollution Control		1,450	0	1,450	4,900	0	4,900
WATER POLLUTANTS							
Suspended Solids							
Wood preparation	Primary	180	0	180	310	0	310
All other steps	Primary	2,730	55	1,130	3,040	0	900
BOD_5							
All	Secondary	1,070	80	860	3,540	49	1,820
Color							
Pulping and bleaching	Carbon adsorption	6,210	70	1,860	8,010	70	2,400
	Lime coagulation	1,440	0	1,440	5,020	0	5,020
Total Residues from Water Pollution Control		11,630		5,460	19,920	48	10,450
Total Residues from Air and Water Pollution Control		13,080		6,910	24,820	38	15,350



[a]Estimated reuse percentage for 1985.

FIGURE V-2
GENERATION OF SOLID RESIDUES: PAPER AND ALLIED PRODUCTS



a Estimated reuse percentage for 1985.

FIGURE V-3
SOLID RESIDUE GENERATION:
CHEMICALS MANUFACTURE

TABLE V-3
SOLID WASTE RESIDUES FROM POLLUTION CONTROLS IN CHEMICALS
SIC 28

Pollutant Method	Treatment Process	1971 Residues Before Reuse (10^6 kg)	1971 Reuse (%)	1971 Solid Waste Residues (10^6 kg)	1985 Residues Before Reuse (10^6 kg)	1985 Reuse (%)	1985 Solid Waste Residues (10^6 kg)
AIR POLLUTANTS							
Particulates							
Sulfuric and phosphoric acid	Venturi scrubber and recycle	40	transferred to water		90	transferred to water	
	Other	60	0	60	130	0	130
Nitrate fertilizer	Wet cyclones and scrubbers	630	transferred to water		1,800	transferred to water	
	Dry cyclones	240	50	120	590	50	300
Phosphate fertilizer	Wet acid scrubber	2,700	transferred to water		3,900	transferred to water	
	Fabric filter	320	50	150	440	0	440
Plastics	Misc. controls	30	25	20	130	25	100
Carbon black	Electrostatic precipitator and baghouse	1,290	0	1,290	1,840	0	1,840
Sulfur Oxides							
Sulfuric acid	Absorption tower and alkali scrubber	1,060	transferred to water		2,310	transferred to water	
Fluorides							
Phosphoric acid	Scrubbers and recycle	40	transferred to water		160	transferred to water	
Total Residues Directly from Air Pollution Control		1,930		1,640	3,130		2,810

TABLE V-3 (Cont.)
SOLID WASTE RESIDUES FROM POLLUTION CONTROLS IN CHEMICALS
SIC 28

Pollutant Method	Treatment Process	1971 Residues Before Reuse (10^6 kg)	1971 Reuse (%)	1971 Solid Waste Residues (10^6 kg)	1985 Residues Before Reuse (10^6 kg)	1985 Reuse (%)	1985 Solid Waste Residues (10^6 kg)
WATER POLLUTANTS							
Suspended Solids							
All	Settling ponds	4,644	40	2,417	9,100		5,062
	Other	26	10	23	9	20	7
Dissolved Solids							
Sodium silicate & sodium metal	Neutralization or separation	23	0	23	12	0	12
Soda ash	Evaporation	122	0	122			
	Evaporation & deep well disposal	1,850	0	1,850	7,220	0	7,220
	Deep well disposal	2,040	0	2,040	0	0	0
T_iO_2	Demineralization plus evaporation	1,560	0	1,560	1,470	0	1,470
Sodium dichromate	Evaporation	1	0	1	2	0	2
Sulfuric acid	Neutralization	10	100	0	30	100	0
Sodium chloride	Storage ponds	6,150	100	0	8,540	100	0
Hydrofluoric acid	Neutralization and land dumping	neg.	0	neg.	neg.	0	neg.
Misc. chemicals	Misc. controls	n.d.[a]			n.d.		

TABLE V-3 (Cont.)
SOLID WASTE RESIDUES FROM POLLUTION CONTROLS IN CHEMICALS
SIC 28

Pollutant Method	Treatment Process	1971 Residues Before Reuse (10^6 kg)	1971 Reuse (%)	1971 Solid Waste Residues (10^6 kg)	1985 Residues Before Reuse (10^6 kg)	1985 Reuse (%)	1985 Solid Waste Residues (10^6 kg)
WATER POLLUTANTS (Cont.)							
Sludge-dry solids							
Plastics	Primary and secondary	n.d.			n.d.		
BOD_5							
Organic chemicals	BPCTA plus BATEA	0			820	0	820
	None	0			0		
Total Residues from Water Pollution Control		16,430	51	8,040	27,210	46	14,590
Total Residues from Air and Water Pollution Control		18,360	46	9,680	30,340	57	17,400

[a]No data available.

forecast to increase from 300 million kg in 1971 to 430 million kg in 1985. Sulfur oxides were forecast to increase from 3,480 million kg in 1971 to 4,990 million kg in 1985. Crude oil spills were forecast to remain constant at 65.5 million kg of oil through 1985, as improved technology offsets increased oil drilling and transportation. Brine salts were forecast to increase from 550 million kg in 1971 to 1,130 million kg in 1985, although this is highly dependent on the percentage reinjected into the ground. Refinery operations produce large quantities of BOD_5, oil and grease, phenols, ammonia, suspended solids, and miscellaneous other pollutants. BOD_5 discharges were forecast to increase from 100 million kg in 1971 to 140 million kg in 1985, and suspended solids from 35 to 50 million kg over the same period.

Refinery particulate emissions are commonly controlled by electrostatic precipitators, although a few baghouses may be used in the future. Sulfure recovery plants are the common method of sulfur oxide control in refineries. These plants produce a saleable by-product and generate no solid waste. The treatment of brines to extract valuable minerals leaves 85 to 90 percent of the original dry weight of brine treated as solid waste requiring disposal. The clean-up of oil spills is done by a combination of surface skimming and the use of various sorbents. The skimmed product may many times be processed to yield refinery crude feedstocks. Sometimes the sorbents are squeezed to yield crude oil and regenerate the sorbents for reuse.

Total solid waste residues from air and water pollution control in the petroleum industry were forecast to increase from 770 million kg in 1971 to 1,490 million kg in 1985. A large proportion of these wastes were forecast to be generated by brine disposal, which is performed near the extraction site and can only be roughly estimated. The mixtures of oil and sorbents from oil spill clean-up are normally sent to landfills when the sorbents are not reprocessed.

Cement and Clay (SIC 324,326).

The main pollutant generated during cement and clay manufacture is particulates. Total pretreated discharges from the sector were forecast to almost double from 1971 (8,200 million kg) to 1985 (15,813 million kg). Some water pollution is created through intermedial transfer to water during control. Estimates of the total solid waste residues from control (presented in Table V-4) were forecast to decrease from 3,780 million kg in 1971 to 2,640 million kg in 1985. This decline was attributed to increased recycling forecast for the future. Most pollutants which are captured in solid formmay be added back into the batch due to the nature of cement and clay. Figure V-4 is a schematic of pollution control processes and solid waste residue generation from control.

The large percentage of kiln dust and wastewater reused in both cement and clay manufacture lessens on solid waste residue generation from pollution treatment processes.

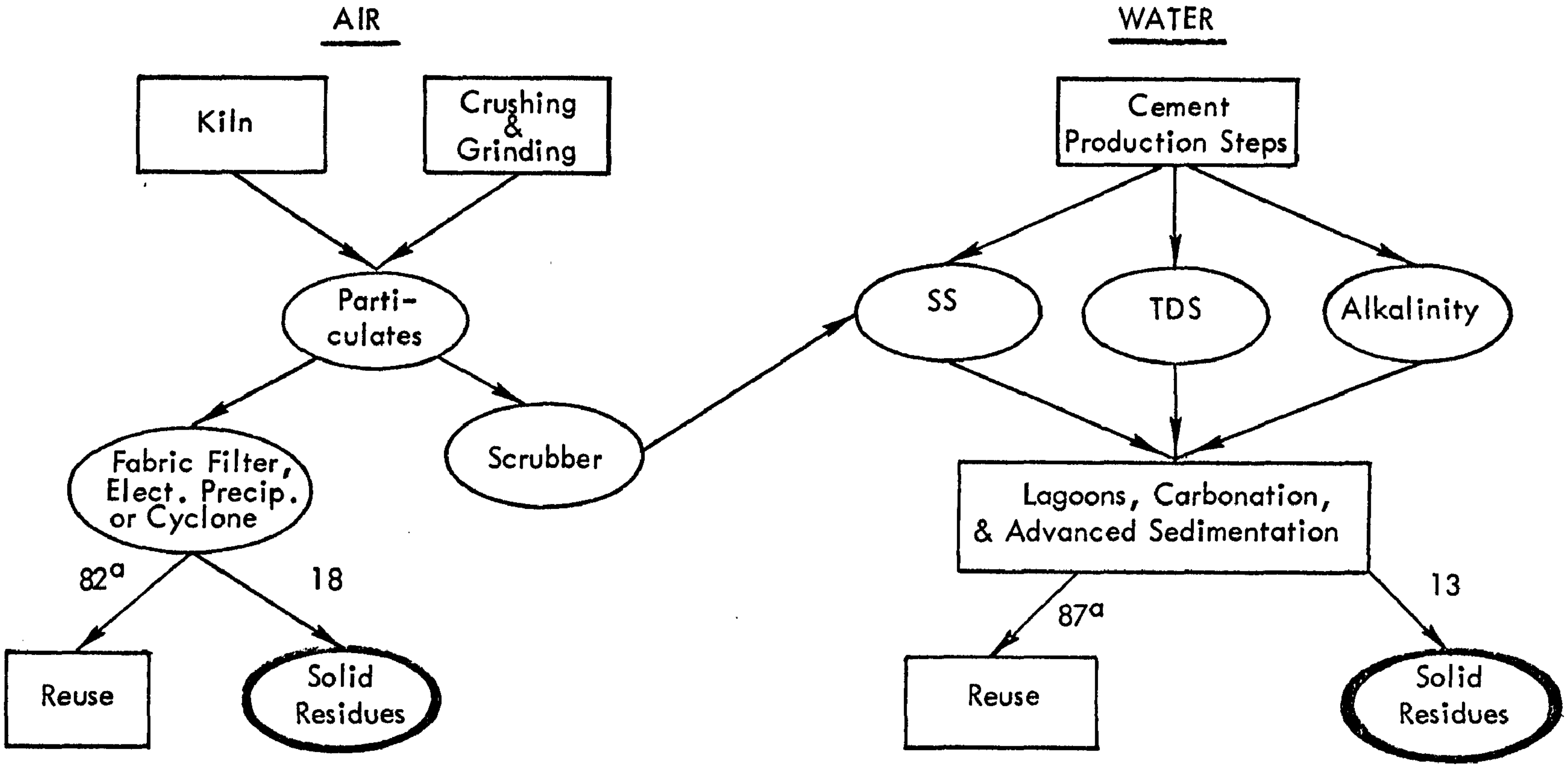
Blast Furnaces and Steel Mills (SIC 331). This industry is a significant contributor to both uncontrolled air pollution (particulates, hydrocarbons, and carbon monoxide) and uncontrolled water pollution (suspended solids). Significant quantities of particulates are generated from steel furnaces (especially basic oxygen), and during coking, reduction, scarfing,

TABLE V-4
SOLID WASTE RESIDUES FROM POLLUTION CONTROLS IN CEMENT AND CLAY
SIC 324, 325, 326

Pollutant Method	Treatment Process	1971 Residues Before Reuse (10^6 kg)	1971 Reuse (%)	1971 Solid Waste Residues (10^6 kg)	1985 Residues Before Reuse (10^6 kg)	1985 Reuse (%)	1985 Solid Waste Residues (10^6 kg)
AIR POLLUTANTS							
Particulates							
All	Fabric filter	2,680	70	810	6,480	80	1,300
	Multi-cyclone	2,600	92	460	4,470	87	570
	Elect.precipitator	1,030	70	310	2,350	80	470
	Wet scrubber	3,720	transferred to water		2,230	transferred to water	
Total Residues Directly from Air Pollution Control		6,310		1,580	13,300	82	2,340
WATER POLLUTANTS							
Suspended Solids							
Scrubber effluent	Settling basins & lagoons	2,110	0	2,110	210	0	210
	Reuse	1,150	100	0	1,950	100	0
Leaching	All	10	0	10	20	0	20
TDS							
Leaching	Lagoons	70	10	60	6	80	1
	Carbonation & adv. sedimen.	5	10	5	130	80	25
Non-leaching	Coagulation & lagoons	8	10	7	1	8	0
	Reuse	5	0	0	20	100	0

TABLE V-4 (Cont.)
SOLID WASTE RESIDUES FROM POLLUTION CONTROLS IN CEMENT AND CLAY
SIC 324, 325, 326

Pollutant Method	Treatment Process	1971 Residues Before Reuse (10^6 kg)	1971 Reuse (%)	1971 Solid Waste Residues (10^6 kg)	1985 Residues Before Reuse (10^6 kg)	1985 Reuse (%)	1985 Solid Waste Residues (10^6 kg)
WATER POLLUTANTS (Cont.)							
Alkalinity							
All	Neutralization	0	0	0	0		0
	Carbonation	5	0	5	40	0	40
Total Residues from Water Pollution Control		3,290	33	2,200	2,370	87	300
Total Residues from Air and Water Pollution Control		9,600	61	3,780	15,670	83	2,640



[a]Estimated reuse percentage for 1985.

FIGURE V-4
GENERATION OF SOLID
RESIDUES: CEMENT AND CLAY

and sintering. Large quantities of suspended solids are discharged to water during blast furnace reduction and sintering, and from steel furnaces and rolling mills. Iron sulfate and sulfuric acid are generated in significant quantities during pickling. Total uncontrolled particulate discharges from SIC 331 were forecast to increase to 18.6 billion kg in 1985 from 14.4 billion kg in 1971; uncontrolled SS discharges were forecast to increase from 11.3 to 15.5 billion kg during the same period.

The main treatment methods that were forecast to be used to control particulate and other air pollutants discharges in blast furnaces are fabric and other filters and precipitators. Control of particulate emissions from steel furnaces can be economically accomplished through wet scrubbers as well as fabric filters and precipitators. Medium energy wet scrubbers are sufficient for particulate control during sintering. Suspended solids generated from blast furnaces and rolling mills and during sintering can be controlled through a combination of recirculation, coagulation, and sedimentation. Iron sulfate and sulfuric acid in pickle liquor can be removed through lime neutralization followed by sedimentation, evaporation followed by crystallization, or dialysis. Potential reuse of pollutants in blast furnaces and steel mills is high. Figure V-5 is a schematic of the generation in the steel industry of solid waste residues from pollution control.

Total solid residues generated from air and water pollution control in blast furnaces and basic steel mills were forecast to increase from 3,210 million kg in 1971 to 4,600 million kg in 1985. (See Table V-5.) Most of these residues will be derived from water pollution control; this includes particulates transferred to water from air pollution controls (scrubbers and precipitators). The main sources of these residues will be particulates generated from blast furnaces and basic oxygen steel furnaces, and suspended solids generated from hot rolling mills. The residues generated from steel furnace pollution control will be fairly dry, inert, and non-biodegradable, and will contain no hazardous substances. Solid residues generated through lime neutralization during pickling will tend to be more corrosive and toxic, but these are a relatively minor contribution to total residues generated.

Iron Foundries and Ferroalloy Production (SIC 3312 and 332).

Particulates are the only significant pollutant generated in this industry. Small quantities of water pollutants are produced but are negligible when compared to particulate emissions and are, therefore, not considered in the report. Most particulate emissions originate from cupola furances in iron foundries or from blast and electric furnaces and material handling in ferroalloy production.

Baghouses and wet scrubbers are the most common air pollution control devices used in this sector. The limited data available on residue reuse indicate that a significant portion is recycled in the ferroalloy industry itself or sold for use in cement production and as trace minerals for fertilizer. The total solid waste residues generated by air pollution control were forecast to increase from 130 million metric tons in 1971 to 650 million kg in 1985.

The chemical composition of furnace fumes is similar to that of the materials charged. Silicon, iron, magnesium, and manganese oxides predominate, although chromium and heavy metal oxides and carbonaceous compounds are sometimes present in the particulates. Most of the particulates generated are relatively insoluble.

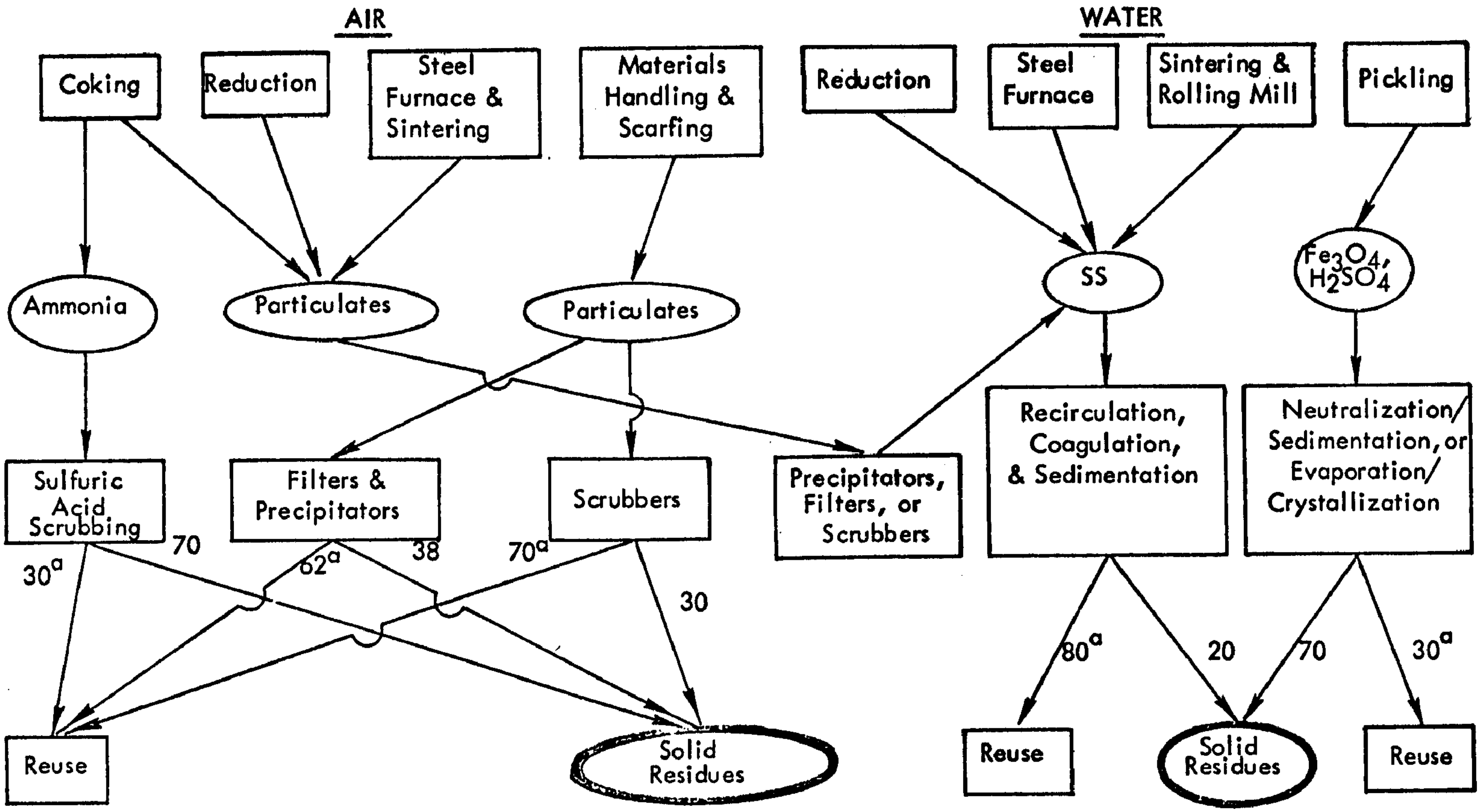


FIGURE V-5
SOLID RESIDUE GENERATION:
BASIC STEEL

[a] Estimated reuse percentage for 1985.

TABLE V-5
SOLID WASTE RESIDUES FROM POLLUTION CONTROLS IN BLAST FURNACES AND STEEL
SIC 331

Pollutant Method	Treatment Process	1971			1985		
		Residues Before Reuse (10^6 kg)	Reuse (%)	Solid Waste Residues (10^6 kg)	Residues Before Reuse (10^6 kg)	Reuse (%)	Solid Waste Residues (10^6 kg)
AIR POLLUTANTS							
Particulates							
Reduction	Filters & precipitators	1,760	transferred to water		3,410	transferred to water	
	Scrubbers	1,760	transferred to water		3,410	transferred to water	
Steel furnace	Precipitators	690	transferred to water		1,250	transferred to water	
	Scrubbers	690	transferred to water		1,240	transferred to water	
	Fabric filters	120	transferred to water		640	transferred to water	
Sintering	Scrubbers	650	transferred to water		570	transferred to water	
Materials handling	Precipitators	640	60	250	610	60	240
Scarfing	Precipitators	60	70	20	130	70	40
	Scrubbers	60	70	20	130	70	40
Ammonia							
Coking	Scrubbers	240	30	170	450	30	310
Total Residues Directly from Air Pollution Control		1,000		460	1,320		630

TABLE V-5 (Cont.)
SOLID WASTE RESIDUES FROM POLLUTION CONTROLS IN BLAST FURNACES AND STEEL
SIC 331

Pollutant Method	Treatment Process	1971 Residues Before Reuse (10^6 kg)	1971 Reuse (%)	1971 Solid Waste Residues (10^6 kg)	1985 Residues Before Reuse (10^6 kg)	1985 Reuse (%)	1985 Solid Waste Residues (10^6 kg)
WATER POLLUTANTS							
Suspended Solids							
Reduction		2,360	80	470	3,460	80	690
Steel furnace	All	3,620	80	720	4,120	80	820
Sintering		460	80	90	4,120	80	60
Hot rolling mills		4,280	70	1,280	6,980	70	2,100
Pickle Liquors							
Pickling	All	640	70	190	1,010	70	300
Total Residues from Water Pollution Control		11,360	86	2,750	15,870	80	3,970
Total Residues from Air and Water Pollution Control		12,160	88	3,210	17,190	80	4,600

Primary and Secondary Nonferrous Smelting and Refining (SIC 333, 334).

Nonferrous smelting and refining is a significant contributor to National discharges of both air and water pollutants. Total particulate discharges before treatment are forecast to increase from 1,420 million kg in 1971 to 2,060 million kg in 1985; over 95 percent of these emissions stem from primary smelting and refining. Sulfur oxide emissions before treatment were forecast to increase from 4,740 million kg in 1971 to 7,430 million kg in 1985. These emissions also stem primarily from primary smelting and refining with secondary nonferrous smelting and refining playing only a relatively minor role. Suspended solids are also significant for this sector, although reliable data exist only for bauxite refining, whose discharges were forecast to increase from 7,250 million kg in 1971 to 15,630 million kg in 1985.

Both mechanical and wet scrubbing methods are used to control particulate emissions, although fabric filters are becoming increasingly popular. Some plants currently control sulfur oxide emissions by the use of sulfuric acid recovery plants. In the future, limestone scrubbers may be used on the recovery plant tail gases in order to achieve the required level of control; this would increase the solid waste residues generated. Ponding and limestone precipitation are the current methods of controlling water pollutants. These methods create residues with little or no potential for reuse with the exception of cryolite precipitation from which 30 percent of the residues may be reused. Figure V-6 is a schematic of pollution control and their generation of solid waste residues.

The total solid waste residues from air and water pollution control in this sector were forecast to increase from 5,990 million kg in 1971 to 27,520 million kg in 1985 (see Table V-6). Limestone scrubbing of sulfur oxide emissions contributes the majority of solid wastes from air pollution control while settled mud from bauxite refining contributes most of the water pollution control solid waste residues. Metal oxides are prevalent in settled mud from bauxite refining. Although the settled mud might potentially be reused in the manufacture of cement or bricks, or as an iron ore source, no economically practical reclamation has yet been developed.[10] A landfill receiving solid waste residues from nonferrous smelting and refining could be expected to have a relatively high metals content in its leachate.

Electric Power Plants (SIC 491).

Fossil fuel and nuclear fission power plants are significant contributors to the National pollution load. The residues from fossil fuel plants are significant in terms of weight; those from fission plants are significant in terms of radioactive hazards. Fossil fuel plants release to the air significant quantities of particulates, sulfur and nitrogen oxides, carbon monoxide, carbon dioxide, and hydrocarbons. Of these, only sulfur oxides (principally sulfur dioxide) and non-hydrocarbon particulates will have significant impacts on solid waste generated from pollution control. Of the three fossil fuels, only coal combustion produces significant amounts of particulates. However, coal, oil, and, to a lesser extent, gas combustion all produce some sulfur oxide emissions. Discharges before treatment of particulates from power plants were forecast to increase

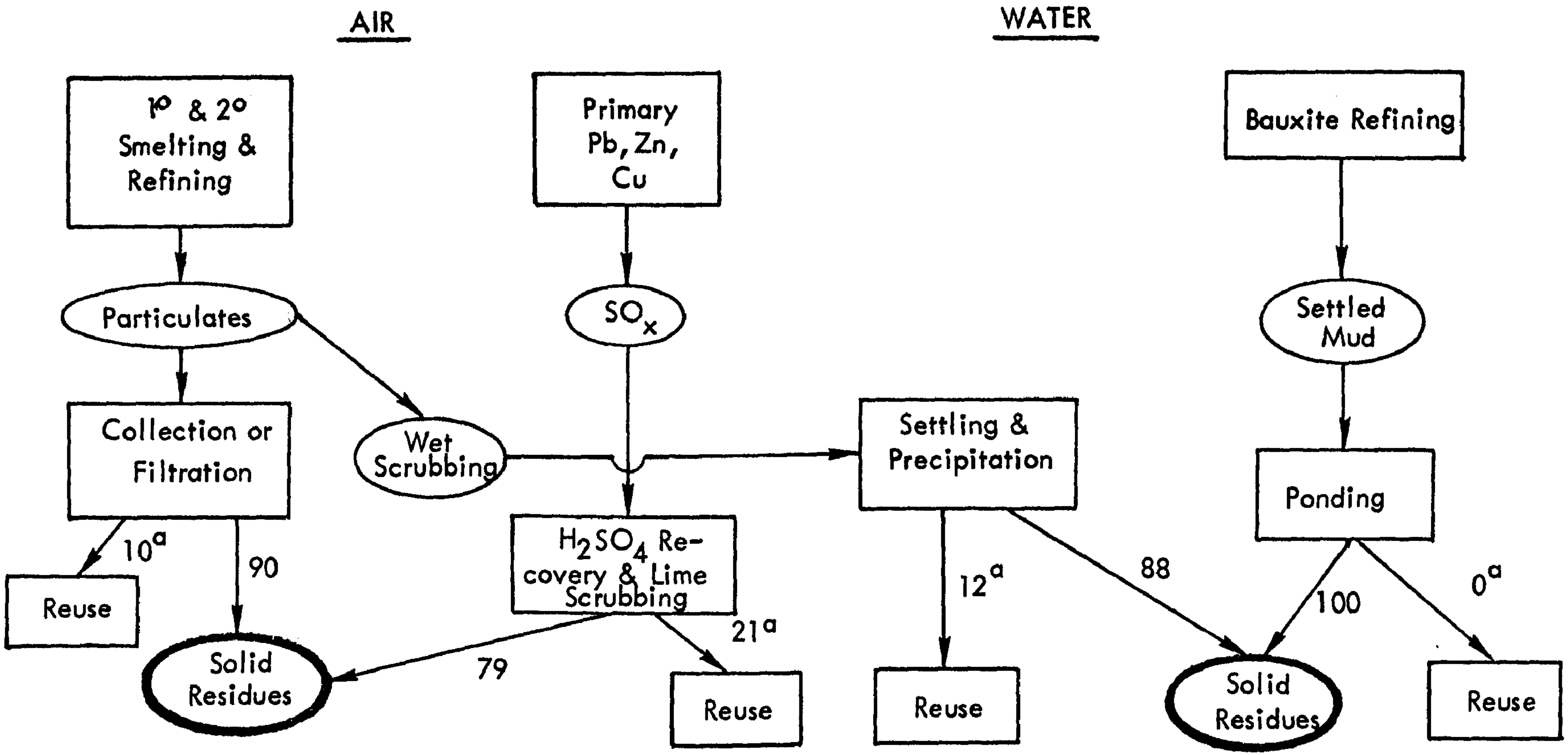


FIGURE V-6
SOLID RESIDUE GENERATION:
NONFERROUS METALS

[a] Estimated reuse percentage for 1985.

TABLE V -6
SOLID WASTE RESIDUES FROM POLLUTION CONTROLS IN NONFERROUS SMELTING AND REFINING
SIC 333, 334

Pollutant Method	Treatment Process	1971 Residues Before Reuse (10^6 kg)	1971 Reuse (%)	1971 Solid Waste Residues (10^6 kg)	1985 Residues Before Reuse (10^6 kg)	1985 Reuse (%)	1985 Solid Waste Residues (10^6 kg)
AIR POLLUTANTS							
Particulates							
Primary aluminum	Dry collection	10	100	0	140	100	0
	Wet scrubber	100	transferred to water		130	transferred to water	
Primary lead, zinc, & copper	Dry collection	690	0	690	1,040	0	1,040
Secondary nonferrous metals	Fabric filter	30	70	10	90	0	90
	Wet scrubber	10	transferred to water		10	transferred to water	
SO_x							
Primary lead, zinc, & copper	Sulfuric acid recovery	1,240	100	1,240	13,340	21	10,590
Total Residues Directly from Air Pollution Control		2,240		2,210	14,610		11,720
WATER POLLUTANTS							
Settled Mud							
Bauxite refining	Ponding	5,180	0	5,180	15,630	0	15,630

TABLE V-6 (Cont.)

SOLID WASTE RESIDUES FROM POLLUTION CONTROLS IN NONFERROUS SMELTING AND REFINING
SIC 333, 334

Pollutant Method	Treatment Process	1971 Residues Before Reuse (10^6 kg)	1971 Reuse (%)	1971 Solid Waste Residues (10^6 kg)	1985 Residues Before Reuse (10^6 kg)	1985 Reuse (%)	1985 Solid Waste Residues (10^6 kg)
WATER POLLUTANTS (Cont.)							
Suspended Solids							
Primary aluminum	All	120	17	100	170	12	150
Secondary aluminum	All	14	0	14	25	0	25
Total Residues from Water Pollution Control		5,310	0	5,290	15,820	0	15,820
Total Residues from Air and Water Pollution Control		7,280	18	5,990	30,430	10	27,520

from 33.6 billion kg in 1971 to 65.8 billion kg in 1985. Similar discharges of sulfur dioxide were forecast to rise at a more rapid rate, from 19.9 billion kg to 42.9 billion kg during the same period.

To control sulfur oxide and particulates generated from fossil fuel plants, three types of abatement measures may be used: low sulfur fuels (primarily for coal and, to a lesser extent, for oil), throw-away flue gas cleaning systems, and three saleable by-product flue gas cleaning systems. The three main throw-away technologies are: lime scrubbing, limestone scrubbing, and furnace injection (primarily dolomite). The three main saleable product systems are: magnesium oxide scrubbing, the Wellman-Lord process, and catalytic oxidation. Considerable uncertainty exists pertaining to the industry-wide application of low sulfur fuels vs. throw-away systems vs. saleable by-product systems. Saleable product systems were forecast to account for 15 percent of total sulfur oxide emissions control by 1975, and for 20 percent by 1980 and through 1985. The treatment of radioactive wastes from nuclear power plants generally involves collection and storage for a sufficient time prior to disposal. Figure V-7 is a schematic of pollution controls and their generation of solid waste residues.

Forecasts of solid waste residues from pollution control are presented in Table V-7. These solid wastes were forecast to increase from 25.6 billion to 135.5 billion kg between 1971 and 1985. The weight of solid wastes from nuclear power plants was forecast to increase from 730,000 kg to 23 million kg between 1971 and 1985; it is assumed that 100 percent control will be enforced throughout this period.

Sewerage Systems (SIC 4952).

Municipal influent including industrial wastes from the serviced population is the main source of pollutants discharged to sewerage systems evaluated in this sector. Solids, BOD_5, total nitrogen, and chlorides are the most significant pollutants contained in municipal sewage. Uncontrolled discharges for these pollutants in 1985 were forecast to be 6.6, 5.6, 1.4, and 2.8 billion kg, respectively. The impact of treatment methods on solid waste will greatly depend on subsequent disposal practices. Secondary treatments will produce more solid waste residues than primary treatments. Disposal methods that will have a significant impact on solid waste residues are primarily landfilling, with or without prior digestion, and,to a lesser extent, incineration. The reuse potential for sewage sludge is great; agricultural or other land application is often feasible, depending primarily on the physiochemical nature of the sludge, but was forecast to remain stable through 1985.

Solid residues generated from water pollution control and subsequent disposal were forecast to increase to 2.8 billion kg in 1985, up 85 percent from 1.5 billion kg in 1971. The predicted growth in sewered population and the increased use of both primary and secondary wastewater treatment plants are the main factors responsible for the forecasted increase. The composition of the residues will be a function of the types of treatments applied to the sludge. Bacteria counts will be high in raw primary sludge, and digested sludges will have less volatile matter, greases and fats, and protein, and more ash and silica than either raw primary or secondary sludges. Sludge from urbanized areas will

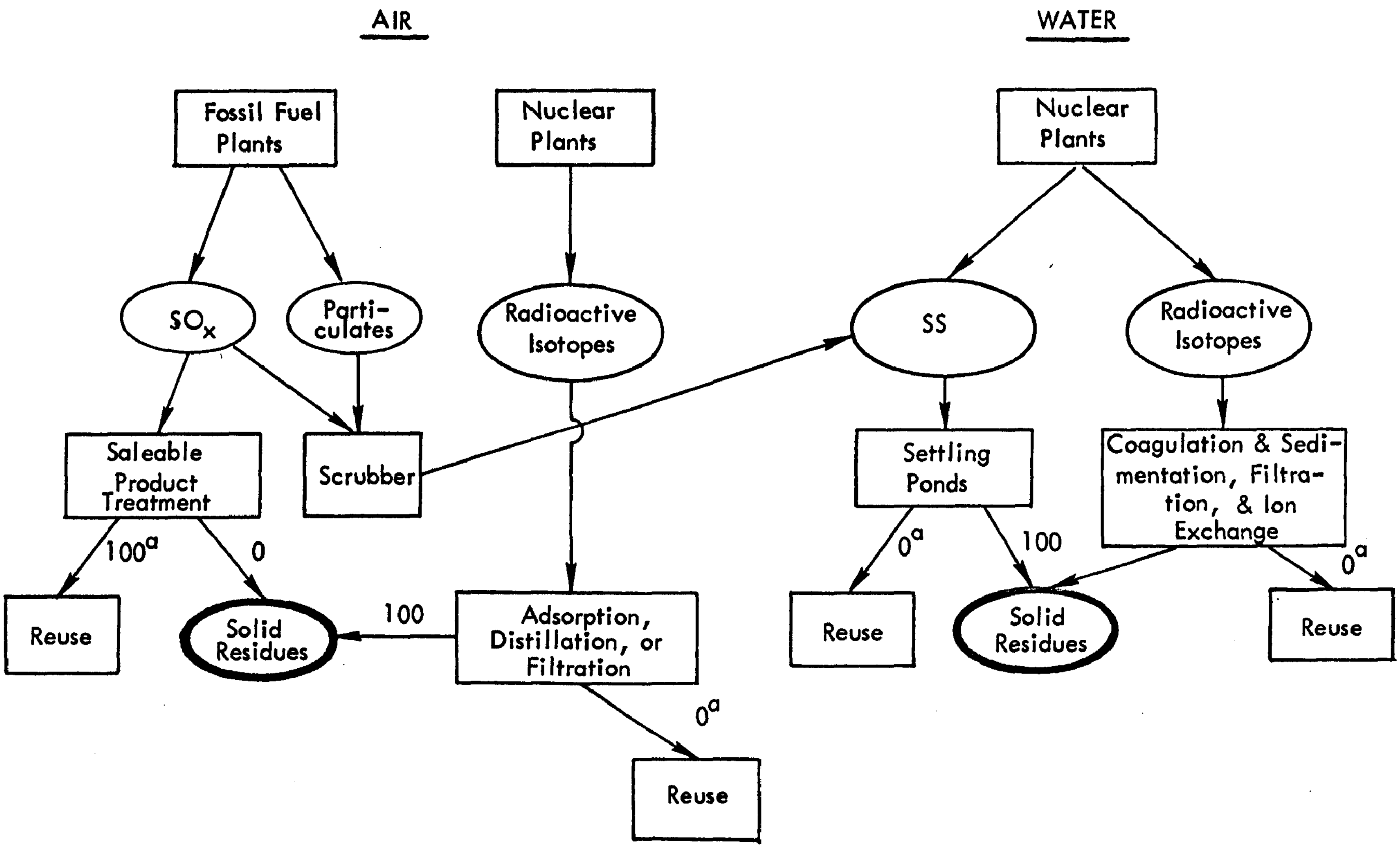


FIGURE V-7
SOLID RESIDUE GENERATION:
POWER PLANTS

[a]Estimated reuse percentage for 1985.

TABLE V-7
SOLID WASTE RESIDUES FROM POLLUTION CONTROLS IN POWER PLANTS
SIC 491

Pollutant Method	Treatment Process	1971			1985		
		Residues Before Reuse (10^6 kg)	Reuse (%)	Solid Waste Residues (10^6 kg)	Residues Before Reuse (10^6 kg)	Reuse (%)	Solid Waste Residues (10^6 kg)
AIR POLLUTANTS							
Particulates							
Coal	Scrubber	28,500	transferred to water		62,320	transferred to water	
Oil	Scrubber			0	190	transferred to water	
Gas	Scrubber			0	20	transferred to water	
Sulfur Oxides							
Coal	Wet limestone			0	56,660	transferred to water	
	Saleable product systems			0	9,040	100	0
Oil	Wet limestone			0	16,340	transferred to water	
	Saleable product systems			0	2,780	100	0
Gas	Scrubber			0	neg.	transferred to water	
Total Residues Directly from Air Pollution Control				0	11,820		0
Total Solids							
Fossil fuel plants	Settling ponds	25,600	0	25,600	135,530	0	135,530

TABLE V-7 (Cont.)
SOLID WASTE RESIDUES FROM POLLUTION CONTROLS IN POWER PLANTS
SIC 491

Pollutant Method	Treatment Process	1971 Residues Before Reuse (10^6 kg)	1971 Reuse (%)	1971 Solid Waste Residues (10^6 kg)	1985 Residues Before Reuse (10^6 kg)	1985 Reuse (%)	1985 Solid Waste Residues (10^6 kg)
Total Residues from Water Pollution Control (Fossil Fuels)				25,600			135,530
AIR AND WATER POLLUTANTS							
Nuclear power plants	All	0.73	0	0.73	23.1	0	23.1
Total Residues from Air and Water Pollution Controls		25,600	0	25,600	147,370	9	135,550

have a much higher concentration of heavy metals than that from rural areas, and thus be less suitable for land reuse.

Other Sources of Solid Wastes Generated by Air and Water Pollution Control.

Untreated discharges of relevant air pollutants from remaining sectors are mainly particulates (largely from paving and roofing materials, concrete, plaster, and gypsum production). Particulate emissions from all sectors evaluated were forecast to increase from 8.4 billion to 18.3 billion kg between 1971 and 1985. Sulfur oxide emissions were forecast to increase from 2.9 billion to 4.7 billion kg during the same period. BOD_5 and suspended solids are the primary water pollutants affecting solid wastes. Textile mills account for a large portion of both these water pollutants, while the beverage industry also discharges significant amounts of BOD_5. Total BOD_5 discharges were forecast to increase from 0.9 to 1.5 billion kg between 1971 and 1985; total suspended solids discharges were forecast to increase from 450 to 660 million kg during this period. Particulate emissions from these assorted industries will be controlled by cyclones, filtration, baghouses and electrostatic precipitation; the specific treatments used will vary by industry. Particulates trapped by pollution controls can, in most industries, be extensively reused; conversely, little reuse of water pollution control solid residues is possible.

Total solid waste residues from pollution control were forecast to increase from 720 million kg in 1971 to 2,300 million kg in 1985. Textile mills, paving and roofing materials production, and incineration of municipal refuse are important contributors to the solid residues derived from pollution control activities.

Hazardous Wastes from Air and Water Pollution Control.

Radioactive wastes were projected to increase very rapidly as the result of the increasing use of nuclear power to replace limited fossil fuel supplies. The largest growth in the production of non-radioactive hazardous waste streams was projected to be from inorganic chemicals, synthetic drugs, organic chemicals, industrial machinery, electrical machinery, aircraft, and power utilities. The discharges were separated into aqueous inorganic solutions, aqueous organic solutions, sludges, and radioactive wastes. Because of the extremely diverse nature of these waste streams, no general statements could be made as to their composition. All the waste streams evaluated in this sector are far more damaging than their mass alone would indicate.

Non-radioactive hazardous wastes are subject to few controls at the present time, but may create increasing amounts of hazardous solid waste residues as advanced treatments are applied by 1985. Evaporation, neutralization, flocculation, sedimentation, carbon adsorption and other treatments are all projected to increase in the future. In general, little reuse potential exists for most hazardous waste residues. Most radioactive wastes are solidified before final disposal.

The total known hazardous wastes from air and water pollution controls were projected to increase from 1,030 million kg in 1971 to 29,770 million kg in 1985. Over 99 percent of this increase is attributable to increased uranium tailings from uranium mines. Uranium tailings were forecast to increase from approximately 1,000 million kg in 1971 to approximately 30,000 million kg in 1985. Quantities of other hazardous solid residues derived from pollution control are much smaller in absolute value and were predicted to show a much slower rate of increase between 1971 and 1985. Hazardous solid residues from inorganic and organic residues plus those from sludges were estimated to be approximately 33 million kg in 1971, and were forecast to increase to 36 million kg by 1985.

Non-radioactive hazardous solid residues, although of minor importance compared to radioactive hazardous solid residues in terms of weight, nevertheless present significant handling and disposal problems. In California, a landfill classification system is in effect which classifies those landfill sites environmentally suitable for hazardous waste disposal; this sytem is a promising method for informing hazardous waste generators where wastes may be properly disposed. Unfortunately, recent regulations have caused industrial confusion concerning acceptable disposal alternatives, resulting in the dangerous practice of storing hazardous residues on-site until disposal alternatives are further clarified.

Relative Contributions by Industrial Sector.

Table V-8 and Figure V-8 present estimates of solid waste residues resulting from air and water pollution controls from major polluting sectors for the years 1971 and 1985. During that period (1971 to 1985), these solid waste residues were forecast to increase from 60,700 million kg to 244,300 million kg--excluding mining wastes. Including mining, the forecast increase was from 560,700 million kg to 1,544,300 million kg.

Figure V-9 shows the relative contributions of major polluting sectors to solid waste generation from pollution control, excluding mining wastes. Power plants are forecast to increase their share from 42 to 55 percent by 1985. The major factor in this increase is the forecast expanded use of limestone scrubbers to control sulfur oxides. Other major industrial sectors generating solid waste residues from pollution control are nonferrous smelting and refining, chemicals, paper, cement and clay, steel, and hazardous-waste producing sectors. Including power plants, these sectors contributed 90 percent of all non-mining solid wastes from air and water pollution control in 1971 and are forecast to contribute 91 percent in 1985.

Table V-9 and Figure V-10 show the contributions of the major industrial sectors to the forecast increase in residues from pollution control during the period 1971 to 1985. Mining accounts for 73.1 percent of the forecast change, power plants 16.1 percent, hazardous 4.2 percent, and nonferrous 3.1 percent. Excluding mining, the important contributors to increased residues from pollution control are power plants--59.9 percent, nonferrous--11.7 percent, and hazardous--15.7 percent.

TABLE V-8

SOLID WASTE RESIDUES FROM AIR POLLUTION CONTROL AND WATER POLLUTION CONTROL (10^6 kg)

Sector	1971	1985	Percent Change
Feedlots	920	1,150	25
Mining	8×10^5	13×10^5	63
Grain mills	500	2,700	440
Paper	6,910	15,340	130
Chemicals	9,680	17,400	80
Petroleum	770	1,490	94
Cement	3,780	2,640	-30
Steel	3,020	4,600	52
Iron foundries	130	650	408
Nonferrous	5,990	27,520	359
Power	25,600	135,550	429
Sewerage	1,540	2,830	84
Hazardous	1,030	29,770	2,790
Misc. and other	830	2,660	220
Total[a]	60,700	244,300	302
Total	560,700	1,544,300	175

[a] Excluding mining residues.

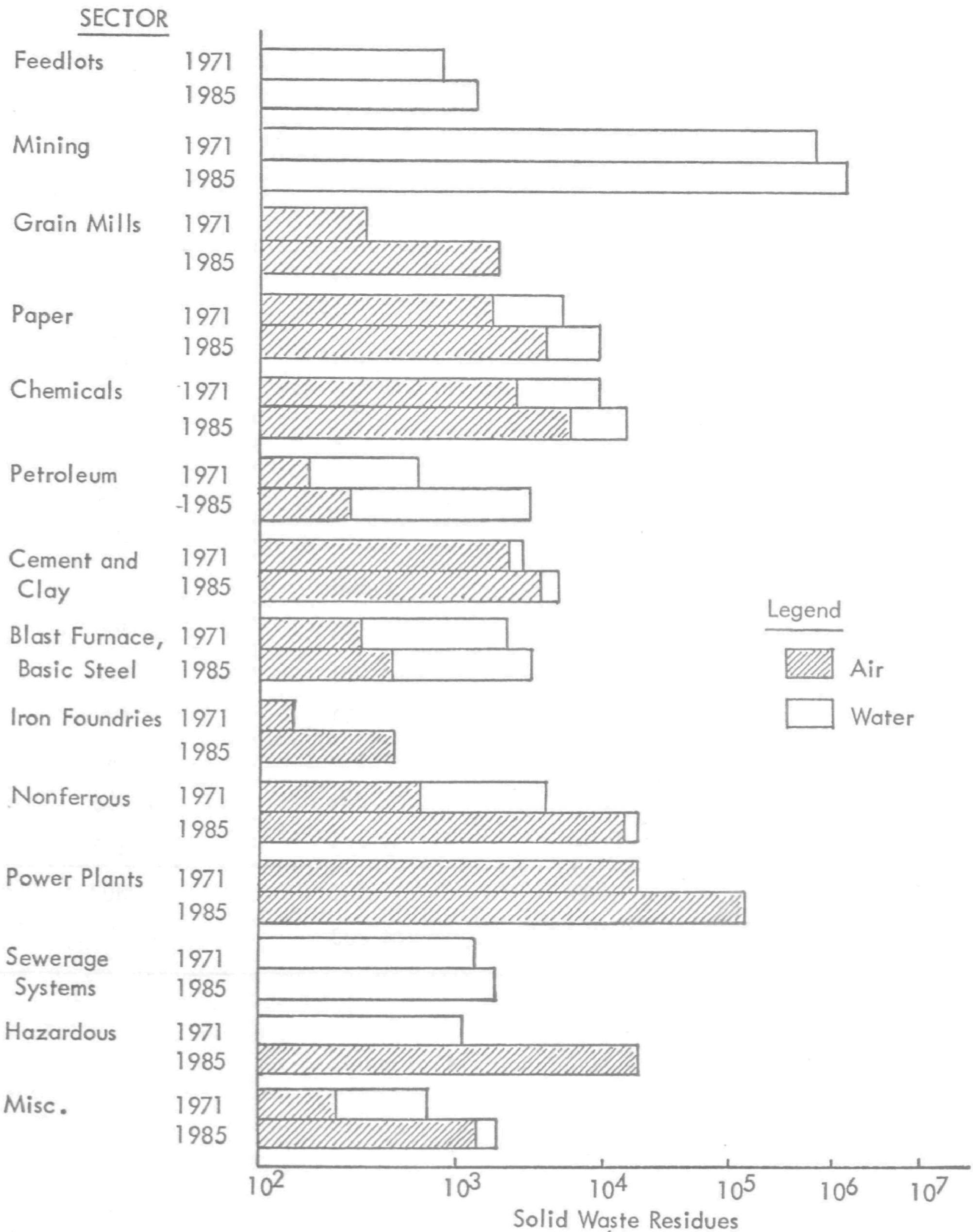


FIGURE V-8
TOTAL IMPACT OF AIR AND WATER POLLUTION CONTROLS IN MAJOR POLLUTING SECTORS ON SOLID WASTE GENERATION

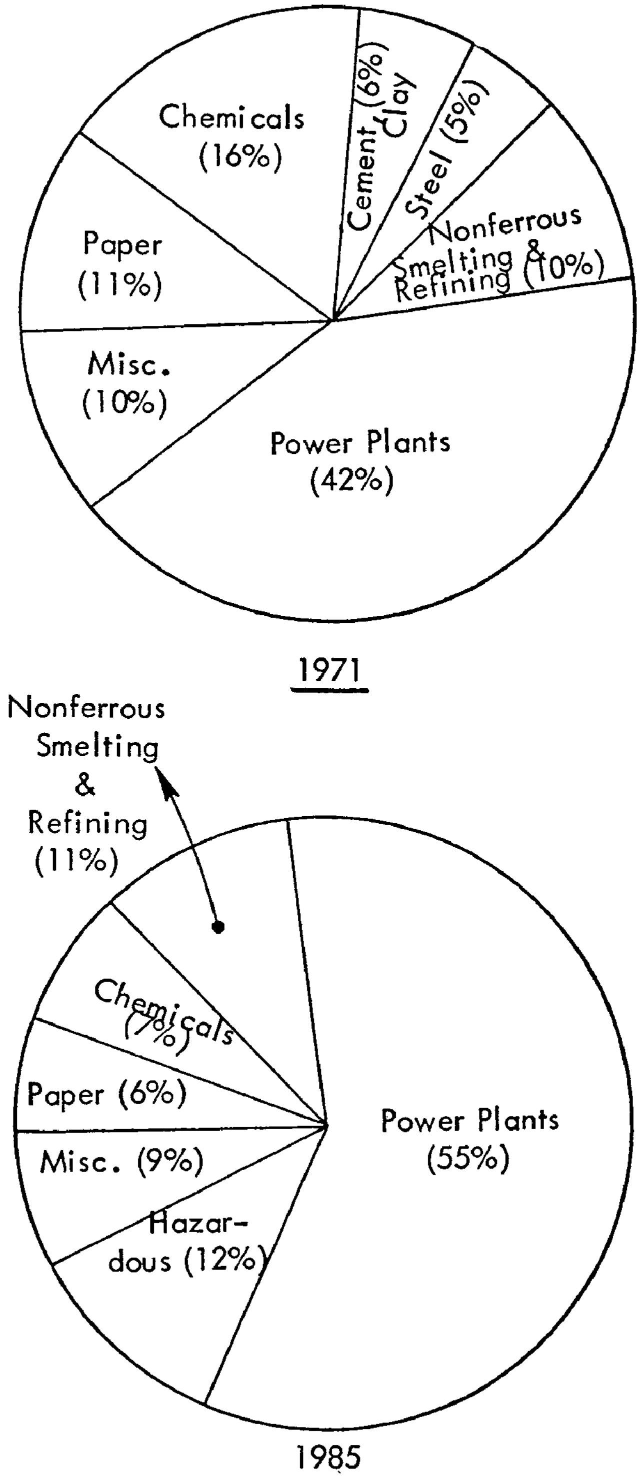


FIGURE V-9
INDUSTRIAL SECTORS
CONTRIBUTING SOLID WASTES
FROM AIR AND WATER
POLLUTION CONTROL

TABLE V-9
INCREASES IN SOLID WASTE RESIDUES FROM AIR AND WATER POLLUTION CONTROLS: 1971-1985

Sector	Change in Residues: 1971-1985 (10^6 kg)	Percent of Total Change	Percent of Total Change[a]
Feedlots	230	≈0	0.1
Mining	5×10^5	73.1	--
Grain mills	2,200	0.3	1.2
Paper	8,430	1.2	4.6
Chemicals	7,720	1.1	4.2
Petroleum	720	0.1	0.4
Cement	-1,140	-0.2	-0.6
Steel	1,580	0.2	0.9
Iron foundries	520	0.1	0.3
Nonferrous	21,530	3.1	11.7
Power	109,950	16.1	59.9
Sewerage	1,290	0.2	0.7
Hazardous	28,740	4.2	15.7
Misc. and other	1,830	0.5	0.9
Total	683,300	100.0	
Total[a]	183,600		100.0

[a] Excluding mining residues.

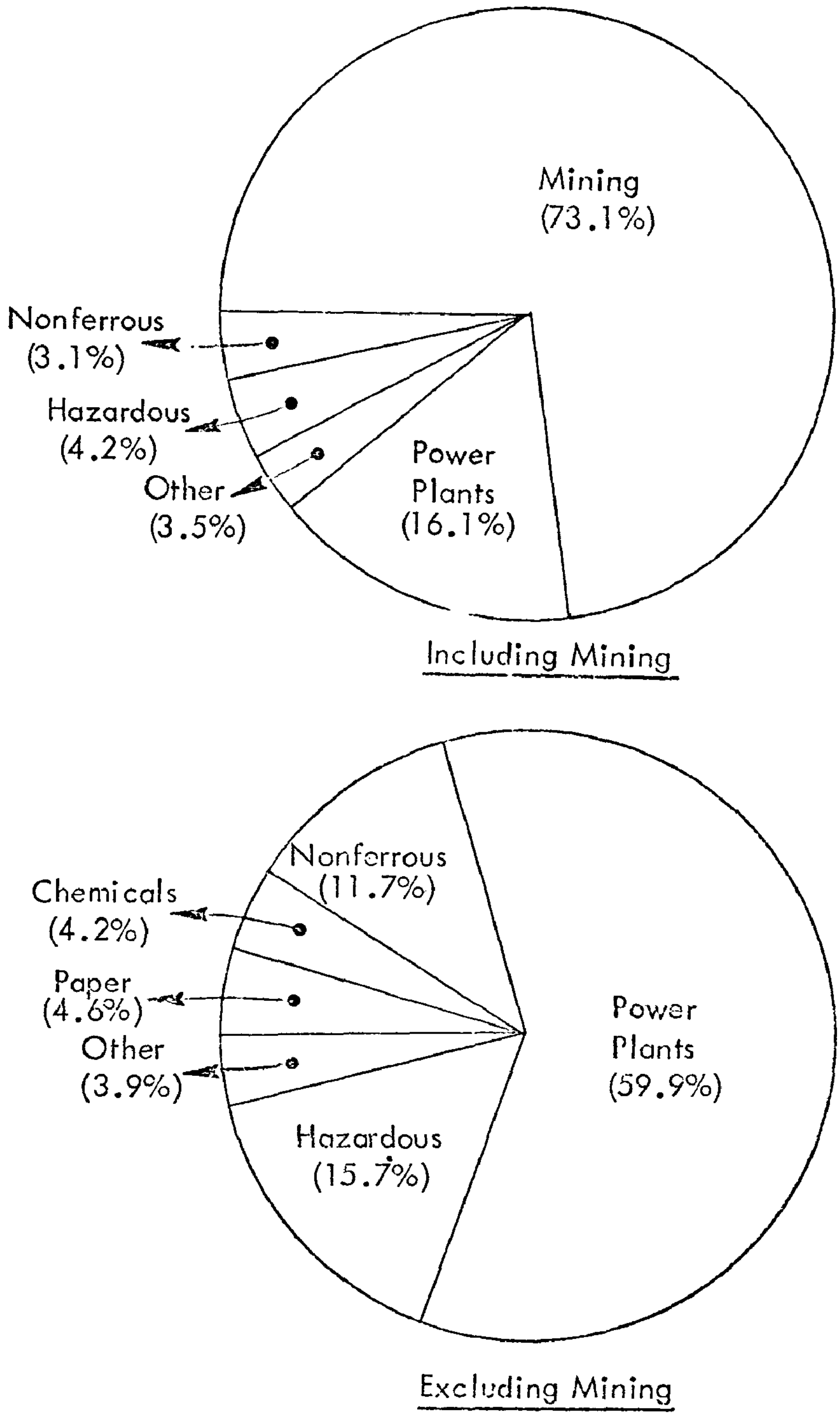


FIGURE V-10
RELATIVE CONTRIBUTIONS TO INCREASES IN SOLID WASTE RESIDUES FROM AIR AND WATER POLLUTION CONTROLS: 1971-1985

SECTION VI
NATURE AND FATE OF SOLID RESIDUES

Biodegradability and Destination of Solid Residues.

Tables VI -1 and VI -2 list estimates of the biodegradability and ultimate destinations (urban vs. rural) for all residues generated from pollution control for the years 1971 and 1985, respectively. Estimates of biodegradability were based on solid residue composition data presented previously. Estimates of urban or rural disposal destinations were based largely on generation sites of the residues; it was assumed that due to transportation costs, residues would be disposed to land areas close to their generation, all other things being equal. For 1971, out of a total 60,705 million kg residues, 10,225 million kg (17 percent) were organic, i.e., biodegradable, and the remaining 50,480 million kg (83 percent)were nonbiodegradable; during the same year, 35,510 million kg (59 percent) were destined for rural areas while 25,195 million kg (41 percent) were destined for urban areas. For 1985, out of a total of 244,240 million kg residues, only 23,730 million kg (10 percent) are forecast to be easily biodegradable, and the remaining 220,510 million kg (90 percent) are forecast to be relatively nonbiodegradable; most of the residues, 185,510 million kg (76 percent) are forecast to be disposed to rural sites, with the remaining 58,730 million kg (24 percent) forecast to be disposed to urban sites. Thus, the trend over time appears to be increasingly nonbiodegradable solid waste residues being produced, whose adverse impact on solid waste management will be mediated somewhat by an increasing trend towards disposal in rural sites.

Comparison of Solid Wastes from Pollution Control with Total Solid Waste from All National Sources.

Table VI –3 compares the total community-type solid wastes generated in the United States with the solid wastes from air and water pollution control alone. In 1971, 61 million metric tons of solid wastes were generated by pollution controls (excluding mining). About 214 million metric tons of solid wastes were produced by post-consumer and industrial U. S. sources in 1971. Wastes from air and water pollution controls, then, contributed approximately 29 percent of all solid wastes produced in 1971. By 1985, total solid wastes from industrial, residential, commercial, and institutional sources were forecast to increase to 370 million metric tons, of which 244 million metric tons are forecast to originate from air and water pollution control, a contribution of 66 percent.

Data are more limited for mineral wastes, but pollution controls are significant here. The 800 million metric tons of wastes from mining tailing ponds for 1971 are over half the 1,540 million metric tons of total mineral wastes for 1969. These 800 million metric tons are forecast to increase to 1,300 million by 1985. Total mining wastes for 1985 are estimated to be 2,895 million metric tons. Most of the wastes listed as air and water pollution control mineral wastes are from tailing ponds, most of which have never been allowed to be released directly to waterways. Very little of the agricultural wastes of 2,070 million metric tons for that year is expected to be derived from air and water

TABLE VI-1

BIODEGRADABILITY AND DESTINATION OF SOLID WASTE RESIDUES FROM POLLUTION CONTROL (10^6 KG)--1971

Sector	Destined for Rural Disposal Sites		Destined for Urban Disposal Sites	
	Easily Biodegradable	Non-Biodegradable	Easily Biodegradable	Non-Biodegradable
Major Sectors				
Feedlots	1,920			
Mining	$(8 \times 10^5)^a$			
Meat and dairy products			65	
Canned and preserved fruits and vegetables			50	
Grain mills	500			
Paper and allied products	6,910			
Chemicals				9,680
Petroleum extraction, refining and trans		550		220
Cement and clay				3,780
Blast furnaces and basic steel				3,020
Iron foundries				130
Primary and secondary nonferrous metals				5,990
Steam electric power plants		25,600		
Sewerage systems			1,540	
Hazardous		1,030		
Minor Sectors				
Forestry		neg.		
Misc. food			50	
Textile mills			150	160

TABLE VI -1 (Cont.)

BIODEGRADABILITY AND DESTINATION OF SOLID WASTE RESIDUES FROM POLLUTION CONTROL (10^6 KG)--1971

Sector	Destined for Rural Disposal Sites		Destined for Urban Disposal Sites	
	Easily Biodegradable	Non-Biodegradable	Easily Biodegradable	Non-Biodegradable
Minor Sectors (Cont.)				
Leather, lumber, and wood			40	50
Paving and roofing material				
Rubber and misc. plastics				
Concrete gypsum and plaster				
Nonferrous foundries				
Railroad transportation				
Trucking and warehousing				
Air transportation				
Automobiles				
Solid waste disposal (incineration control)			270	
Totals	8,330	27,180	1,895	23,300
Total rural	35,510			
Total urban	25,195			
Total biodegradable	10,225			
Total not easily biodegradable	50,480			
Grand total	60,705			

[a]Not included in totals.

TABLE VI -2

BIODEGRADABILITY AND DESTINATION OF SOLID WASTE RESIDUES FROM POLLUTION CONTROL (10^6 KG)-- 1985

Sector	Destined for Rural Disposal Sites		Destined for Urban Disposal Sites	
	Easily Biodegradable	Non-Biodegradable	Easily Biodegradable	Non-Biodegradable
Major Sectors				
Feedlots	1,150			
Mining		$(13 \times 10^5)^a$		
Meat and dairy products			220	
Canned and preserved fruits and vegetables			140	
Grain mills	2,700			
Paper and allied products	15,340			
Chemicals				17,400
Petroleum extraction, refining and trans	1,000			490
Cement and clay				2,640
Blast furnaces and basic steel				4,600
Iron foundries				650
Primary and secondary nonferrous metals				27,520
Steam electric power plants		135,550		
Sewerage systems			2,830	
Hazardous		29,770		
Minor Sectors				
Forestry				
Misc. food			70	
Textile mills			240	250

TABLE VI -2 (Cont.)

BIODEGRADABILITY AND DESTINATION OF SOLID WASTE RESIDUES FROM POLLUTION CONTROL (10^6 KG)-- 1985

Sector	Destined for Rural Disposal Sites		Destined for Urban Disposal Sites	
	Easily Biodegradable	Non-Biodegradable	Easily Biodegradable	Non-Biodegradable
Minor Sectors (Cont.)				
Leather products, lumber and wood			40	30
Paving and roofing materials				320
Rubber and misc. plastics				
Concrete gypsum and plaster				
Nonferrous foundries				
Railroad transportation				
Trucking and warehousing				
Air transportation				
Automobiles				
Solid waste disposal (incineration control)				1,350
Totals	20,190	165,320	3,540	55,190
Total rural	185,510			
Total urban	58,730			
Total biodegradable	23,730			
Total not easily bio-degradable	220,510			
Grand total	244,240			

[a] Not included in totals.

TABLE VI -3
SOLID WASTE RESIDUES FROM AIR AND WATER POLLUTION CONTROL VS. TOTAL SOLID WASTES

Source	Millions of Metric Tons					
	1971			1985		
	From Pollution Control	Total	%	From Pollution Control	Total	%
Post-consumer[11]	--	114	--	--	182[a]	--
Industrial, except mineral	--	100[b]	--	--	188[c]	--
Subtotal: post-consumer & industrial	61	214	29	244	370	66
Mineral	800	1,540[b]	52	1,300	2,895[c]	45
Agricultural	neg.	2,070[b]	0	neg.	3,891[c]	0

[a] Assumes 60 percent increase between 1971 and 1985.

[b] 1969 data from Reference 12.

[c] Assumes 88 percent increase between 1971 and 1985.

pollution controls. Solid waste residues from pollution control are expected to form a significantly greater percentage of total post-consumer and industrial solid waste, increasing from 29 percent in 1971 to an estimated 66 percent in 1985.

Figure VI-1 presents total solid waste residues from air and water pollution control versus other solid wastes generated in the United States. Solid wastes from various societal sources (post-consumer, industrial, mineral, and agricultural) are shown as percentage contributions of total U.S. solid wastes generated and total solid waste residues from pollution control alone for the years 1971 and 1985. For 1971, total solid waste generation was primarily from agriculture (54 percent) and mining (40 percent); post-consumer and industrial sources each contributed but three percent. The corresponding 1971 figures for residues from air and water pollution control are: mining - 93 percent; and post-consumer/industrial - seven percent. Total 1985 solid waste residue generation by contributing source is forecast to maintain the same percentages as in 1971. However, residues from pollution control in 1985 will likely show a percentage decrease from 1971 for mining to 84 percent, with post-consumer/industrial sources registering a projected sixteen percent.

Of prime significance, then, is the forecast change between 1971 and 1985 in the percentages of solid waste residues generated from air and water pollution control by various societal sectors. Post-consumer and industrial sources (subtotalled) will increase rather substantially as a percentage of the total solid wastes from pollution control; this will be a result of the more stringent controls to be effected in the coming years on the residues and waste-producing activities of these sectors. Mining residues as a relative percentage of solid wastes generated from pollution control will accordingly decrease (although the absolute quantity of residues will increase - see Table VI-3). Agricultural solid waste residues, controlled negligibly in 1971, are expected to similarly receive little control through 1985.

Solid Wastes from Pollution Control Identified by the Pollutant from which they were Originally Derived.

Table VI-4 and Figure VI-2 show the total solid wastes from air and water pollution for 1971 and 1985 broken down by the pollutant from which they were derived. Particulates, sulfur oxides, and miscellaneous air pollutants are identified, while all water pollutants are grouped together. It was impossible to separate the source of the residues from water pollution control, since suspended solids and biological oxygen demand overlap. The pollutant contributions in Table VI-4 are broken down by major contributing sectors. In 1971, 62 percent of all solid wastes from air and water pollution control were generated by particulate control, while 37 percent were generated by the control of water pollutants. Solids removed from air pollution scrubber effluent water were counted with the appropriate air pollutant category. By 1985, sulfur oxides are forecast to have increased very significantly to 39 percent with particulates having fallen to 40 percent, and water pollutants to 21 percent. The main cause of this large predicted relative shift is the projected control of sulfur oxides in electric power plants by limestone scrubbing.

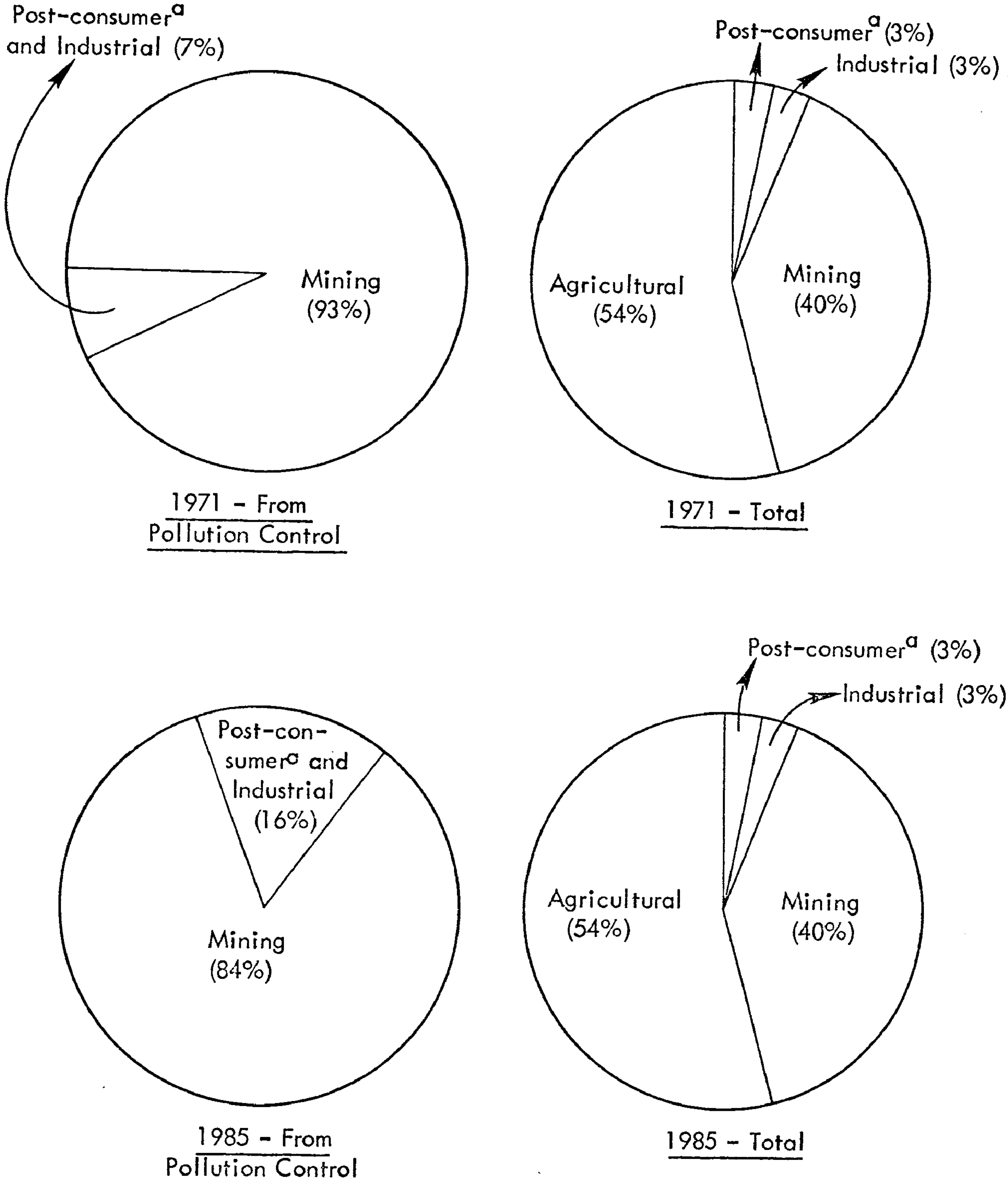


FIGURE VI-1
SOLID WASTE RESIDUES FROM
AIR AND WATER POLLUTION CONTROL
VS. TOTAL U.S. SOLID WASTE GENERATION

[a] Normal solid waste.

TABLE VI -4

AIR AND WATER POLLUTANTS WHOSE CONTROL GENERATES SOLID WASTE RESIDUES

Industry	1971 10^6 kg Residues (dry wt.)				1985 10^6 kg Residues (dry wt.)			
	Particulates	Sulfur Oxides	Other Air	Water	Particulates	Sulfur Oxides	Other Air	Water
Feedlots	0	0	0	920	0	0	0	1,150
Mining	460	0	0	8×10^5	1,410	0	0	13×10^5
Meat and dairy	0	0	0	60	0	0	0	220
Fruits and vegetables	0	0	0	50	0	0	0	100
Grain mills	500	0	0	0	2,700	0	0	0
Paper and allied prod.	2,440	0	0	4,470	5,800	0	0	9,540
Chemicals and allied products	3,140	470	20	6,050	5,860	1,300	90	10,150
Petroleum refining	200	0	0	570	420	0	0	1,070
Cement and clay	3,690	0	0	90	2,550	0	0	90
Blast furnaces and steel	300	0	170	2,550	320	0	310	3,970
Iron foundries	130	0	0	0	650	0	0	0
Nonferrous metals	800	0	0	5,190	2,350	9,070	0	16,100
Power plant	25,600	0	0	0	62,530	73,000	0	20
Sewerage systems	0	0	0	1,540	0	0	0	2,830
Other sources	370	0	0	350	1,820	0	0	480

TABLE VI -4 (Cont.)
AIR AND WATER POLLUTANTS WHOSE CONTROL GENERATES SOLID WASTE RESIDUES

Industry	1971 10^6 kg Residues (dry wt.)				1985 10^6 kg Residues (dry wt.)			
	Particulates	Sulfur Oxides	Other Air	Water	Particulates	Sulfur Oxides	Other Air	Water
Total	37,170 + 460	470	190	21,940[a]	84,950	83,370	400	45,760[a]
Hazardous waste streams:	1,030 x 10^6 kg in 1971				29,770 x 10^6 kg in 1985			
Percent of total	62	0.7	0.3	37	40	39	0.2	21

[a] Excluding mining.

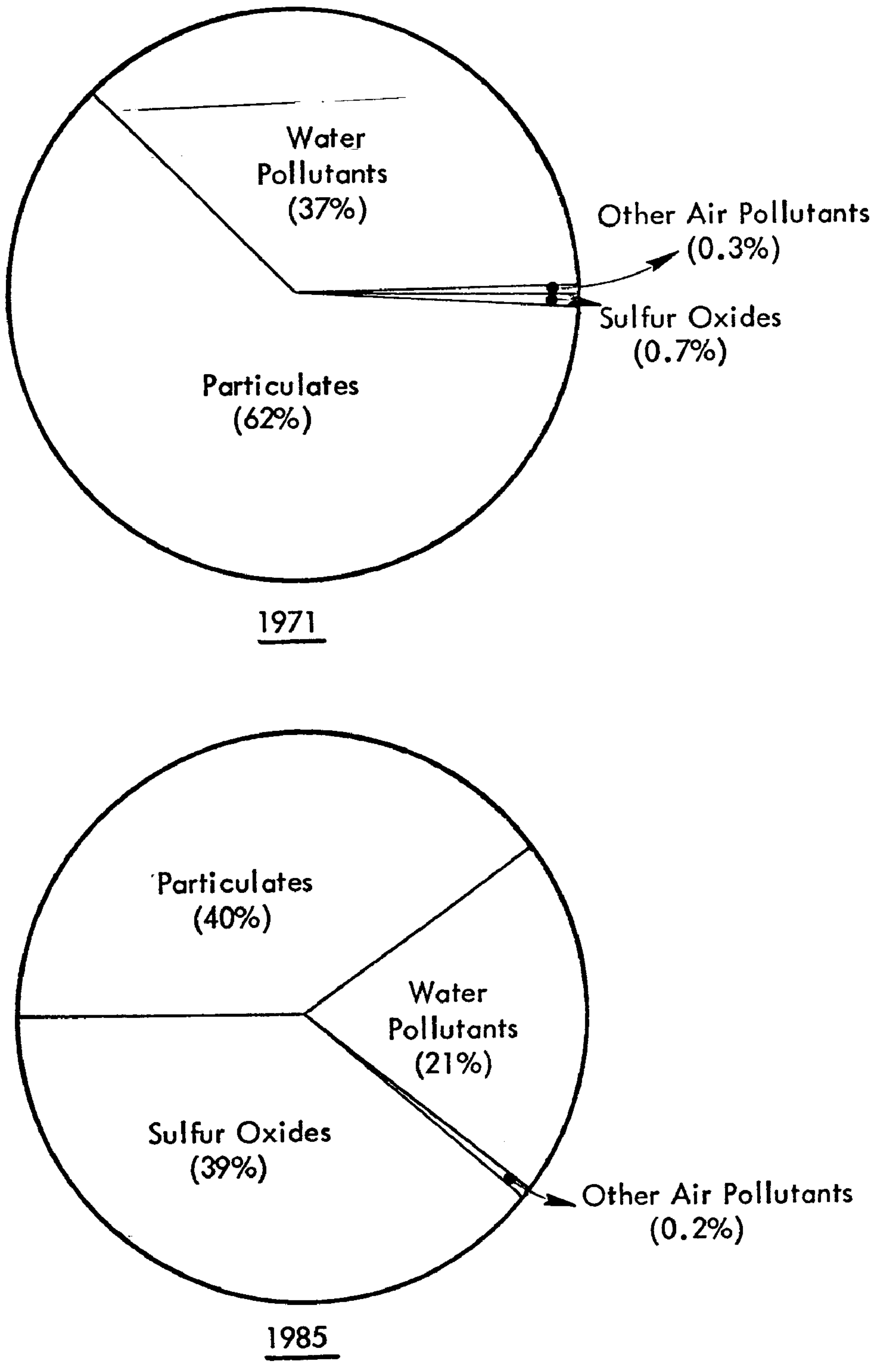


FIGURE VI-2
AIR AND WATER POLLUTANT CONTRIBUTIONS
TO SOLID WASTE RESIDUES

Relative Solid Waste Contributions by Pollution Treatment Process.

Tables VI-5 and VI-6 list the total solid wastes from air and water pollution control for 1971 and 1985, respectively, identified by the air and water treatments which generated the residues. Contribution of treatments is diagrammed in Figure VI-3. The air pollution treatments are categorized into mechanical, electrostatic, water scrubbing, and wet chemical treatment. Mechanical air treatment includes those treatments which use dry physical removal mechanisms such as cyclones and baghouses; electrostatic treatment includes mainly electrostatic precipitators. Water treatment scrubbers use pure water to scrub solids from flue gases; wet chemical treatments include methods which use chemicals in the scrubber water to capture gaseous pollutants. The most significant wet chemical method is limestone scrubbing, which reacts limestone with sulfur oxides in order to form calcium sulfate and sulfite, which then may be precipitated from water. Although these treatments require further water treatment to remove the solids created, the residues produced are categorized with the air treatment residues.

Water pollution treatments are categorized as primary, chemical secondary, biological secondary, and advanced. Primary treatments include physical systems such as screening, flotation, and sedimentation. Chemical secondary treatments react chemicals with the pollutants in order to cause them to precipitate from solution, while biological treatments utilize bacteria in order to decompose organics in water. Advanced treatments include methods which are efficient in the removal of dissolved solids such as ion exchange, reverse osmosis, etc.

In 1971, 49 percent of all solid residues were produced by water scrubbing systems, 20 percent by primary water treatment, and 10 percent by chemical water treatments. By 1985, chemical scrubbing had increased to 40 percent of all solid wastes from air and water pollution control, reducing water scrubbing and primary water treatment to 32 and 12 percent, respectively. The main source of this increase in the contribution of chemical scrubbing was the projected application of limestone scrubbing of electric power plant sulfur oxide emissions.

TABLE VI -5
POLLUTION TREATMENT PROCESSES CONTRIBUTING TO SOLID WASTE GENERATION - 1971[a]

Industry	Air Treatment (10^6 kg)				Water Treatment (10^6 kg)				Industry Total
	Mechanical	Electrostatic	Wet		Primary	Secondary		Advanced	
			Water	Chemical		Chemical	Biological		
Feedlots	0	0	0	0	250	0	770	0	920
Mining	0	0	0	0	8×10^5	1,260	0	0	8×10^5
Meat and dairy	0	0	0	0	20	20	20	0	60
Fruits and vegetables	0	0	0	0	40	10	1	2	50
Grain mills	500	0	0	0	0	0	0	0	500
Paper and allied prod.	0	1,450	990[b]	0	320	370	1,920	1,860	6,910
Chemicals and allied prod.	890	730	1,540	470	4,480	1,570	0	0	9,680
Petroleum refinery	0	200	0	0	550	0	0	20	770
Cement and clay	1,120	460	2,100	0	0	80	20	0	3,780
Blast furnaces and steel	30	80	200	170	0	2,540	0	0	3,020
Iron foundries	80	0	50	0	0	0	0	0	130
Nonferrous metals	800	0	0	0	5,190	100	0	0	5,990
Power plants	0	0	25,600	0	0	0	0	0	25,600
Sewerage systems	0	0	0	0	370	580	590	0	1,540
Other sources	110	200	60	0	90	50	210	0	720
Total (excluding mining)	3,500	3,080	29,400	1,780	12,470	5,920	2,850	1,880	59,670
Percent of total	5	5	49	3	20	10	5	3	

[a] Does not include hazardous wastes.
[b] Unless otherwise shown, effluent from wet air pollution controls is assumed to be handled by sedimentation.

TABLE VI -6
POLLUTION TREATMENT PROCESSES CONTRIBUTING TO SOLID WASTE GENERATION- 1985[a]

Industry	Air Treatment (10^6 kg)				Water Treatment (10^6 kg)				Industry Total
	Mechan-ical	Electro-static	Wet		Primary	Secondary		Advanced	
			Water	Chemical		Chemical	Biological		
Feedlots	0	0	0	0	310	0	840	0	1,150
Mining	0	0	0	0	1.3×10^6	32,690	0	0	1.3×10^6
Meat and dairy	0	0	0	0	10	70	20	120	220
Fruits and vegetables	0	0	0	0	90	20	0	30	140
Grain mills	2,700	0	0	0	0	0	0	0	2,700
Papers and allied prod.	0	4,900	900[b]	0	310	5,120	1,710	2,400	15,340
Chemicals and allied prod.	1,760	1,010	3,180	1,300	7,850	2,300	0	0	17,400
Petroleum refinery	0	420	0	0	1,000	0	0	70	1,490
Cement and clay	1,770	570	210	0	0	90	0	0	2,540
Blast furnaces and steel	90	400	240	310	0	3,560	0	0	4,600
Iron foundries	350	0	300	0	0	0	0	0	650
Nonferrous metals	1,130	0	150	10,590	15,610	40	0	0	27,520
Power plants	3	0	62,530	73,000	0	0	0	20	135,550
Sewerage systems	0	0	0	0	510	11,600	1,160	0	2,830
Other sources	470	1,080	270	0	70	70	340	0	2,300
Total (excluding mining)	8,270	8,380	67,780	85,200	25,760	12,430	4,070	2,640	214,530
Percent of total	3	4	32	40	12	6	2	1	100

[a] Does not include hazardous wastes.

[b] Unless otherwise shown, effluent from wet air pollution controls is assumed to be handled by sedimentation.

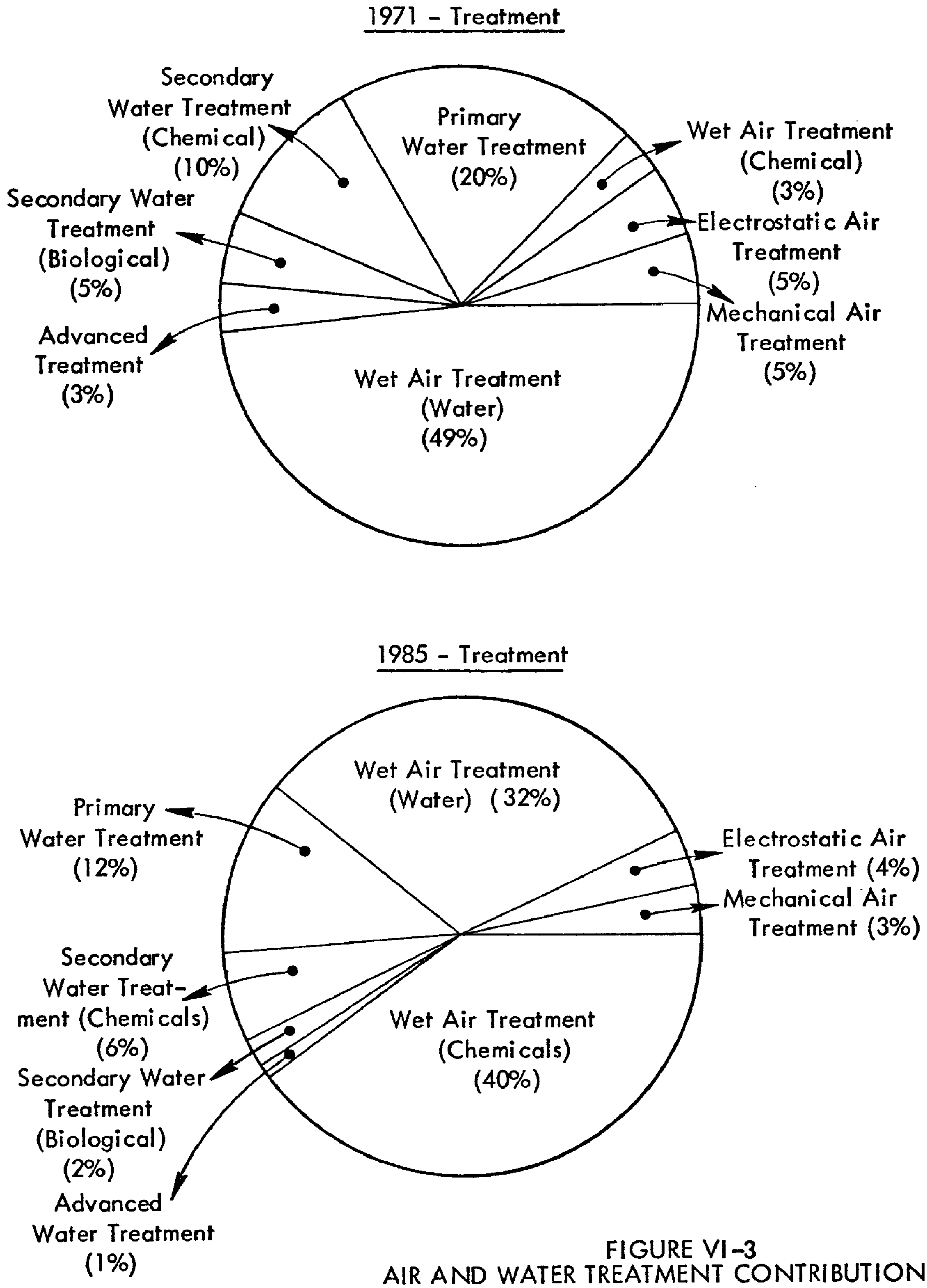


FIGURE VI-3
AIR AND WATER TREATMENT CONTRIBUTIONS
TO SOLID WASTE RESIDUES

SECTION VII
GLOSSARY

Abbreviations

Measures of Energy and Weight

BTU	British thermal unit
kcal	Kilogram-calorie (3.9685 BTU)
kwh	Kilowatt-hour (10^3 watts for one hour)
kg	Kilogram
kkg	Metric ton (10^3 kilograms)

Measures of Volume and Length

l	Liter (.2642 U. S. gallons)
m^3	Cubic meter
μ	Micron - (10^{-6}m)
cm	Centimeter
m	Meter

Measures of Radioactivity

Ci	Curie-measure of radioactivity in which 3.7×10^{10} disintegrations per second occur
μc	Microcurie (10^{-6} curies)

Pollutants

BOD_5	Five-day biological oxygen demand
SS	Suspended solids
TDS	Total dissolved solids
TS	Total solids

Conversion Factors from English to Metric Units

1 kg/metric ton = 2 lbs/short ton

1 metric ton = 1.1022 short tons

1 liter = .2642 gallons (U.S.)

1 m^3 = 35.34 cubic feet

1 kcal = 3.9685 BTU

GLOSSARY

Definitions

General Terms

Intermedial	A pollutant capable of transfer between air-water-land media
Intramedial	A pollutant incapable of transfer between media
Media	The media (air, water, or land) in or on which a pollutant is found
Pollutant	Any material which may contribute to environmental degradation and thus must be controlled
Reuse	The reclamation or use of a solid residue or waste product for beneficial purposes
Solid waste residue	Solid waste material left over from a pollution treatment process; solid waste residues may or may not be in solid form; in fact, many residues are dissolved or suspended in liquid medium
Solid waste	For specifically forecasting purposes, solid waste residues for which no economic opportunity for reuse exists; more generally, wastes destined for primarily land disposal
Treatment process	Method of eliminating a pollutant or transferring it to another media

Water Pollutants

Biological oxygen demand	The amount of oxygen used up by the natural decomposition of waste matter usually measured as the amount demanded in 5 days (BOD_5)
Pickle liquor	Waste liquid from pickling of mill scale in steel mills
Suspended solids	Solids in water which are not in solution. Unless otherwise indicated in this study it will include settleable and flotable solids
Total dissolved solids	Total solid material in a dissolved state in water
Total solids	Suspended plus dissolved solids

Air Pollutants

Ammonia	NH_3, a gaseous air pollutant
Carbon monoxide	CO, an intramedial air pollutant, controlled by conversion to CO_2

GLOSSARY

Definitions (Cont.)

Air Pollutants (Cont.)

Fluorides	Various fluorine compounds which may be in gaseous or particulate form
Hydrocarbons	Particulate and gaseous hydrocarbons. Particulate hydrocarbons are included with the measure of particulates
Hydrogen sulfide	H_2S
Nitrogen oxides	NO, NO_2, NO_3, almost a completely intramedial pollutant, predominantly NO_2
Sulfur oxides	SO_2, SO_3, predominantly SO_2; is capable of generating large amounts of solid residues when treated with lime scrubbing methods followed by sedimentation
Particulates	Solid particles of all types emitted into the air and capturable by filters

SECTION VIII
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16. ABSTRACT

The effects of air and water pollution controls on solid waste generation were evaluated. The solid wastes from pollution control were identified for individual industrial sectors by their original air or water pollutant constituents, and the treatment process applied. The wastes were categorized by type and by location (rural or urban). Total solid wastes from pollution control activities were estimated for 1971 and projected for 1985. Particulates and sulfur oxides were identified as the major air pollutants capable of generating solid wastes when treated; suspended solids and biological oxygen demand were identified as the principle means of estimating the impact of water pollution control on solid wastes. Important sectors generating solid wastes included power plants (SIC 491), paper and pulp (SIC 26), chemicals (SIC 28), cement and clay (SIC 324-326), steel furnaces (SIC 331), nonferrous smelting and refining (SIC 333, 334), sewerage systems (SIC 4952), and hazardous wastes from uranium mining (SIC 10). Mine tailing ponds were estimated to be a greater source than all the above sources but were not seen to be a landfill disposal problem. This publication is a summary of the more extensive report "Forecasts of the Effects of Air and Water Pollution Controls on Solid Waste Generation" (EPA-670/2-74-095b), submitted by Ralph Stone and Company, Inc., to the U.S. Environmental Protection Agency in fulfillment of Contract No. 68-03-0244. That report is available from the National Technical Information Service, Springfield, Va. 22151.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
*Air pollution, *Water pollution, *Abatement, Contaminants, *Industrial wastes, *Waste disposal, *Water treatment, *Residues, *Wastes	*Pollution control, Solid waste residues, *Intermedia transfer	13B

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