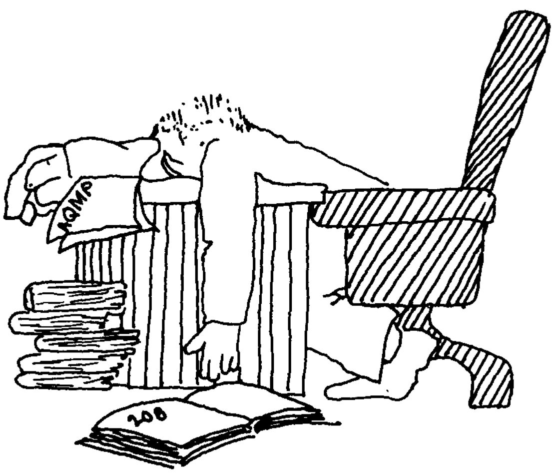
EPA-600/1-76-01/B
Socioeconomic Environmental Studies Series

Water Quality Guidance

DEVELOPMENT OF RESIDUALS MANAGEMENT STRATEGIES



REPORT

U.S. Environmental Protection Agency
Washington, D.C. 20460

DEVELOPMENT OF RESIDUALS MANAGEMENT STRATEGIES

Grant No. R-803313-01-1

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June 1975

Prepared for
Office of Research and Development
U.S. Environmental Protection Agency
Washington, D.C. 20460

EPA REVIEW NOTICE

This document has been reviewed by the Office of Researrh and Development, U.S. Environmental Protection Agency, and approved for publication as an INTERIM report. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency. This report is under review for its technical accuracy, the validity of its conclusions, and policy implications. Following this review, it is planned to make appropriate changes and publish a final report. Publication of this interim report is, therefore, on a limited basis.

ABSTRACT

Purpose

The purpose of this report is to provide a comprehensive and systematic approach for developing and evaluating strategies for residuals management. It is based on the concept that wastes (material and energy residuals) which adversely affect environmental quality are generated as a result of all human activity.

Major Points

Section I contains the conclusions and recommendations.

Section II provides the conceptual basis for the study and background information that is useful in putting residuals management in perspective.

Section III provides (i) the definitions of terms used in describing the residuals generation and discharge process and (ii) a general planning process for selection of strategies to overcome or alleviate environmental problems.

Section IV describes the residuals generation and discharge process in detail.

Section V links the residuals generation and discharge process with the decision-making process which results in identification of points in the process at which changes may be made, and how these changes can be made, to overcome or alleviate identified environmental problems.

Section VI delineates the methods for evaluating strategies

CONTENTS

FIGURES

TABLES

FOREWORD

The Environmental Protection Agency's legislative mandates contained in the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500), the Clean Air Act Amendments of 1970 (P.L. 91-604), the Solid Waste Disposal Act of 1965 (P.L. 89-272), as amended by the Resource Recovery Act of 1970 (P.L. 91-512), and the Noise Control Act of 1972 (P.L. 92-574) call for the delegation of authority to state or designated regional and local agencies to develop and implement the requirements of Federal environmental quality regulatory programs. Included in these requirements are the development of state-wide continuous planning processes to enforce water quality standards (FWPCA 303e), areawide waste treatment management plans (FWPCA 208), water quality facilities plans (FWPCA 201), solid waste disposal plans (SWDA, as amended, 207), and state air quality implementation plans (CAA 110), including plans for the prevention of significant deterioration, air quality maintenance, transportation management, and so on.

In order to achieve and maintain ambient air and water quality standards, particularly under the air quality maintenance and 208 programs, environmental quality management agencies at the state, regional and local levels are required to identify and evaluate complex control strategies, including non-structural controls, to regulate the residuals or waste discharges of the criteria pollutants from all sources—point, line and area. Strategies to achieve and maintain specified ambient environmental quality levels can potentially include transportation and land use controls, proposals to modify the final demand for goods and services in a given region, changes in the assimilative capacity of the natural environment, and so on, in addition to the more traditional structural control technologies, such as wastewater treatment facilities or air pollution control technologies on automobiles and smokestacks.

In order to provide technical research support to local governments, as well as to improve the ability of the agency to evaluate the planning efforts of state, regional and local governments undertaken in response to agency requirements, the Office of Research and Development, through its Regional Environmental Management program, is now conducting research in the following general areas:

1. Definition and quantification of the relationship between land use activities and residuals generation and discharge, specifically what mixes, quantities, and rates of residuals generation and discharge are implied by alternative land use combinations and patterns;
2. Definition and assessment of the effects of "physical methods" (i.e., specified management actions which result in a physical change in the quantity, type, timing, or spatial location of residuals discharged to the environmental media) on ambient environmental quality;
3. Evaluation of the costs and effectiveness of alternative "implementation measures" (i.e., policy mechanisms, such as local zoning powers, tax policy, and capital improvements programs, through which control measures are implemented) to achieve and maintain over time specified levels of ambient environmental quality;
4. Identification and evaluation of alternative institutional arrangements (e.g., level of government, function of government, public/private decision-making relationships, and so on) to effectively manage regional environmental quality; and

5. Development of techniques for the systematic evaluation of alternative regional environmental quality management strategies (i.e., various combinations of control measures, implementation incentives, and institutional arrangements) required by agency regulatory programs.

As part of this overall research effort, this report provides an introduction to a comprehensive and systematic approach to the identification, selection, and evaluation of strategies for regional residuals management. It provides a common language with which environmental engineers, usually unfamiliar with non-structural options, can communicate with environmental planners and managers. The report builds upon the work of Blair T. Bower, formerly of Resources for the Future, Washington, D.C., and the work of the Regional Environmental Management program's staff.

The study was conducted by Richard S. Howe, School of Public and Environmental Affairs, and Nicholas L. White, School of Law, Indiana University, Bloomington, Indiana 47401, under a grant from the Washington Environmental Research Center.

ACKNOWLEDGEMENTS

Professors Richard S. Howe and Nicholas L. White of Indiana University School of Public and Environmental Affairs and School of Law, respectively, prepared the substantive work of this project and take editorial responsibility for preparing the final report.

Four individuals from whom we sought and received advice and counsel throughout the study were: Blair T. Bower, Consultant; Charles N. Ehler, project manager for Office of Research and Development, U.S. EPA; John G. Morris, President, John G. Morris Environmental Engineers; and H.W. Poston, Commissioner Department of Environmental Control, City of Chicago. Reviewers of the final draft provided valuable criticisms that have strengthened the clarity of the final product.

Reviewers include: Donald Benson, Director of Planning, Seattle Metro, Seattle, Washington; William Cook, President, Cook Inc. and member of Bloomington Utilities Service Board and the Lake Monroe Regional Waste Management District, Bloomington, Indiana; Anthony H.J. Dorey, Assistant Administrator, Westwater Research Centre, University of British Columbia; Wayne Echelberger, Professor, SPEA, Indiana University, South Bend; Helen Hollingsworth, Shirley Cordes, and Ann Rippy, League of Women Voters, Bloomington, Indiana; Neil Horstman, Executive Director, The Indiana Heartlands Coordinating Commission, Indianapolis, Indiana, Craig Nelson, Associate Professor of Biology and Director, Environmental Studies Program, Indiana University; Dod Nobel, Sanitary Engineer, Beam, Longest and Neff Consulting Engineers; John Patton, Professor of Geology, Indiana University and Director, Indiana State Geological Survey; David Shepherd, Mayor, Oak Park, Michigan.

Editorial assistance for the report was provided by John Woodcock, Assistant Professor, English, Indiana University. Preparation and review of copy for the executive summary was provided by Judith Davis, Associate Scientist, SPEA, Indiana University.

Gary Simmons, Assistant Professor of Message Design and Publications, University of Arkansas prepared the illustrations and format for the executive summary as well as assisting with the format of the main report.

The authors extend their thanks to the following people:

John Mikesell, Associate Professor, SPEA, Indiana University, Bloomington, participated in some of the early work on evaluation of alternative RM strategies. Janet Swarens, SPEA graduate and currently a budget analyst with the City of Tampa, Florida, helped develop the bibliography and some of the background material for the economic evaluation criteria. Linda Taliaferro, Michael Smith and Alex Ruhe helped with the bibliography. Ms. Taliaferro is a SPEA graduate student. Messrs. Smith and Ruhe are law students. Sue Shadley, a law student, assisted with proofreading and checking citations in final copy.

Administrative and technical support for the study was provided by the Division of Research of the School of Public and Environmental Affairs. Mr. Ralph K. Jones and Jack Merritt assisted with this aspect of the work. Linda Steele and Cynthia Mahigian coordinated the publication activities. Throughout the study Marsha Craney assisted the authors in coping with the myriad details that accompany every undertaking.

SECTION I

Conclusions and Recommendations

Conclusions

1. Human activity results in residuals that are generated and discharged into the environment, affecting its quality. To the extent that human activity can be changed, environmental quality can be enhanced.
2. A planning process to identify, evaluate, and select strategies for overcoming or alleviating environmental problems caused by residuals discharge can be based on the framework of a residuals generation and discharge model.
3. This model identifies different methods for complying with recent federal legislation that requires a specified level of environmental quality.
4. This model provides a method for identifying and evaluating residuals management strategies. These strategies are helpful in the formulation of environmental assessments and impact statements.
5. The residuals management model identifies many points in the residuals generation and discharge process at which physical methods can be introduced, or changes made, to reduce or alleviate the effect of discharging residuals into the environment.
6. A planning process that uses the residuals management model can prove beneficial to elected officials and administrators at all levels of government. It is particularly useful to local and regional officials who must deal with problems first-hand.

Recommendations

1. A planning process for residuals management (pollution control) could use the residuals generation and discharge model as a framework.
2. The planning process for identifying residuals management strategies should start *without* considering legal, political, technological, or social constraints so that officials can examine the broadest possible range of alternatives.
3. Decision-makers should consider all reasonable alternatives; they should not limit themselves to conventional, end-of-the-pipe solutions to residuals problems.
4. A planning process that uses the residuals generation and discharge model should be followed by consumers, labor, business, and government—by all decision-makers concerned about environmental quality—so that they share a common base for their residuals management decisions.

SECTION II

Introduction

Approach and Conceptual Basis

At national, state, county and city levels, we are confronted with environmental problems. For the most part the problems are localized to definable areas—air pollution in urban-industrial areas, water pollution in watersheds and solid waste pollution in areas of population or industrial concentration. This report provides a framework for a systematic approach to the identification, evaluation and selection of strategies to alleviate or overcome these problems.

The approach set forth is based on the following concepts:

> First, human activity results in residuals (pollutants) which usually adversely affect environmental quality—e.g., supplying electrical power may generate sulfur dioxide which pollutes our air; an automobile eventually becomes junk which bespoils our land; laundering of clothing results in dirt and detergent laden water which contaminates our streams and lakes.
>
> Second, changes can be made in human activities—i.e., the demand, furnishing, and use of goods and services by people. These changes can result in reducing the residuals, changing their form, and/or lessening their adverse effect. In addition changes can be made which optimize the environment's natural capacity to assimilate these residuals and thereby maintain a desired level of environmental quality.[1]

The approach set forth emphasizes that there are numerous alternative methods for resolving environmental problems. Decision-makers in government should identify and consider these alternatives rather than relying solely on what may be called "conventional, end-of-the-pipe" solutions.

To fully understand environmental problems and the alternative approaches to solving them, it is essential to understand the whole sequence of events by which human activity results in these problems—i.e., the effects of residuals on the quality of the environment. In this report, this sequence or process is depicted by a model identified as the "residuals generation and discharge model" (RGD model). This process portrayed by the model starts with the demands of people for goods and services and moves through the production processes which satisfy these demands until residuals are discharged into the environment. At this point the process continues as these residuals become a part of the environment and affect its quality. As a final step, this change in the environment's quality—usually adverse—affects human beings, other animal life, plant life, and all other objects.

The "residuals generation and discharge model" provides the framework by which numerous alternative methods can be identified for alleviating or overcoming environmental problems. It does this by breaking down each part of the sequence into components such as demand for goods and services, providing such goods and services, etc. Thus, it identifies key points where changes can be made and permits creative solutions to environmental problems.

Factors that Contribute to Environmental Pollution Problems

The disposal services of the environment are absolutely essential since no production process is 100 percent efficient in transforming raw materials into desired output and since there are always "residuals" after consumer use. Human beings, as a result, require these disposal services to enable them to carry out their activities. While residuals are the unavoidable result of human activity, other factors contribute to the magnitude and seriousness of the environmental problems caused by discharge of these residuals into the environment.

The first of these other factors is that natural environmental resources have been considered a "free" resource in the production of goods and services. Historically, in determining the costs of goods and services, all economic systems have considered some combination of capital, labor, and raw materials (including land). Environmental resources as inputs (e.g., air for combustion processes) and as depositories for residuals (e.g., streams for liquid residuals) were not considered a factor in determining the cost of supplying goods and services. In other words, environmental resources have been assumed to have zero cost. Hence, that combination of capital, labor, raw materials, and environmental services was adopted which used more intensively environmental services at zero price. This is a fundamental cause of the magnitude and seriousness of the environmental pollution problem.[2]

Other factors that contribute to the magnitude and seriousness of environmental pollution problems are the notions of consumption ("consumer goods") and discard ("throw-away"). Goods provide utility (satisfaction, service) for shorter or longer time periods. Sooner or later a car, appliance, furniture, machine tool, suit of clothes, or building no longer has utility. When that time comes it is "thrown away." Where is away? The laws of conservation of energy and mass are still operational in all societies. Thus, the same quantity of material which went into the product remains in existence and must be disposed of in some way. Goods are not really consumed, they merely change form and are discharged into the environment.

Until the time when human activity became sufficiently concentrated to create substantial adverse effects on the environment, there was little concern. Put another way, the environment was adequate to the task of assimilating residuals without significant adverse environmental effects. It is now realized that the assimilative capacity of the environment is finite and that the quality of human life is adversely affected when the environment is taxed beyond this capacity.[3]

Usefulness of this Report to Decision-Makers and Managers

The systematic approach set forth should be useful to elected officials (mayors and governors, city councils and state legislatures), appointed administrators (commissioners of city departments, directors of state agencies), public interest groups (special interest groups and those with general environmental objectives), as well as planners and analysts. It is, however, directed primarily to the elected officials and appointed administrators of local and regional governments (towns, cities, counties, "metros") who have the major responsibility for the level of environmental quality in their jurisdictions.

This approach provides the opportunity to achieve a desired level of environmental quality, and, at the same time:

1. Minimize the costs borne by the general taxpayer by:
   - Reducing the need for publicly financed, capital intensive expenditures—e.g., treatment works.
   - Reducing operation and maintenance costs of publicly owned and operated facilities.
2. Reduce the cost of public (governmental) supervision and regulation of the discharge of residuals into the environment.
3. Maintain flexibility in selecting methods to protect and improve the environment by avoiding being "locked-in" to a costly, capital intensive solution—e.g., treatment works which when built must be paid for, maintained and operated.
4. Provide incentives to residuals generators to produce at lowest cost for given output levels, thereby saving money and complying with environmental regulations.
5. Protect citizens from the inequities and hardships which result from implementation of environmental controls without considering all possible alternatives.

The foregoing may be accomplished by transferring to the generators of residuals much of the responsibility and costs for reducing such residuals and their adverse impact on the environment. This permits these generators to exercise their ingenuity and inventiveness in fulfilling this responsibility.

This report will also be useful in other important ways. It provides the mechanism for identifying different methods of complying with recent federal legislative mandates to protect and improve the quality of our water, air and land resources.[4] It provides a framework for identifying and evaluating alternatives when environmental assessments and environment impact statements are required.[5] It provides a framework and record of the alternatives considered, evaluated and selected in the event the strategy selected is challenged in a legal proceeding by those generators who are affected by the decision.[6]

Summary

First: It must be recognized that human activity results in generation of residuals which may be harmful to environmental quality.

Second: Environmental problems have been aggravated in the past by the notion that natural environmental resources are "free."

Third: The planning process set forth in this report is beneficial to elected officials and administrators at all levels of government, but is particularly useful to local and regional officials and administrators who must deal with the problems first-hand.

Fourth: The planning process identifies different methods for complying with recent federal legislation requiring a specified level of environmental quality.

Fifth: The planning process also provides a method for identifying and evaluating alternatives when environmental assessments and impact statements are required.

The next section sets forth basic terminology and the general planning process for selection of a residuals management strategy.

Notes

1. Blair T. Bower and his colleagues at Resources for the Future, Washington, D.C., and elsewhere are the sources for the basic concepts and much of the exposition contained in this introduction and throughout this report. For examples of their work, see:

   Bower, Blair T., and W.R. Derrick Sewell, "Selecting Strategies for Air-Quality Management," Policy Research and Coordination Branch Department of Energy, Mines, and Resources, Ottawa, Canada, Resource Paper No. 1, 1971.

   Bower, Blair T., and Daniel J. Basta, "Residuals—Environmental Quality Management: Applying the Concept," The Johns Hopkins University Center for Metropolitan Planning and Research, October 1973.

2. Kneese, Allen V. and Blair T. Bower, *Managing Water Quality: Economics, Technology, Institutions*, Johns Hopkins Press, 1968:Kneese, Allen V., Robert U. Ayres and Ralph C. d'Arge, *Economics and the Environment—A Materials Balance Approach,* Johns Hopkins Press, 1970.

3. See Boulding, Kenneth E., "The Economics of the Coming Spaceship Earth," in *Environmental Quality in a Growing Economy,* edited by Henry Jarrett, Johns Hopkins Press, 1966; Jackson, Barbara (Ward), *Spaceship Earth,* Columbia University Press, 1966; Caldwell, Lynton Keith, *Environment,* Doubleday & Co. 1971.

4. These legislative mandates include the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500): the Clean Air Act Amendments of 1970 (P.L. 91-604); the Solid Waste Disposal Act of 1965 (P.L. 89-272), as amended by the Resource Recovery Act of 1970 (P.L. 91-512); the Noise Control Act of 1972 (P.L. 92-574); the Coastal Zone Management Act of 1972 (P.L. 92-583); and the Energy Supply and Environmental Coordination Act of 1974 (P.L. 93-319). Each of these Acts calls for a state or designated regional and local agencies to exercise their authorities to develop and implement the requirements of federal environmental quality programs. These requirements include, for example, the development of area wide waste management plans (FWPCA §208), water quality facilities plans which require alternatives to be identified and evaluated (FWPCA §201), solid waste management plans (SWDA, as amended, §207), and state air quality implementation plans (CAA §110) including plans for the prevention of significant deterioration and air quality maintenance as well as requirements for indirect source review. As an example of the necessity for identifying and evaluating alternative techniques, §201(g)(2)(A) of the FWPCA requires that "alternative waste treatment management techniques have been studied and evaluated" before a grant for a municipal treatment works can be made. This provision of the FWPCA is implemented by EPA regulations (40 C.F.R. §35, 925-13) and guidance (See §2.8 of Guidance for Facilities Planning, EPA, January 1974).

5. See National Environmental Policy Act of 1969, P.L. 91-190, §102(c), 42 U.S.C. 4322(c). See also Appendix, Chapter 4, Fifth Annual Report of the Council on Environmental Quality (lists states with environmental impact statement requirements).

6. When a regulation or statute impacts a particular industry or business, there is always the possibility that such industry or business will challenge the legality of the regulation or statute on the basis that it is being denied "equal protection of the law." As a general rule of law, if the singling-out of such industry or product is reasonable—i.e., the industry or product is a contributor to pollution and the control thereof will enhance environmental

quality, and, perhaps, other controls will not be as effective or efficient—the regulation or statute will be upheld. This requires some objective criteria on which to base the selection.

See *American Can Co. v. Oregon Liquor Control Commission,* 4 ERC 1584 (Ore. Cir. Ct. 1972) (Oregon tax on disposable bottles and ban on pull-top beverage containers upheld on basis that the classification did not violate equal protection.); *Hocking Glass Corp. v. Barber,* 105 A. 2d 271 (Vt. Sup. Ct. 1954) (Vermont ban on sale of malt products in non-returnables upheld.); *Procter and Gamble Co. v. Chicago,* 7 E.R.C. 1328 (U.S. 7th Cir. 1975) (Chicago ban on phosphate based household detergents upheld). But see, *Society of Plastics Industry v. New York City,* 3 E.R.C. 1370 (N.Y. Sup. Ct. 1971) (New York City tax on plastic containers held unconstitutional; failure to prove that reducing plastic containers in trash would alleviate a solid waste environmental problem).

SECTION III

Residuals Management and Process for Strategy Selection

Definitions

Two groups of words and terms are used in describing the approach set forth in this report. Words and terms in the first group have technical meanings which, in some instances, may differ from common usage of the word or term. Terms in the second group are new in the sense that they are used in this report to describe the residuals management strategy which is the focal point of the report.

First Group:[1]

- Products
- Non-Product Outputs
- Intermediate Products
- Residuals

Second Group:

- Physical Methods
- Implementation Measures
- Institutional Arrangements
- Residuals Management Strategy

In the first group, products, non-product outputs, intermediate products and residuals are terms used in describing the production process for, and use of, goods and services. In fulfilling the demands for goods and services, producers and suppliers respond by providing certain *products*—i.e. goods and services. In so doing, other outputs result which are not the primary or intended products. These are *non-product outputs.* Non-product outputs may be utilized or discarded depending on their economic value. If utilized, they are *intermediate products;* if discarded, they are *residuals.* The distinction between intermediate products and residuals is a practical one based solely on economic value and *without* consideration of the effect of environmental controls. In other words, residuals are non-product outputs which would not be recycled, reused or recovered unless some type of environmental or pollution control was imposed on the producer.[2]

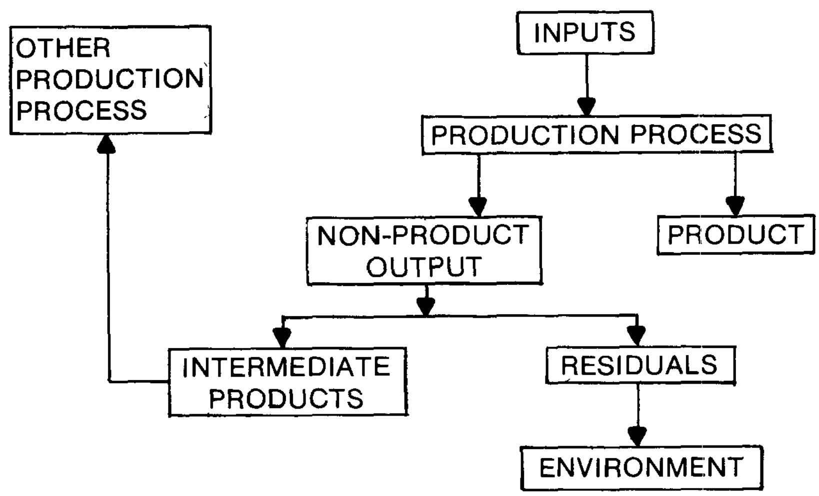
It should be noted that external factors which change from time to time and which are beyond the control of the producer of goods and services determine whether the non-product output is an intermediate product or a residual. As an example, at a given point in time it may be more profitable for an industry to use virgin raw material than to recover the same raw material that is a non-product output (e.g., virgin iron ore vs. scrap or virgin fiber vs. recycled newsprint). Thus, the non-product output is a residual. Later, due to price increase or unavailability of the virgin raw material, it may become profitable to recover and reuse the non-product output which thereby is changed from a residual to an intermediate product. This distinction between intermediate products and residuals is important since it is residuals that are the targets of environmental controls.

In the second group, physical methods, implementation measures, and institutional arrangements are used to describe the components of the residuals management strategy (pollution control strategy) of this report. They are defined in detail since they are the basis for describing the residuals management strategy.

> *Physical Methods:* Technological or structural actions which result in a change of the quantity, type, timing, or spatial location of residuals discharged into the

FIGURE III-1

Illustration of Production Process and Source of Residuals



ambient environment and/or improve the assimilative capacity of the natural environment. Examples of physical actions are changes in production process technologies, changes in the operating rate of the production process, treatment of residuals (changing form), in-stream aeration, and so on.

Implementation Measures: Non-structural actions such as laws, regulations and ordinances to induce implementation of desired physical methods. Implementation measures also achieve established goals and objectives consistent with established policies. Examples of implementation measures include performance and product specifications, emissions (residuals) limitations, zoning, federal funding for treatment plants, accelerated depreciation for pollution control devices, phosphate limitation on home laundry detergents, and so on.

Institutional Arrangements: The established public organizations at all levels which establish goals and objectives, which select, initiate, operate, and enforce physical methods, and which have the authority to identify and adopt implementation measures. Institutional arrangements also include intra-organization and inter-organization arrangements. Examples include federal, state, city, county, regional, and interstate legislative and administrative bodies.[3]

Residuals Management Strategy: A combination of physical methods, implementation measures, and institutional arrangements adopted for the purpose of reducing or eliminating the discharge of residuals into the environment and/or reducing or eliminating their impact if discharged—i.e. achieving environmental quality objectives.[4]

Physical methods may be viewed as the "hardware" as compared to the other components which may be viewed as the "software" of the residuals management strategy.

Summary View of the Process for Selection of a Residuals Management Strategy

The public and their governments are increasingly aware that decisions are needed concerning:

- Levels of environmental quality desired
- Costs to be incurred in attaining environmental quality and who shall bear such costs
- Benefits of achieving environmental quality and who shall enjoy such benefits
- Strategies for achieving a desired level of environmental quality and how to implement such strategies

The final decisions by the public and their governments are not made solely on environmental considerations, but are made in competition with economic and social goals and within the context of technological, economic, political, social and legal constraints.

The process of selecting a residuals management strategy starts with the public and their governments perceiving what is deemed to be an environmental problem such as "dirty water" or streams which are so dirty that they can not be used for fishing or swimming. The public through their elected representatives then decide that their goal is that the water be cleaned up and maintained in clean condition. Objectives are selected which might include that the discharges of pollutants be eliminated by a certain date, and that, in the interim, water quality should be achieved which provides for the protection and propagation of fish, shellfish and aquatic wildlife.[5]

Having established goals and objectives, sources or causes of the water quality problems are then identified.

To overcome or alleviate the identified problems, alternative residuals management strategies are identified, evaluated and selected. This identification, evaluation and selection process is the subject of this report.

Identification requires that a broad range of physical methods, implementation measures and institutional arrangements—i.e. components of residual management strategies—be identified. In so doing, decision-makers and managers are alerted to the variety of means for achieving environmental quality in a cost-effective and equitable manner. In order that decision-makers and managers will be made aware of the many possible means of improving and protecting the environment, this step in the process must be undertaken *without* consideration of constraints such as level of technology currently available, legal authority to implement, economic impacts, political feasibility, etc. In this manner, all possible means may be set forth unhampered by the idea that "we can't do this because. . ." The constraints are not disregarded, of course, but they are more constructively considered in the later evaluation and selection phases of the process. Another advantage of this approach is that decision-makers who perceive that a possible strategy has economic and political advantages, as well as improving environmental quality, will undertake to remove or avoid constraints by new legislation, educational campaigns and other measures available to them.

After the alternative residual management strategies are identified, they are analyzed. Physical methods, implementation measures and institutional arrangements are analyzed separately and in combination as to their effectiveness.

Following analysis, evaluation and selection takes place. Evaluation and selection are based on criteria such as effectiveness to overcome problem (the analysis will have provided much of this), economic effects (direct and indirect), legal considerations, administrative flexibility, time phasing considerations, political feasibility and public responsiveness.

Although this report stops at this point in the process, it is obvious that, after selecting the residuals management strategy, it must be implemented. Implementation must be followed by enforcement which includes monitoring and surveillance. There must be a credible enforcement procedure to assure adequate continuing performance of all program elements. Enforcement includes sanctions appropriate to coerce desired behavior and the will to use them. In other words, enforcement encompasses all of those powers that will be utilized to assure that the selected strategy is implemented.

The strategy as implemented is then subject to ongoing evaluation with continuing feed-backs so that decision-makers can make necessary changes. The entire selection process is a repetitive process with continuous feed-backs and recognition of the interrelation of each step as depicted in Figure III-2.[6]

Since the environmental problems affect limited areas and since the ability or capacity of decision-makers is limited to their political jurisdictions, the residuals management strategy is limited in its application to such areas and jurisdictions. The strategy is also limited in its scope in that its function is to attain a desired level of environmental quality. The strategy selection process must, therefore, consider and be able to cope with external factors and variables. External factors in the geographic sense include those for which the source is external, but which affect the quality of the environment in the given area. As an example, agricultural run-off may be the cause of the deteriorated condition of a stream passing through an urban-industrial area. Other external factors are those decisions made by public and private entities for reasons other than improving environmental quality that nonetheless affect residuals generation patterns.[7] Examples of such external factors include federal/state tax policies and policies that affect prices of inputs to production processes. If tax policies favor depletion allowances for mining iron ore, there is a disincentive to use scrap iron. This results in more residuals, since mining produces residuals and since scrap iron having no economic value is a residual.

Summary

For the purposes of the report goals and objectives are "given." Another "given" of this report is that institutions engaged in residuals management have done or can identify their problems and have done or can do source inventory and data collection required for analysis, description, and prediction—i.e., have or can identify the sources, quantities, and kinds of residuals discharged into the environment and existing levels of ambient environmental quality.[8] The report does not include the implementation, enforcement, and implementation evaluation steps in the on-going selection process. These on-going steps are, of course, important, but are not included in this report.

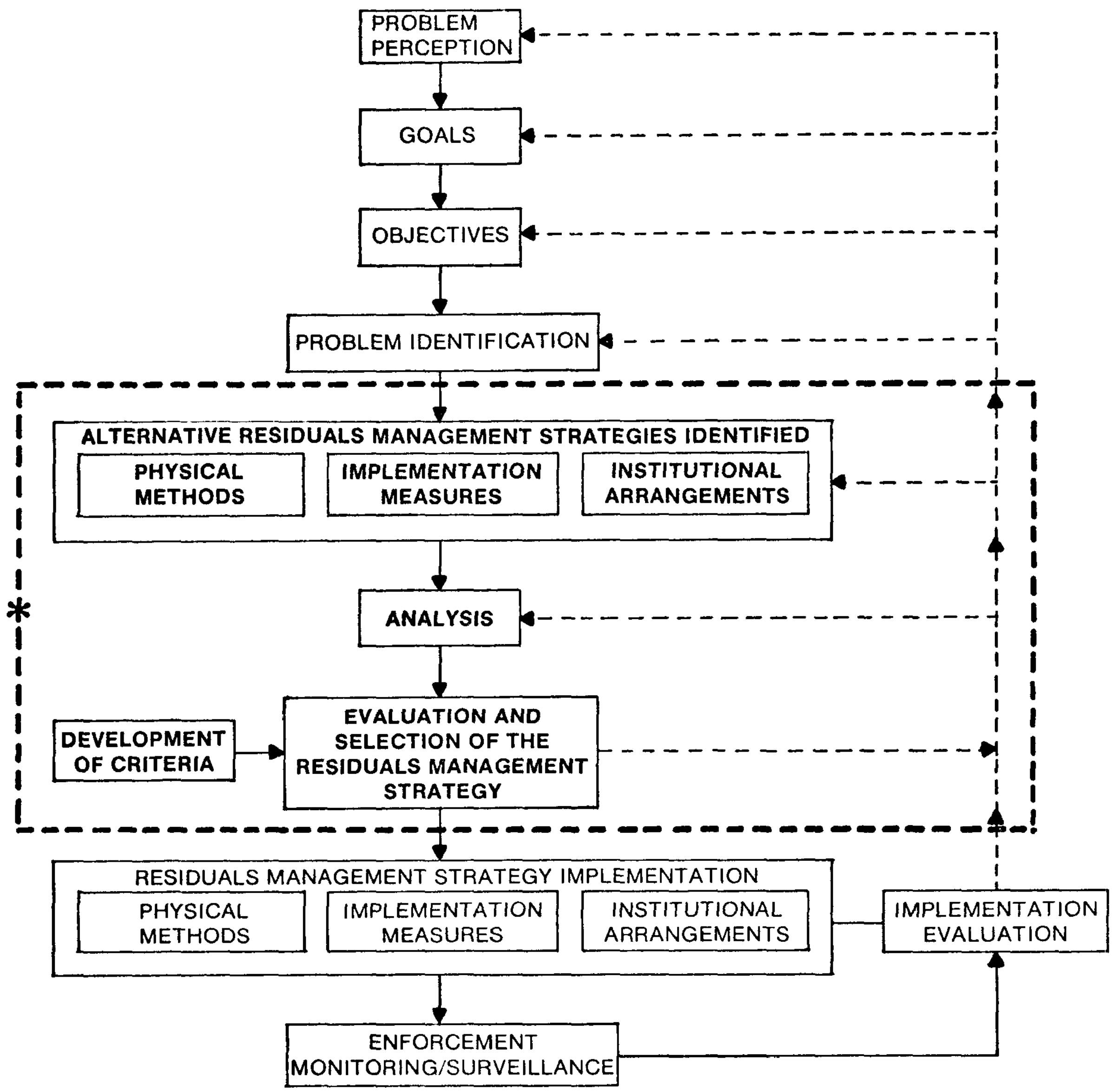
Two important points are:

> *First:* This report concentrates on the identification, analysis, and evaluation and selection of the residuals management strategy.
>
> *Second:* In the process of identifying residuals management strategies, it should start *without* consideration of legal, political, technological, or social constraints. This results in the broadest range of alternatives being identified for consideration.

The next section of the report describes the residuals generation and discharge process as a framework from which alternative strategies can be identified.

FIGURE III-2

Process for Selection of Residuals Management Strategy



*This report concentrates on these portions of the planning process. See Figure VI-1, p. 32 for a more detailed portrayal of this part of the process.

SECTION III

Notes

1. Technical definitions of these four terms are:

   Products: The primary products services supplied by manufacturers, extractors, commercial businesses, etc. As examples, milk is the product of the dairy farmer, coal for the miner, haircuts for the barber, chairs for the furniture manufacturer, electric energy for the power company, etc.

   Non-Product Outputs: Materials (solid, liquid or gaseous) and energy (heat, light, etc.) outputs from the production processes and providing of services (extractive, agriculture, manufacturing, transportation, etc.) other than the primary product or service.

   Intermediate Products: Non-product outputs which without consideration of environmental controls have sufficient economic value so as to be reused or recycled rather than discarded:

   Residuals: Non-product outputs which without consideration of environmental controls, have no economic value in existing markets or have a value less than the incremental costs of conversion to marketable form. These no-value or low-value materials and energy flows tend to be (i) collected off-site for recycling or reuse by someone other than the generator, or (ii) treated on-site or off-site before discharge into the environment, or (iii) discharged into the environment without treatment. All production and use (consumption) activities produce such residuals. The neutral term "residuals" is meant to replace more traditional but emotionally loaded terms like "wastes," "pollutants," and so on.

   The term residuals as used in this report is an economic definition and should be distinguished from its use in a narrower sense as in the Federal Water Pollution Control Act of 1972. §208(b) (2) (J) of that Act refers to "residuals waste" which means only sludge from wastewater treatment plants.

2. These definitions are not original with the authors although they have been changed somewhat by the authors to meet the purposes of this report. They are based on definitions emerging in environmental literature and reports. For example, see: "Development of a Trial Air Quality Maintenance Plan Using the Baltimore Air Quality Control Region," September, 1974 (EPA Publication No. 450/3-74-030); Office of Air and Waste Management, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina 27711.

3. The definition of institutional arrangement is limited to governmental entities in their capacity as regulators (legislation, implementation and enforcement). Private institutions and governmental entities in their capacity as generators of residuals are not part of the institutional arrangement as set forth in this report. The generators of residuals are, in many instances, free to select the physical method or methods which respond to the implementation measures adopted by the governmental entity which regulates them. Public interest groups, trade associations, professional associations and similar entities are not deemed part of the institutional arrangement for purpose of this report, since they have no authority or responsibility to legislate, implement or enforce.

   It is acknowledged that these generators and non-governmental institutions may be considered a part of the overall institutional arrangement, but this report emphasizes the responsibility of governmental institutions as representatives of the people to respond to environmental problems.

4. A primary component of environmental quality management is residuals management. The literature combines the terms residual management and environmental quality management into a residual environmental quality management system. This term is not always understood; so we have elected to use the term "residuals management."

   A consideration in choosing to differentiate between residuals management and environmental quality management was the results of a survey of city and county officials as to what "environment" meant. The survey posed four alternative definitions:

   (1) "The first restricts the definition to the natural environment or the categories of pollution (residuals): air (gaseous), noise (energy), sewage (liquids), solid waste (solid), toxic substances (gaseous, liquid, solid), water (liquid)."

   (2) "The second alternative broadens the definition slightly to add energy, historical preservation, land use, open space, radiation, population, and wild life preservation."

   (3) "The third adds to all of the above factors aesthetics, health, housing, mass transportation, recreation, streets, and highways."

   (4) "The final definition is the broadest, reflecting a quality of life scope, adding economic development, education, employment, public safety and welfare."

More than half of the cities (57%) and counties (58%) viewed the environment in one of the broader definitions.

See Carter, et al., Environmental Management and Local Government, EPA-600/5/73-016 Feb. 1974.

5. As an example, Congress enacted the Federal Water Pollution Control Act Amendments Act of 1972. (P.L. 92-500; U.S.C.). The goal of the Act was "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." (P.L. 92-500, §101 (2); U.S.C. Objectives included "wherever attainable. . .water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water. . .by July 1, 1983" and "that the discharge of pollutants into navigable waters be eliminated by 1985." (P.L. 92-500, §101 (a); U.S.C.). Policies in the Act include financial assistance to construct publicly owned treatment works (P.L. 92-500, §101(a) (4); U.S.C.); areawide waste treatment management planning (P.L. 92-500, §101(a) (5), U.S.C.); recognize, preserve, and protect the primary responsibilities and rights of the States to prevent pollution (P.L. 92-500, §101(b), U.S.C.); and to the maximum extent possible encourage the drastic minimization of paper work. (P.L. 92-500, §101(f); U.S.C. In the opinion of many state and local governments and agencies, this policy has not been followed—in fact, quite the opposite has resulted.)

6. For an elaboration of this on-going process, see Sewell, W.R. Derrick, "Broadening the Approach to Evaluation in Resources Management Decision-Making," 1 Journal of Environmental Management 33-60, 1973. At p. 35 the author states:

   > "The decision-making process may be thought of as a series of interconnected elements or steps, leading from the recognition of a problem and the identification of potential solutions to the selection and adoption of an appropriate strategy. Ideally, the various steps follow in sequence, and there is feedback amongst particular elements. Sometimes only one person, or a single group of people, is involved in the various steps. More often, however, different groups play particular roles at various stages in the process.
   >
   > "Figure 1, describes the basic elements in an idealized planning and policy-making process. The process begins with a statement of the goals sought and

is followed by the identification of the specific problems to be solved, and the delineation of the planning or policy-making context in which the analysis is to be undertaken. It continues with a delineation of potential solutions, formulation of alternative sets of strategies, and the evaluation of each of these sets. It reaches a final stage with the selection of an optimal solution or set of strategies. Hindsight reviews of experience with the selected solution provide an input into future planning and policy-making processes."

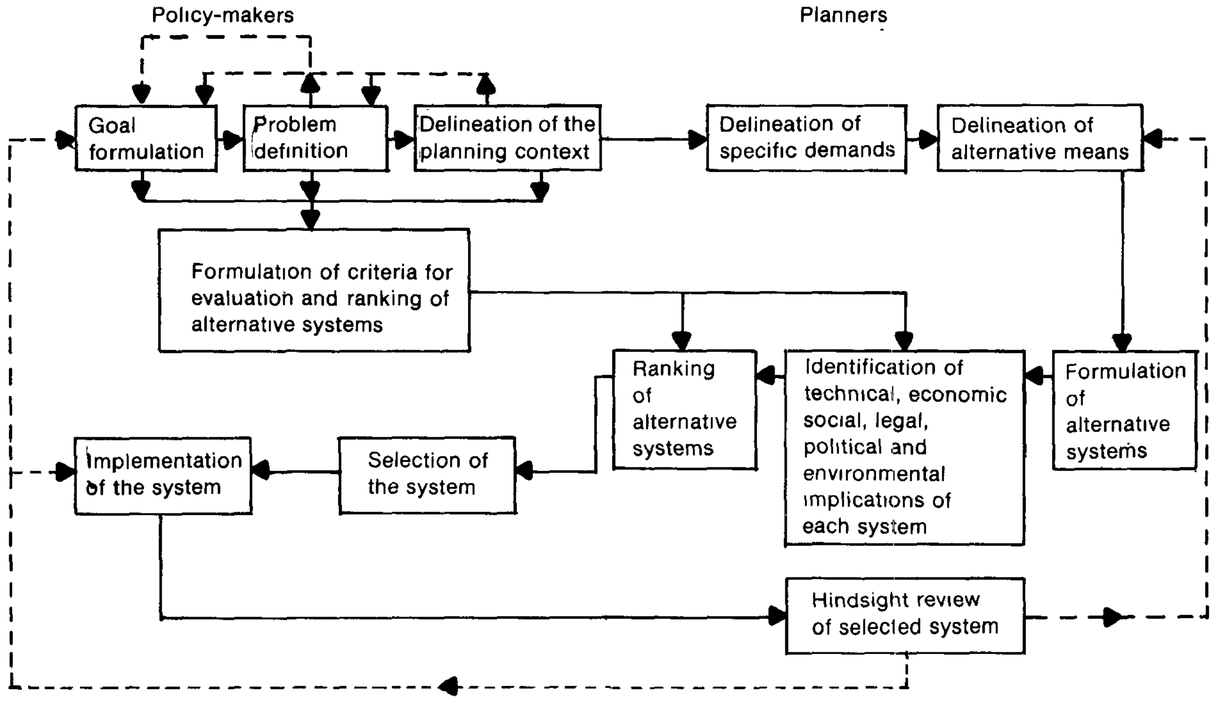


Figure 1. Schematic representation of the planning and policy-making process Note· The planning and policy-making process is a continuous one involving constant iteration and frequent policy decisions. Only the major feedbacks and policy check points are shown here.

7. See Russell, Clifford S., "Models for Investigation of Industrial Response to Residuals Management Actions," 73 Swedish Journal of Economics, No. 1, 137, 1971.
8. For a detailed example as to problem identification, see Chapters I through VI, "Development of a Trial Air Quality Maintenance Plan Using the Baltimore Air Quality Control Region," September, 1974 (EPA Publication No. 450/3-74-030); Office of Air and Waste Management, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina 27711.

SECTION IV

Residuals Generation and Discharge Model

The residuals generation and discharge process (chain of human activities) can be portrayed by a model. This residuals generation and discharge (RGD) model illustrates how residuals are introduced into the environment and their effect on ambient environmental quality. The RGD model provides a framework for identifying where physical methods may be introduced in this chain of human activities in order to eliminate or reduce residuals, or to reduce their adverse impact on ambient environmental quality.

The model starts with the final demand of people for goods and services. In response thereto the production process supplies these goods and services. In this production process, non-product outputs in the forms of intermediate products and residuals are generated. The intermediate products flow back into the production process while residuals—either treated to change their form or untreated—are discharged into the environment. Their effect on ambient environmental quality depends upon a number of factors including the assimilative capacity of the environment. Some residuals may be assimilated with little or no perceptible adverse effect on ambient environmental quality, while others may have significant adverse effect. The resulting ambient environmental quality affects human beings, other animals, plant life, and other objects.

Thus the residuals generation and discharge process depicts the flow of human activities from the demands of human beings for goods and services to a point at which humans are affected by the level of ambient environmental quality.

The RGD model is depicted in Figure IV-1.[1] It is to be considered as restricted to a given area or region. This model is useful for the purpose of (i) illustrating the complexity of the process and (ii) depicting the many points in the process at which physical methods can be introduced to improve ambient environmental quality.

Figure IV-1 is explained as follows:

Point A: Final demand for goods and services by consumers. In response to this final demand, the production process (Point B) brings together raw materials, labor and energy at a time and place to produce goods and services at Point C.

Point B: Production process results in desired goods and services (Line B-1 to Point C) and non-product outputs which become part of a mass of gases, liquids, solids and energy (Line B-2 to Point D).

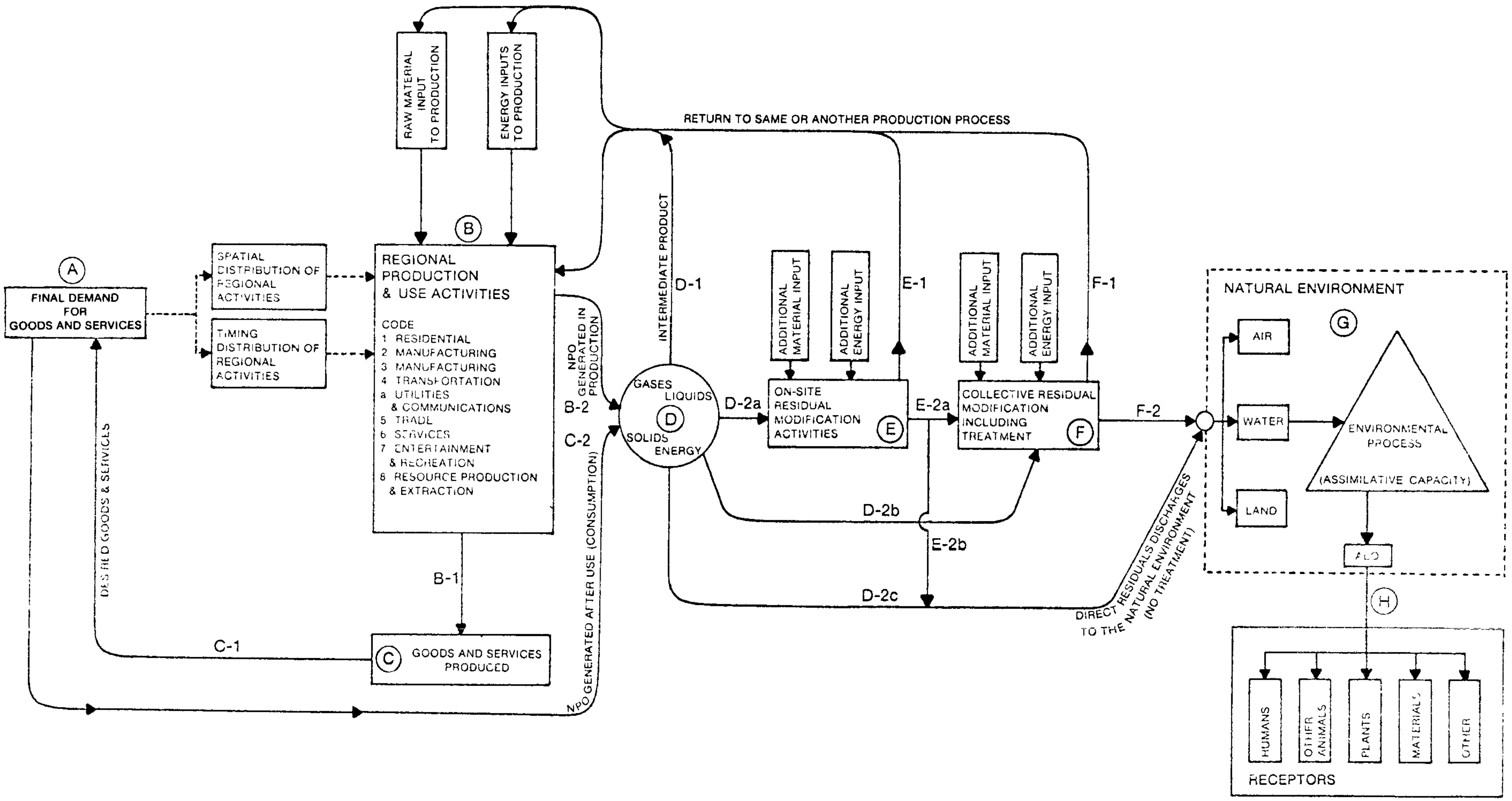
Point C: Desired goods and services (products) flow to the consumer (Line C-1 to Point A) and after use that which is left over may be deemed the non-product output of consumer activity. It becomes part of the mass of gases, liquids, solids and energy which no longer has use as a desired product (Line C-2 to Point D).

Point D: At this point, it is determined whether the non-product output has economic value in its present state and is, therefore, an intermediate product, or whether it has no economic value and is a residual. If it is an intermediate product, it is returned to the production process (Line D-1 to Point B). If it is a residual, one of three things may occur: (i) it may be modified (treated) on-site (Line D-2a to Point E); (ii) it may be collected and modified (treated) off-site (Line D-2b to Point F); or (iii) it may be discharged untreated into the environment (Line D-2c to Point G).

Point E: On-site modification (processing and treatment). This may result in recovery of residuals for return to the production process (Line E-1 to Point B). If not recovered, the

FIGURE IV-1

Residuals Generation and Discharge Process



residual may be collected for off-site modification (Line E-2a to Point F) or discharged without further modification into the environment (Line E-2b to Point G).

Point F: Off-site modification (processing and treatment). This point represents the publicly or privately owned treatment works—the "end-of-the-pipe" before discharge into the environment. This modification may result in recovery of residuals for return to the production process (Line F-1 to Point B). If not recovered, the modified residual may be discharged into the environment (Line F-2 to Point G).

Point G: Natural environment. Residuals discharged into the natural environment may be assimilated—i.e. changed in form, transported, dispersed, etc.—depending upon the capacity of the environment. This environmental process results in the level of ambient environmental quality (AEQ).

Point H: Receptors (human beings, other animal life, plants, etc.) respond to the level of AEQ.

Effects of External Factors on the Residual Generation and Discharge Model

Since the RGD model is limited to a given area or region, external factors must be considered. As noted previously, these external factors—i.e., factors which are beyond the control of a producer of non-product outputs—may well determine whether a non-product output has economic value (intermediate product) or no economic value (residual) to the generator. It was also noted that these external factors are ever changing and that they are not based on environmental considerations. These also affect the residuals generation and discharge process since they affect decisions as to management of the non-product outputs and residuals. As an example, an import tax to protect American business may make a needed raw material or component in short supply or, at least, more costly. As another example, high minimum wages or unemployment compensation may affect the availability of labor to perform low paying reclamation tasks.

Such external factors are constantly bringing about substitutions in materials, changes in production processes, utilization of more energy, and other changes all of which are implemented, but not as a response to solving a residuals problem.[2]

Summary

The relationship between the residuals generation and discharge process and ambient environmental quality is complex. An understanding of the process, however, facilitates informed decision-making.

Important points are:

> *First:* Absent environmental controls or regulation, how we handle non-product outputs (leftovers of the production process or what is left after use of the product) is a question of economics. If the non-product output has economic value, it will be reused; if not, it will be discarded as a residual.
>
> *Second:* The RGD model provides a framework for understanding how and where residuals are generated and their adverse impact on ambient environmental quality.

With the RGD model as a framework, points in the process can be identified where changes can be introduced which will maintain or attain a desired level of ambient environmental quality. In Section V, the points are identified at which physical methods (one component of the residuals management strategy) can be introduced to accomplish these purposes.

SECTION IV

Notes

1. Blair T. Bower and his colleagues at Resources for the Future, Washington, D.C. and elsewhere are the sources for the conceptual basis of this approach. For examples of their work, see:

   Bower, Blair T., and Daniel J. Basta, "Residuals—Environmental Quality Management: Applying the Concept," The Johns Hopkins University Center for Metropolitan Planning and Research, October 1973.

   Bower, Blair T., and W.R. Derrick Sewell, "Selecting Strategies for Air-Quality Management," Policy Research and Coordination Branch, Department of Energy, Mines, and Resources, Ottawa. Canada, Resources Paper No. 1, 1971.

   The process was further developed by the Office of Research and Development, EPA, Washington, D.C. under the direction of Charles N. Ehler.

2. Bower, Blair T., and Daniel J. Basta, "Residuals—Environmental Quality Control: Applying the Concept," pp. 30 et seq., The Johns Hopkins University Center for Metropolitan Planning and Research, October 1973.

   An activity model is set forth which depicts in more detail the effects of external (exogenous) factors on production variables.

SECTION V

Using the RGD Model to Identify Alternate Residuals Management Strategies

The final step of the RGD model depicts the impact of ambient environmental quality on receptors including human beings. Human beings perceive the adverse effects of a deteriorated level of ambient environmental quality and respond by establishing goals and objectives for improving environmental quality. Once these goals and objectives are established, the means of accomplishing them must be identified, evaluated and selected.[1] The residuals management strategy comprised of physical methods, implementation measures and institutional arrangements is such a means.

Identifying Points of Introduction of Physical Methods in the RGD Model

Residuals can be reduced or eliminated and/or their adverse effect on the environment lessened or eliminated by changes at many points along the RGD model. In other words, physical methods may be introduced in the residuals generation and discharge process at any point in the process. In many instances, it is neither necessary nor desirable to wait until the residual is about to be discharged into the environment ("end-of-the-pipe") to remedy the problem.

The physical methods and points of introduction in the RGD model are depicted in Figure V-1 and are identified as follows:[2]

A. Methods to Reduce and/or Modify "Final Demand" for Goods and Services

B. Methods for Reducing the Discharge of Residuals or Modifying them to a Less Objectionable Form

  1. Methods for Reducing Residuals Generation

     a. Change in (i) raw material and/or (ii) energy inputs to the production process

     b. Change in the (i) technology and/or (ii) operating rate of the production process

     c. Change mix of product inputs

     d. Change product output specifications

  2. Methods for Modifying Residuals After Generation

     a. Apply materials or energy recovery technology—i.e. utilize as an intermediate product

     b. Apply waste treatment (pollution control) technology without recovery of any materials or energy at (i) on-site or (ii) off-site (joint or collective) facility

     c. Utilize by-products of residuals modification after (i) on-site modification or (ii) off-site modification

C. Methods Directly Improving the Assimilative Capacity of the Natural Environment

  1. Methods for Making Better Use of the Existing Assimilative Capacity

     a. Change spatial distribution of existing or new activities (generators)

b. Change timing distribution of existing or new activities (generators)

c. Change the spatial distribution of the discharge of residuals

d. Change the timing distribution of the discharge residuals

2. Methods for Increasing the Assimilative Capacity of the Natural Environment

D. Final Protective Methods

Two matters deserve special mention. First, the methods for modifying residuals after generation can be carried out in a single or in a joint facility. The latter refers to a facility which handles residuals generated in several locations. Examples include a waste oil reclamation plant which processes oil residuals from many garages and gas stations; plant for recovery of acid from used steel mill pickling liquor from several mills; a municipal incinerator, landfill, sewage treatment plant; and installation for processing paper residuals from multiple sources. Joint facilities usually achieve economies of scale, thus making economically feasible an activity which would not be so if it were undertaken by each individual residuals generator.

Second, waste treatment—either conventional or advanced—does not reduce the total quantity of residuals discharged into the environment, it simply transforms them so that they can be discharged into the environment with fewer or no adverse effects. It should be emphasized, however, that, in order to make the transformation, additional inputs of material and energy are required and hence additional residuals are generated.

It is now readily apparent that a broad spectrum of physical methods can be considered to eliminate or reduce the harmful effect of the discharge of residuals into the environment. It should be noted that the point and manner of introduction significantly determine the cost of the method and final distribution of that cost. These latter factors are considered in the evaluation process described in Section VI.

At this stage, the points of introduction have been identified but not activated. The points of introduction may be viewed as "valves" to control the residuals generation and discharge process, but the valves have not yet been turned to change the residuals generated or discharged. It is the function of the residuals management strategy to determine which valve or valves to turn, how much to turn those selected, and who should do the turning. The actual turning of the valves may be viewed as the function of the implementation measure component of the strategy—the component which induces or requires a physical method to be introduced into the process.

Classifying Components of the Residuals Management Strategy

To assist in identifying possible components of the residuals management strategy, the components may be classified as follows:

A. Physical Methods by Points of Introduction in the RGD Model

- Physical methods as so classified can then be compared with source activities generating residuals

B. Implementation Measures as to their Effect or Purpose

- Selected physical methods can then be compared with implementation measures which will induce implementation of such physical methods

C. Institutional Arrangements as to Different Levels and Types of Government

- Implementation measures can then be compared with institutional arrangements which have the capacity and capability to enact such implementation measures

These classifications should prove helpful in identifying the broad range of alternatives available for each component of the residuals management strategy.

A. *Classification of Physical Methods:* Physical methods may be classified by points of introduction as depicted in the RGD model—e.g. final demand, production process, etc. (See points of introduction listed with Figure V-1).

In order to identify physical methods and points of introduction as they relate to a particular residuals problem, it may be helpful to identify broad categories of activities which are sources of the residual. The source activities may be classified as follows:[3]

1. Residential
2. Manufacturing (food and kindred products, etc.)
3. Manufacturing (rubber and plastic products, etc.)
4. Transportation

4a. Utilities and Communications

5. Trade
6. Services
7. Entertainment and Recreation
8. Resource Production and Extraction
9. Undeveloped Land and Water areas

These source activities may be further subdivided as needed to deal with the residuals problem confronted. For example, the manufacturing category may be subdivided using the Standard Industrial Classification (SIC) and even further by identifying a specific source by location.[4]

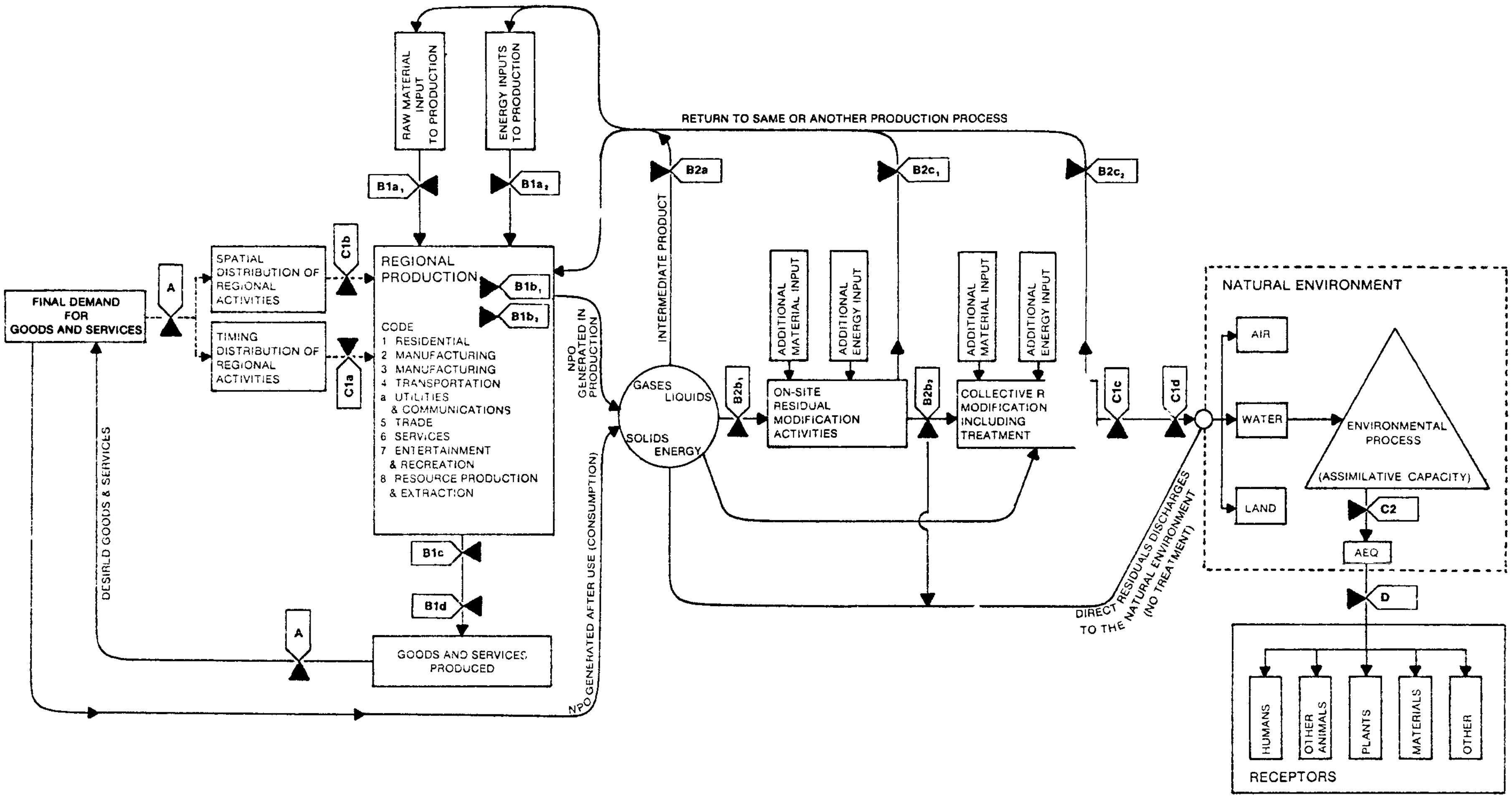
The physical methods and source activities so classified may be related on a simple chart. This will assist in the process of identifying physical methods. (See Appendix C, Table C-1, for an example of such chart applied to a specific residuals problem. See Appendix A for an illustrative list of physical methods categorized by source activity.)

B. *Classification of Implementation Measures:* Implementation measures may be classified as to their effect or purpose as follows:

1. Regulatory measures—laws and/or regulations that *require* certain physical methods be implemented. Examples: standards, both ambient and effluent; permits and licensing programs; specifications of raw material inputs and product outputs, specifications of allowable activities, intensity of use, and conditions of use; rationing. Compliance monitoring and enforcement programs are required to operationalize these measures.
2. Economic measures—measures designed to enhance ambient environmental quality through incentive charges, placing a price upon residuals actually discharged and/or placing a price to cover costs of providing residual control services. Examples: effluent charges; user charges; fees; taxes; rate structures; assessments; loans; depreciation allowance schedules; tax credits.
3. Administrative measures—routine procedures and activities of public organizations that can be used to reduce or eliminate residuals generation and discharge by such organization. Examples: purchasing procedures; separation of materials for recycling; siting of government facilities; conservation practices.
4. Provision of Information—all means used to convey information to people. These include educational programs, training activities, workshops, media, and public awareness activities. Examples: media advertising; displays and demonstrations; forums/seminars/workshops; educational programs; literature distribution.

FIGURE V-1

Illustration of Points of Introduction by Physical Methods in the Residuals Generation and Discharge Model



To help identify the appropriate implementation measure, a simple chart may be utilized which relates physical methods classified as to points of introduction in the residuals generation and discharge process to classes of implementation measures. (See Appendix C, Table C-2, for an example of such a chart applied to a specific residuals problem. See Appendix B for an illustrative list of implementation measures.)

C. *Classification of Institutional Arrangements:* The different levels of general jurisdiction governments are responsible for environmental goals, objectives and policies.[5] The same general jurisdiction governments may adopt implementation measures, or as is many times the case, limited jurisdiction (special purpose) entities of government may adopt or promulgate the implementation measures. These different levels of general jurisdiction governments and limited jurisdiction entities, together with intergovernmental arrangements comprise the institutional arrangements component of the residuals management strategy.

Institutional arrangements may be usefully classified as follows:

I. General Jurisdiction
   A. Federal—e.g., Congress
   B. State—e.g., Legislative
   C. Local (City, County, Metro, etc.)—e.g., Councils, Boards of Commissioners, etc.

II. Limited (Special) Jurisdiction
   A. Federal—e.g., agencies such as EPA, Department of Interior, Corps of Engineers
   B. State—e.g., agencies such as Boards of Health, Departments of Natural Resources
   C. Local—e.g., sanitary districts, school districts, drainage districts, etc.

III. Intergovernmental Arrangements
   A. Cooperative—e.g., Councils of Governments (COG's)
   B. Mandated—e.g., required areawide arrangements for water quality (§208 of the Federal Water Pollution Control Act of 1972) or for air quality (air quality maintenance plans as required by (§110 of the Clean Air Act of 1970).

To help identify appropriate institutional arrangements, a useful comparison with selected implementation measures should be undertaken. This comparison should indicate which institutional arrangements are best suited—i.e., have the legal capacity and actual capability—to adopt selected implementation instruments and to see to it that they are accomplished. A simple chart relating institutional arrangements and implementation measures should be of assistance. (See Appendix D, Table D-3, for an example of such a chart.)

The identification process for institutional arrangements is more complicated, however, since it must also include the interrelationship among institutions. As an example, one level of government may adopt the implementation measure, another level or entity of the government may implement it, and still a third may enforce it. It is not unusual to find that one governmental entity does not have the capacity to adopt, implement, enforce, and review the effect of an implementation measure.

Identification of Residual Management Strategies

The first step in identifying a residuals management strategy is identification of the residuals problem and its source or sources. As noted previously, it is assumed that this can be, or has been, done by those confronted with handling the residuals problem.[6] With these source activities identified, possible residuals management strategies may be identified which, when brought to bear upon the source activities, will eliminate or alleviate the residuals problems created by such source activities. This identification of possible components of the strategies can be accomplished as follows:

First: Identify physical methods which can be introduced at each point of introduction ("valve") in the RGD model.

Second: Identify implementation measures which will induce implementation of the identified physical methods—i.e., turn the "valve."

Third: Identify the institutional arrangements which have the capacity to adopt, implement and enforce the identified implementation measures.

This step by step process results in identifying the components of various residuals management strategies. This procedure should be followed for each point of introduction in the RGD model. In some instances, it will be readily apparent that few, if any, physical methods may be introduced. In other instances, it will be apparent that a selected physical method may be introduced at several points.

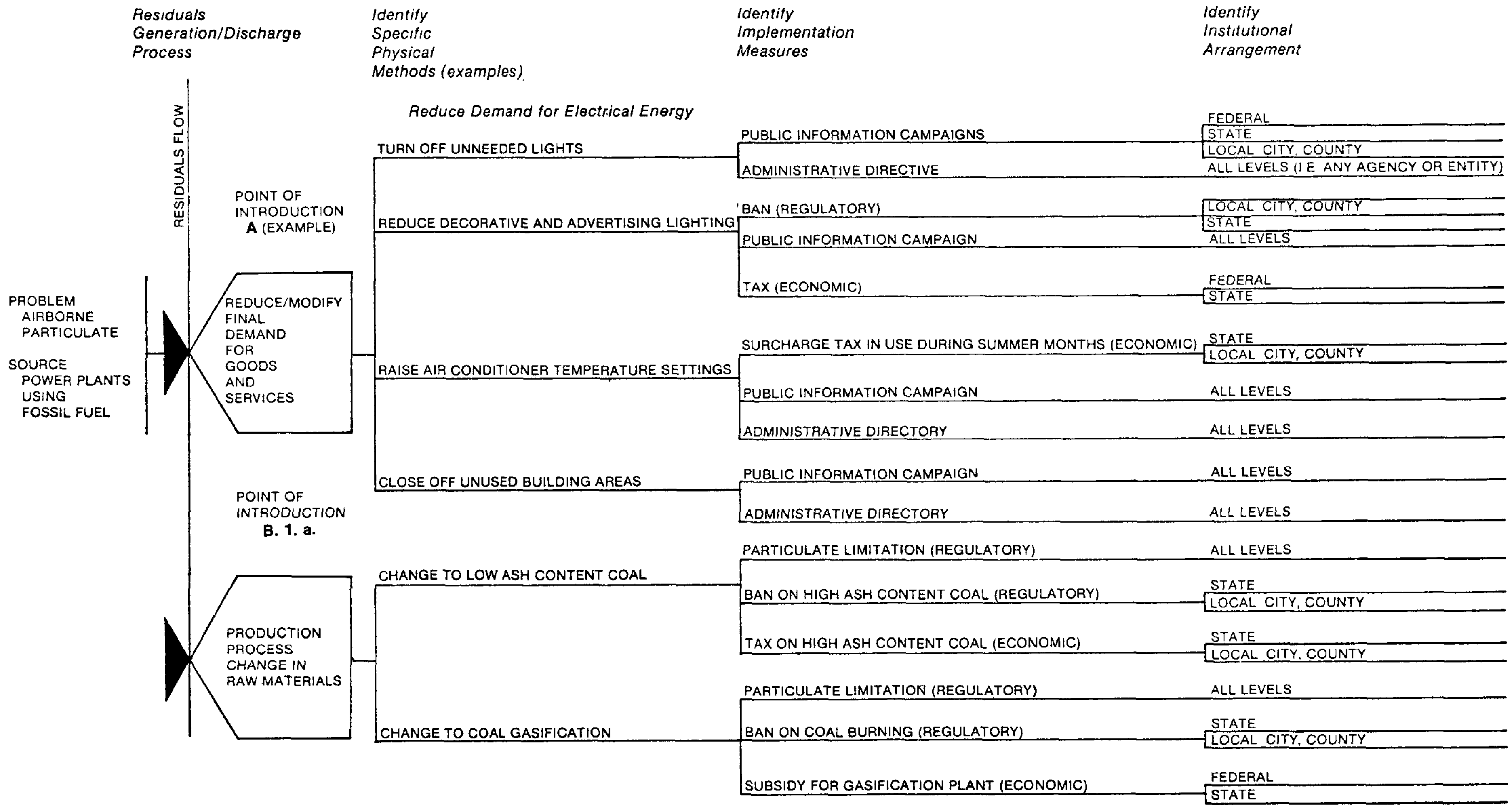
As an illustration of this process, assume that the residuals problem is airborne particulates from two sources—a fossil-fueled, electrical generation plant and a steel mill. Starting with reduction or modification of final demand as the first point of introduction in the RGD model, several physical methods which would reduce demand for electrical energy can be identified—e.g., turn-off unneeded electric lights, reduce decorative and advertising lighting, raise temperature settings on air conditioner thermostats, and close off unused portions of buildings. For each of these physical methods, several implementation measures can be identified—e.g., for reducing decorative or advertising lighting there could be a regulation banning them, a tax on them, an educational program to reduce them, etc. In identifying the institutional arrangement, it appears that a regulation banning them could be enacted under the police power of the state or local government (analogous to land use controls). Taxation might more appropriately be enacted at the state or federal level.

The same process can be followed in the case of the steel mill source, although it becomes apparent that reducing or modifying final demand at the local level will be less effective. For the steel mill problem, physical methods for modifying residuals after generation is a better illustration. There are a number of physical methods that can be applied at this point. These include settling chambers, cyclones, wet scrubbers, electrostatic precipitators and fabric filters ("bag houses"). Regulatory implementation measures such as emission standards could be combined with economic incentives such as accelerated depreciation (income tax benefits) or lower property taxes. Regulatory measures might be imposed by federal, state or local governments, but local governments would appear to be most appropriate. Economic incentives such as income tax advantages would be on the federal level while property tax advantages would be on the federal level while property tax advantages would most likely be on a state level.

The foregoing processes are depicted in Figures V-2 and V-3.

FIGURE V-2

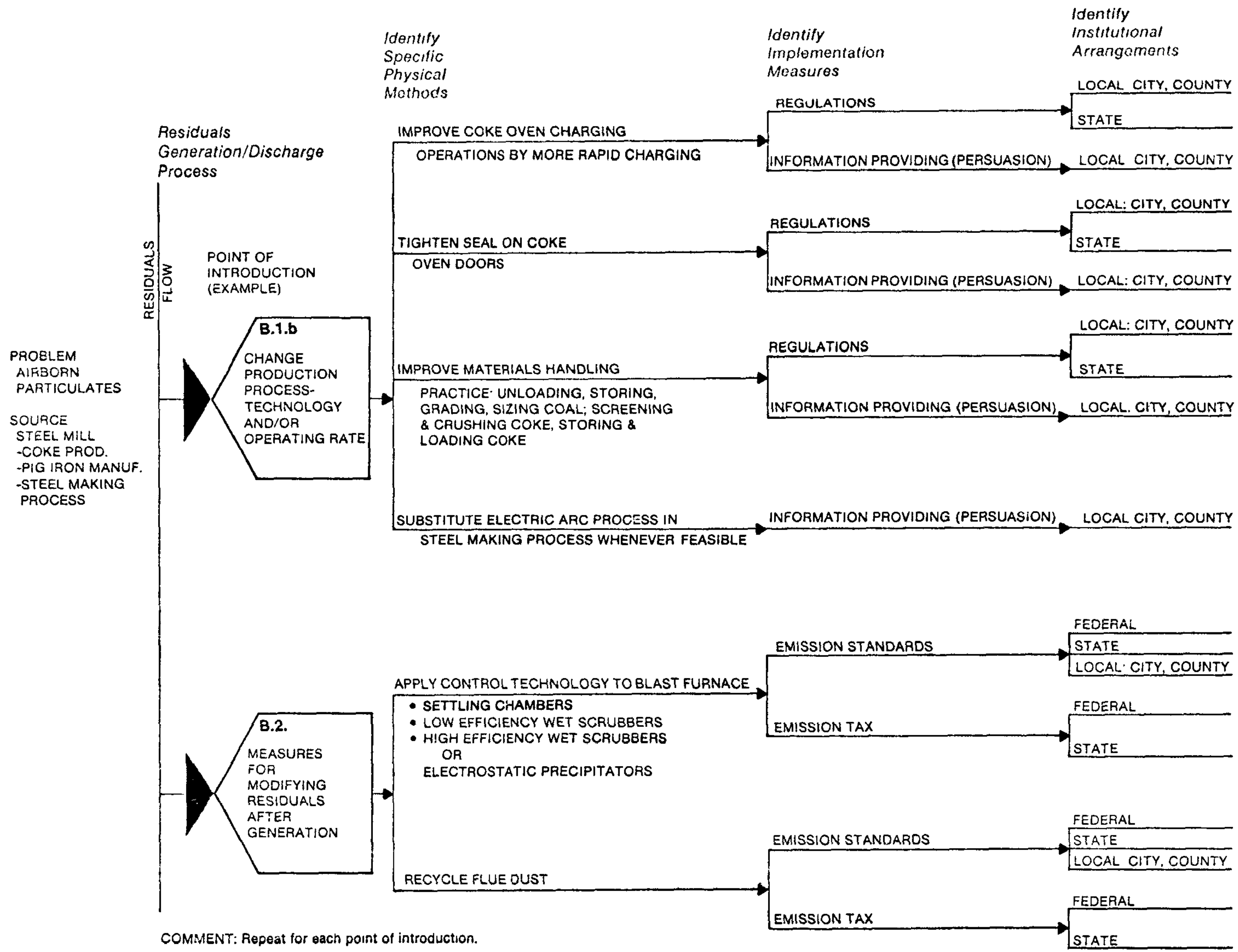
Identifying Components of Residuals Management Strategy (Power Plant Source of Particulates)



COMMENT: Repeat for each point of introduction.

FIGURE V-3

Identifying Components of Residuals Management Strategy (Steel Mill Source of Particulates)



COMMENT: Repeat for each point of introduction.

Summary

While the classifications of the components of the residuals management strategy are useful, they are not mandatory. The classifications and comparisons may be expanded, reduced or changed to fit the needs of the particular situation.

Important points are:

First: There are many points depicted in the RGD model at which physical methods may be introduced to reduce or alleviate the adverse effect of the discharge of residuals into the natural environment.

Second: In identifying the components of a residuals management strategy, a three step procedure may be followed:

1. Identify physical methods which can be introduced at each point in the RGD model
2. Identify implementation measures which will induce implementation of the identified physical methods
3. Identify institutional arrangements which have the capacity to adopt, implement and enforce the identified implementation measures

Having identified the alternatives for each component of the residuals management strategy, they must be evaluated and then a selection made. This evaluation and selection process is covered in Section VI.

SECTION V

Notes

1. See Section III, Overview of the Process for Selection of Residuals Management Study.
2. The conceptual basis for this approach and categorization was developed by Blair T. Bower and his colleagues at Resources for the Future, Washington, D.C. The approach was further developed by the Office of Research and Development, EPA, Washington, D.C. under the direction of Charles N. Ehler.

   These categorizations and subcategorizations of points of introduction are not precise. As an example, in-plant recycling might be considered part of the production process or part of direct residuals processing. As another example, changing product output specifications may be considered part of demand modification or production modification. Preciseness in categorizing control measures is not as important as is the recognition of the large variety of physical methods available.

   For a slightly different approach, see Bower, Blair T., and Daniel J. Basta in "Residuals-Environmental Quality Management: Applying the Concept," pp. 9-11 (Johns Hopkins Press, 1973).
3. The classification of source activities is that set forth for land use activities by Marion Clawson and Charles L. Stewart in "Land Use Information," Resources for the Future, Inc.; distributed by Johns Hopkins Press (1965). See appendix A for a listing through the two digit-level.
4. Id. pp. 304-352. Classification is set forth in two-, three- and four-digit levels.
5. It is recognized that the private sector may be considered a part of the institutional arrangement component of the Residuals Management Strategy. For purposes of this report, institutional arrangements are limited to governmental entities—i.e., entities having the legal capacity to legislate, plan, regulate and enforce. Private institutions—particularly trade associations, manufacturer's associations and public interest groups—may influence governmental decision-making by lobbying, etc. As noted in Section VI (Developing and Evaluating Residuals Management Strategy), the capacity and willingness of private institutions to respond is a factor to be considered in developing, evaluating and selecting a Residuals Management Strategy. The cooperation and responsiveness of the generators of residuals is an important evaluative factor.
6. For a detailed example as to problem and source identification, see Chapters I through IV, "Development of Trial Air Quality Maintenance Plan Using the Baltimore Air Quality Control Region," September, 1974 (EPA Publication No. 450/3-74-030); Office of Air and Waste Management, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina 27711.

SECTION VI

Developing and Evaluating Residuals Management Strategies

The purpose of this section is to provide a procedure for developing and evaluating residuals management strategies aimed at achieving and maintaining ambient environmental quality objectives. Illustrative applications are included as examples. This approach is developed from the perspective of governments of general jurisdiction (e.g., city, county, state). These are the institutions with the prime responsibility for managing environmental problems.[1] They are also the institutions most likely to have, or be able to obtain, the authority necessary to implement and enforce strategies.

This section provides an approach for developing and evaluating residuals management strategies. The challenges of implementation and enforcement are not dealt with explicitly in this report.

Approach

The essential steps for developing and evaluating residuals management strategies are depicted in Figure VI-1. The seven steps are described in more detail below.

Step 1: *Define Problem* in terms of residual characteristics (gaseous, liquid, solid, energy); sources (industrial, residential, agricultural, service, transportation, commercial, energy conversion, mining, collective residuals processing); and media (air, water, land). Each residual should also be classified in terms of its intermedia effects. For example, particulates in air may be transformed into suspended solids in water which in turn may be transformed into sludge on the land; SO_2 in the air may be transformed into SO_3 and SO_4 in water; heavy metals in water can become heavy metals on land through the intervening mechanism of sediments that are dredged from stream or lake beds or sludge from wastewater treatment plants deposited on the land.

Step 2: *Specify Alternative Physical Methods* with respect to problem sources. Differentiate among sources in terms of point and non-point (area) sources. Examples of physical methods applicable to specific sources are shown in Table VI-1.

Steps 1 and 2 are usually undertaken in response to: (a) legislative requirements such as the Air Quality Maintenance Planning provision of the Clean Air Act of 1970 and the 208 Areawide provision of Federal Water Pollution Control Amendments of 1972; (b) need for integration of related programs such as air/water/solid waste; and/or (c) complaints from constituents. These two steps provide a "baseline" inventory and analysis of problems.

Step 3: *Analysis of Alternative Physical Methods* in terms of their physical and economic effects. The analysis step identifies factors, both direct and indirect, affecting generation of residuals by source category and develops appropriate cost information for them. The analytical process may be as elaborate and sophisticated as resources and state-of-art allow.

Step 4: *Identify Alternative Implementation Measures and Institutional Arrangements* for implementing and enforcing the alternative physical methods that emerge from the analytical step. For example, an ordinance limiting the sulfur content of fuels used in City of Chicago[2] is an implementation measure that induced large point sources to switch to low sulfur coal and many small sources (e.g., 3 flats that individually

FIGURE VI-1

Procedure for Developing and Evaluating Residuals Management

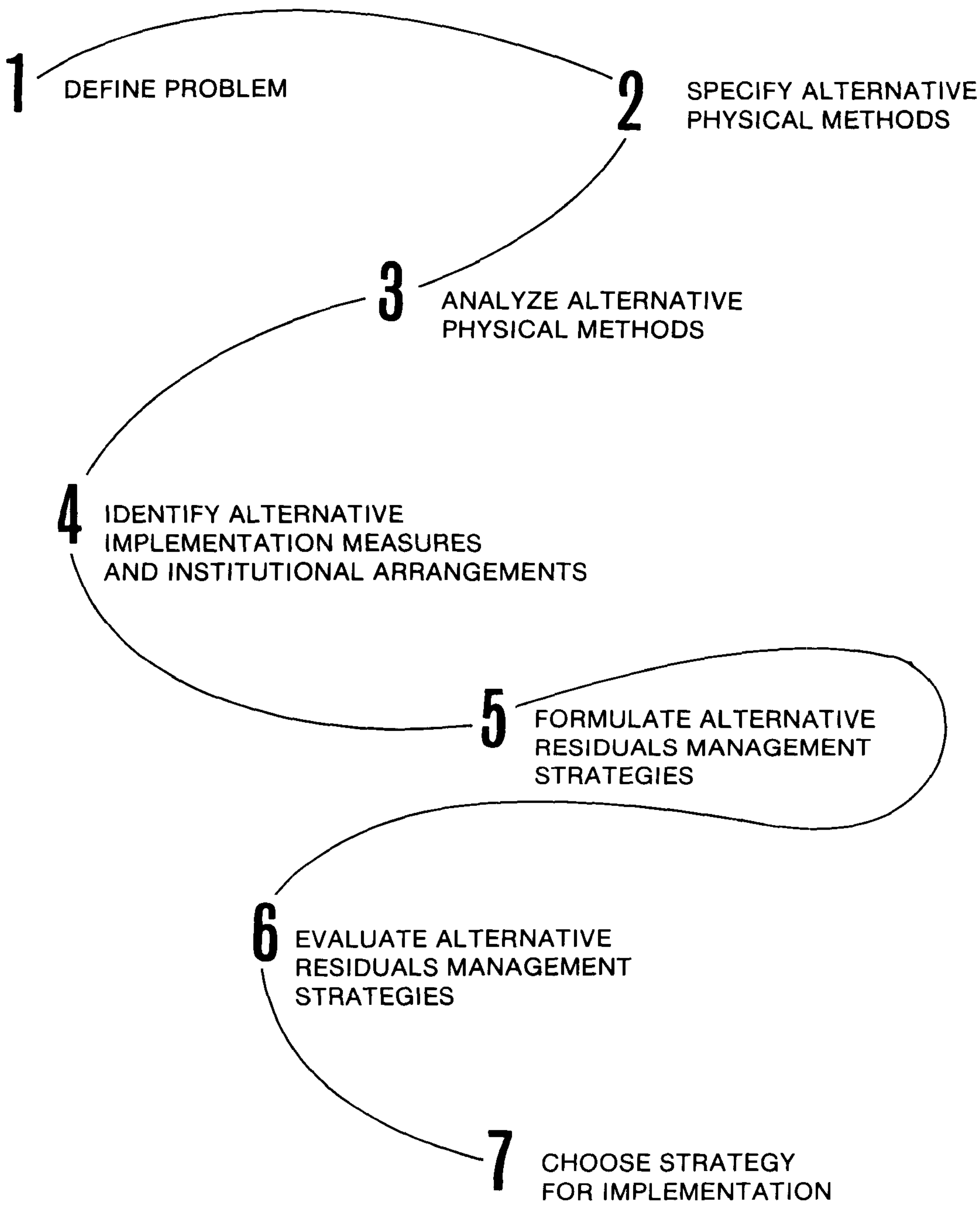


TABLE VI-1

Source	*Problem*	*Physical Methods*
Power Plant	Particulates Sulfur Dioxide	Electrostatic Precipitator SO^2 Scrubber Burn Low Sulfur Fuel Increase Stack Height Cooling Towers
Municipal Wastewater Outfall	Organic Heavy Metals Suspended Solids	Higher degree of treatment by municipal plant Pretreatment
Manufacturing Process	Gaseous, Liquid, Solid	Change Production Process Change Product Mix Change Raw Material Inputs
Agricultural Operation Field	Pesticides, Herbicides Nutrients	Limit quantity of fertilizer, pesticides, herbicides used.
Construction Sites	Erosion, Sediment	Collect sediment on-site Clean wheels of vehicles as they leave site Minimize disturbance of natural landscape

contribute an inconsequential amount of residuals but aggregated for a square mile represent a substantial residuals source) to convert from coal to natural gas. An illustrative hypothetical example is a change in consumer demand with respect to color of paper products for the kitchen and bathroom as the implementation measure that induces paper industry to reduce use of bleaching process and thus eliminate a substantial source of residuals.[3]

Step 5: *Formulate Alternative Residuals Management Strategies* with the outputs (results) that may be expected from each strategy. These outputs indicate the effects of each strategy on the ambient environmental quality and on the economy. Information developed in Step 3 would be assembled and summarized for each Residuals Management Strategy. At a minimum, these results would indicate the reductions to be achieved for each residual in terms of both percent removals and pounds per day and generally what the costs are for each strategy. Whenever possible these reductions would be translated into ambient environmental quality (e.g., a reduction in sulfur dioxide of X pounds per day improves ambient quality by Y micrograms per cubic meter.)

Step 6: *Evaluate Alternative Residuals Management Strategies* in terms of a set of explicit criteria. The outputs (results) of analysis are the inputs to the evaluation process. It is the function of evaluation to assign "weights" (judgments, both objective and subjective) to each of the physical and economic effects emerging from analysis. The outcome of this evaluation process "feeds" into and provides a rational basis for choosing a strategy. Based on the evaluation it will be possible to rank order the residuals management strategies. Criteria for evaluation of strategies are:

A. Physical Effects:
   1. Reduction in quantities discharged to ambient environment.
   2. Improvements in ambient environmental quality.

B. Economic Effects:
   1. Direct costs are expenditures required in responding to a particular strategy. These include investment and operating costs for control equipment, incremental costs of fuel switching, costs of production, process changes, emission monitoring costs, administrative costs for accounting and reporting, costs of supervision of operating personnel, and costs required of the governmental unit for implementing and enforcing a strategy, such as operating costs for permit review programs, monitoring air quality, review source inventories, and source surveillance.[4]
   2. Other economic effects are the benefits and costs that accrue to society as a result of implementing a particular residuals management strategy. These may include employment, income to other firms, change in income tax, changes in property taxes, change to new receptors, increased cost of user goods, and dislocation of people.

C. Legal consideration in terms of:
   1. Existing enabling legislation.
   2. Nature and extent of legal precedents.
   3. Susceptibility of implementation measure to legal challenge.
   4. New legislation required.

D. Administrative considerations in terms of flexibility; i.e., the strategy must be able to respond effectively to:
   1. Seasonal variations.
   2. Changes in prices, technology, etc. over time.
   3. New information—e.g., as the national system (ambient environment) responds the strategy must be able to adjust.
   4. New goals, new priorities—e.g., as society's needs and desires change, new people are elected or appointed to decision-making positions.

E. Time considerations—institutional arrangements must account for lapsed time from passage (adoption) of ordinance or regulation (implementation measure) to actual response by residuals generators in initiating their actions (selection of physical methods):
   1. Time required to implement strategy.
   2. Time required to obtain first results and/or benefits.

F. Political considerations in terms of feasibility of adoption. (Use a 3-part scale ranging from readily feasible to not feasible.)

G. Public responsiveness in terms of acceptability. (Use a 5-part scale ranging from most acceptable to unacceptable.)

Step 7: *Choose strategy* based on the outcome of the formal evaluation process of Step 6 and whatever additional considerations are or seem appropriate to those with authority and who are responsible for choosing the strategy.[5]

SECTION VI

Notes

1. Those institutions situated nearest the problem jurisdictionally are generally the most appropriate focal points for developing, selecting, implementing, and enforcing residuals management strategies.
2. Environmental Control Ordinance, Chapter 17 of the Municipal Code of Chicago, Section 17-2.5(3) (a), adopted April 1970 and becoming effective July 1, 1970.
3. The product specifications other than color would *not* change.
4. RTI Draft Report, *Guidelines for Preparation of 10-Year Air Quality Maintenance Plan,* p. 1-15, (1974).
5. Those who choose residuals management strategies must/should be accountable for their implementation and enforcement.

SECTION VII

Bibliography

General

Allan, Leslie, Eileen Kohl Kaufman, and Joanna Underwood, *Paper Profits,* Council on Economic Priorities, MIT Press, 1972.

Atkinson, Scott E., and Donald H. Lewis, *A Cost Evaluation of Alternative Air Quality Control Strategies,* EPA 600/5-74-003, January 1974.

Bacon, Edmund M., "Urban Population Expansion and the Preservation of Nature," in *Land Use and the Environment: An Anthology of Readings,* Virginia Curtis (ed.), Office of Research and Monitoring, EPA-PB-225 521/4, 63-65, May 1973.

Bain, Joe S., *Environmental Decay: Economic Causes and Remedies,* Little, Brown, and Company, Boston, 1973.

Boulding, Kenneth E., "The Economics of the Coming Spaceship Earth," *Environmental Quality in a Growing Economy,* Henry Jarrett (ed.) John Hopkins Press, 1966.

Bower, Blair T., and W.R. Derrick Sewell, *Selecting Strategies for Air Quality Management,* Policy Research and Coordinating Branch, Department of Energy, Mines and Resources, Ottawa, Canada, 1971.

Bower, Blair T., and Daniel J. Basta, "Residuals-Environmental Quality Management: Applying the Concept," The Johns Hopkins University Center for Metropolitan Planning and Research, October 1973.

Caldwell, Lynton Keith, *Environment: A Challenge for Modern Society,* Natural History Press, New York, 1970.

Cannon, James, *A Clear View: Guide to Industrial Pollution Control,* Inform, May 1975.

Cannon, James S., *Environmental Steel—Pollution in the Iron and Steel Industry,* Jean M. Halloran (ed.), Council on Economic Priorities, Praeger Publishers, 1974.

Clawson, Marion, *Land Use Information: A Critical Survey of U.S. Statistics,* Including Possibilities for Greater Uniformity, Division of Community Planning, Johns Hopkins Press, 1966.

Davis, Robert K., *The Range of Choice in Water Management: A Study of Dissolved Oxygen in the Potomac Estuary,* Johns Hopkins Press, Baltimore, 1968.

"Development of a Trial Air Quality Maintenance Plan Using the Baltimore Air Quality Control Region," EPA-450/3-74-050, September 1974.

Dorfman, R., "Discussion," 63 *American Economic Review,* No. 2, 253, May 1973.

"Guidelines for Preparation of 10-year Air Quality Maintenance Plan," Office of Air and Waste Management, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, EPA, 1974.

Jackson, Barbara (Ward), *Spaceship Earth,* Columbia University Press, 1966.

Kneese, Allen V., "Strategies for Environmental Management," 19 Public Policy 37-52, 1971.

Kneese, Allen V., and Blair T. Bower, *Managing Water Quality: Economics, Technology, and Institutions,* Johns Hopkins Press, 1968.

Kneese, Allen V., Robert U. Ayres, and Ralph C. D'Arge, *Economics and the Environment—A Materials Balance Approach,* Johns Hopkins Press, 1970.

MacLeod, Scott. "One Earth and the Third World: A Stockholm Review," 14 *International Development Review,* No. 4, 3-8, 1972.

Note, "Federal Environmental Pesticide Control Act of 1972: A Compromise Approach," 3 *Ecology Law Quarterly* 277-310, Spring 1973.

Phosphates in Detergents and the Eutrophication of America's Waters, Comm. on Gov't. Operations, H.R. 91-1004, 91st Cong., 2d Sess. (1970).

Phosphates and Phosphate Substitutes in Detergents: Government Action and Public Confusion, Comm. on Gov't. Operations, H.R. 92-918, 92d Cong., 2d Sess. (1972).

Russell, Clifford S. and W.J. Vaughan, "A Linear Programming Model of Residuals Management for Integrated Iron and Steel Production," 1 *Journal of Environmental Economics and Management,* No. 1, 17-42, May 1974.

Russell, Clifford S., Models for Investigation of Industrial Response to Residuals Management Actions," 73 *Swedish Journal of Economics,* No. 1, 134-156, 1971.

Russell, Clifford S., and W.O. Spofford, Jr., "A Quantitative Framework for Residuals Management Decision," *Environmental Quality Analysis,* Kneese and Bower (eds.), Johns Hopkins Press for Resources for the Future, Baltimore, 1972.

Van Tassel, Alfred J., (ed.), *Environmental Side Effects of Rising Industrial Output,* Health Lexington Books, Lexington, Massachusetts, 1970.

Witherspoon, Robert, *et. al., Governmental Approaches to Air Pollution Control: A Compendium Annotated Bibliography,* Institute of Public Administration, Washington, July 15, 1971.

Zalkind, Joe, *et. al., Guide to Corporations: A Social Perspective,* Council on Economic Priorities, the Swallow Press, Chicago, 1974.

Adams, Carl E. Jr., "Removing Nitrogen from Wastewater," 7 *Environmental Science and Technology* 696, 1973.

"Air Pollution Control" 78 *Chemical Engineering* 131-141, June 21, 1971.

Ayres, Robert U., and Richard P. McKenna, *Alternatives to the Internal Combustion Engine: Impacts on Environmental Quality,* Johns Hopkins Press, 1972.

Black and Veatch, *Processing Design Manual for Phosphate Removal,* EPA-PB-214 553/0, October, 1971.

Bryant, David A., *Study and Evaluation of Computer Carpool Programs in Certain Metropolitan Areas,* EPA-450/3-74-041, April 1974.

Chansky, Steven, Billy McCoy, and Norman Suprenant, *Waste Automative Lubricating Oil as a Municipal Incinerator Fuel,* EPA-R2-73-293, September 1973.

Compilation of Air Pollutant Emission Factors, EPA, Office of Air and Water Programs, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, April 1973.

Control Techniques for Particulate Air Pollutants, Department of Health, Education and Welfare, Public Health Service, Environmental Health Service, National Air Pollution Control Administration, Washington, D.C., January 1969.

Coughlin, Robert E., and Thomas R. Hammer, *Stream Quality Preservation Through Planned Urban Development,* EPA-R5-73-019, May 1973.

Dawson, Alexander D., "Earth Removal and Environmental Protection," 3 *Environmental Affairs* 166-187, 1974.

Denis, Sylvain, *Some Aspects of the Environment and Electric Power Generation,* Rand Corporation, Santa Monica, February 1972.

Diaper, E.W.J., "Tertiary Treatment by Microstraining—Case Histories," 120 *Water and Sewage Works,* Number 8, 42, August 1973.

Dobney, George, Q.C. "Review of the Development Control System," *Journal of Planning and Environmental Law,* 59, February 1974.

Emerson, Frank C., "River Quality and Industrial Adjustment: A Case Study," 3 *Environmental Affairs* 188-97, 1974.

Gatley, W.S., "Industrial Noise Control," 93 *Mechanical Engineering* 29-37, April 1971.

Goeller, B.F., *et al.,* "Strategy Alternatives for Oxidant Control in Los Angeles Air Quality Control Region," EPA, September 1973.

Hershaft, Alex, "Solid Waste Treatment Technology," 6 *Environmental Science and Technology,* No. 5, 412-421, May 1972.

Hill, Christopher T., "Thermal Pollution and Its Control," 2 *Environmental Affairs* 406-420, 1972.

Kosowski, Z.V., *Control of Mine Drainage from Coal Mine Mineral Wastes, Phase II,* EPA-R2-73-320, May 1973.

Lea, W.L., G.A. Rohlich, and W.J. Katz, "Removal of Phosphates from Treated Sewage," 26 *Sewage and Industrial Wastes,* No. 3, 261-275, April 1954.

Logsdon, Joe E., and Thomas L. Robinson, *Radioactive Waste Discharges to the Environment from Nuclear Power Facilities,* EPA, October 1971.

Ludwig, John H., "Air Pollution Control Technology," 33 *Law and Contemporary Problems* 217, 1968.

McClure, Paul T., *Some Projected Effects of Jet Noise on Residential Property Near Los Angeles International Airport by 1970,* Rand Corporation Paper, P-4083, April 1969.

McGriff, E. Corbin, Jr., and Ross E. McKinney, "The Removal of Nutrients and Organics by Activated Algae," 6 *Water Research,* No. 10, 1155-1164, 1972.

Mallory, C.W., *The Beneficial Use of Stormwater,* EPA, January 1973.

Martin, Edward J., and Garth D. Guntz, *State of Maryland Waste Oil Recovery and Reuse Program,* EPA-670/2-74-013, January 1974.

Note, "Reclaiming of the Urban Environment: The San Francisco Urban Design Plan," 3 *Ecology Law Quarterly* 535-595, Summer 1973.

Papetti, R.A., *et al., Air Pollution and Power Plant Siting in California,* Rand Corporation, Santa Monica, March 1973.

Pound, Charles E. and Ronald W. Crites, *Wastewater Treatment and Reuse by Land Application,* EPA-660/2-73-006a, August 1973.

Preliminary Report of Phosphorus Trends at Municipal Sewage Treatment Plants and in Indiana Streams for Years 1971, 1972, and 1973, Division of Water Pollution Control, Indiana State Board of Health, Indianapolis, 1974.

Rosen, H.M., "Use of Ozone and Oxygen in Advanced Wastewater Treatment," 45 *Journal of Water Pollution Control Federation* 2521, 1973.

Shuyler, Lynn R., *National Animal Feedlot Research Program,* EPA-R2-73-157, February 1973.

"Solid Waste Disposal," 78 *Chemical Engineering* 155-159, June 21, 1971.

Spore, Robert L., "Economic Problem of Coal Surfacing Mining," 2 *Environmental Affairs* 685-693, 1973.

Teller, Aaron J., "Air Pollution Control," 79 *Chemical Engineering* 93-98, May 8, 1972.

Ventre, Gerard G., and Kenneth E. Case, "Control and Abatement of Transportation Noise," 10 *Transportation Journal* 54-9, Summer 1971.

"Water Pollution Control," 78 *Chemical Engineering* 65-75, June 21, 1971.

Wesler, J.E., "Surface Transportation Noise and Its Control," 23 *Air Pollution Control Association Journal, No. 8, 701-703, August 1973.*

Witt, Philip A., Jr., "Solid Waste Disposal," 79 Chemical Engineering 109-113, May 8, 1972.

Wukasch, Ronald F., "The Dow Process for Phosphorus Removal," Federal Water Pollution Control Administration, Phosphorus Removal Symposium, Chicago, 1968.

Anderson, Kent, *Some Implications of Policies to Slow the Growth of Electricity Demand in California,* Rand Corporation, Santa Monica, 1972.

Baxter, William F., and Lillian R. Altree, "Legal Aspects of Airport Noises," 15 *Journal of Law and Economics* 1-113, April 1972.

Dales, John Harkness, *Pollution, Property, and Prices,* University of Toronto Press, Toronto, Canada, 1968.

Doctor, R.D., *The Growing Demand for Energy,* Rand Corporation Paper, P-4759, January 1972.

Doctor, R.D., and K.P. Anderson, *California's Electricity Quandry, III, Slowing the Growth Rate,* Rand Corporation, Rand Report, R-1116 Santa Monica, January 1972.

Environmental Control Ordinance, Ch. 17 of the Municipal Code of Chicago, §17-2.5 (3) (a), adopted April 1970, effective July 1, 1970.

Ferrar, Terry A., "Progressive Taxation as a Policy for Water Quality Management," 9 *Water Resources Research,* No. 3, 563, 1973.

Ferrar, Terry A., and Andrew Whinston, "Taxation and Water Pollution Control," 12 *Natural Resources Journal* 307-17, 1972.

Freeman, A. Myrick III, and Robert H. Haveman, "Residual Charges for Pollution Control: A Policy Evaluation," 177 *Science* 322-29, July 28, 1972.

Gerber, Jeffry C., and Peter W. Kitson, "Compulsory Licensing of Patents under the Clean Air Act of 1970," 3 *Environmental Law* 33, No. 1, Spring 1973.

Gerhardt, Paul H., "Incentives to Air Pollution Control," 33 Law and Contemporary Problems 358-68, 1968.

Hagevik, George, "Legislating for Air Quality Management: Reducing Theory to Practice," 33 Law and Contemporary Problems 369-98, 1968.

Howe, Richard S., John G. Morris, and H.W. Poston, *Laundry Detergents and Environmental Quality,* May 1973.

Kramon, James M., "Inverse Condemnation and Air Pollution," 11 *Natural Resources Journal,* No. 7, 148-161, 1971.

Larsen, Thomas A., "Federal Regulation of Strip Mining," 2 *Environmental Affairs* 533-561, 1972.

McFarland, W.E., "Strategies in Water Quality Control," 12 *Natural Resources Journal* 318-29, 1972.

McGeorge, Robert L., "Approaches to State Taxation of the Mining Industry," 10 *Natural Resources Journal* 156-70, January 1970.

Mierzejewski, Edward A., "The Economics of Transportation Control Strategies for Reducing Air Pollution," 44 *Traffic Engineering,* No. 1, 22-28, October 1973.

Mutch, James, *The Potential for Energy Conservation in Commercial Air Transportation,* Rand Corporation, Santa Monica, 1973.

Note, "Environmental Considerations: New Arguments for Large Lot Zoning," 7 *Urban Law Annual* 370-380, 1974.

Note, "Land Quality: The Regulation of Surface Mining in Wyoming," 9 *Land and Water Law Review* 97-132, 1972.

Note, "Phased Zoning: Regulation of the Tempo and Sequence of Land Development," 26 *Stanford Law Review* 585-617, Fall 1974.

Note, "Phosphate Detergent Regulation," 7 *Urban Law Annual* 381-9, 1974.

Note, "Public Trust in Public Waterway," 7 *Urban Law Annual* 219-46, 1974.

Note, "Validity of Zoning an Entire Community Residential," 7 *Urban Law Annual* 304-310, 1974.

Page, Talbot, "Failures of Bribes and Standards for Pollution Abatement," 13 *Natural Resources Journal* 677-704, 1973.

Pen, J., "Seven Methods of Anti-Pollution Policy: An Essay in Taxonomy," *Economic Quarterly Review,* No. 24, 5-12, March 1971.

Permar, David H., "A Legal Solution to the Electric Power Crisis: Controlling Demand Through Regulation of Advertising, Promotion, and Rate Structure," 1 *Environmental Affairs* 670-693, 1971.

"Phosphate Control," *Fifth Annual Report on the Council on Environmental Quality,* 288-290, December 1974.

Renshaw, E.F., "Should the Federal Government Subsidize Industrial Pollution Control Investments?" 1 *Journal of Environment Economics and Management,* No. 7, 84-88, May, 1974.

Rose, J.B., "Proposal for the Separation and Marketability of Development Rights as a Technique to Preserve Open Spaces," 51 *Journal of Urban Law* 461-89, Fall 1974.

Sax, J.L., and J.F. DiMento, "Environmental Citizen Suits: Three Year's Experience Under the Michigan Environmental Protection Act," 4 *Ecology Law Quarterly,* No. 1, 1, Winter 1974.

Selig, Edward I., "Effluent Charges on Air and Water Pollution: A Conference Report," Environmental Law Institute, Washington, D.C., October 1971.

Strong, Ann L. and John C. Keene, *Environmental Protection Through Public and Private Development Controls,* EPA-R5-73-018, May 1973.

Ticer, Wilmer R., "Comments, Legal Methods of Eliminating Certain Undesirable By-Products of the Air Transportation Industry," 11 *Natural Resources Journal,* No. 1, 177-89, 1971.

Tihansky, Dennis P., *A Cost Analysis of Waste Management in the Steel Industry,* Rand Corporation, Santa Monica, January 1972.

Wilkerson, R.R., "Tools for a Land Use Guidance System," 62 *Landscape Architecture* 122-23, January 1972.

Bower, Blair T., and Walter O. Spofford, "Environmental Quality Management," 10 *Natural Resources Journal* 655, 1970.

Carter, Steve, Murray Frost, Claire Rubin, and Lyle Sumek, *Environmental Management and Local Government,* EPA-600/5-73-016, February 1974.

Comptroller General of the United States, *Assessment of Federal and State Enforcement Efforts to Control Air Pollution from Stationary Sources,* EPA Report to the Congress, August 23, 1973.

Downing, Paul B., and William D. Watson, Jr., *Enforcement Economics in Air Pollution Control,* EPA-600/5-73-014, December 1973.

Freeman, A. Myrick III, and Robert H. Haveman, "Water Pollution Control, River Basin Authorities, and Economic Incentives: Some Current Policy Issues," 19 *Public Policy* 53-74, 1971.

Haefele, Edwin T., *Representative Government and Environmental Management,* Johns Hopkins Press, Baltimore, 1973.

Mandelker, Daniel R., *The Zoning Dilemma,* Bobbs-Merrill, Indianapolis, 1971.

Panton, James E., and John C. Meyer, Jr., "Expanding the Role of Local Police in Environmental Protection," 2 *Environmental Affairs* 358-364, 1972.

Pollack, Lawrence W., "Legal Boundaries of Air Pollution Control—State and Local Legislative Purpose and Techniques," 33 *Law and Contemporary Problems* 331-57, 1968.

Ranney, David, C., *Water Quality Management: An Analysis of Institutional Patterns,* University of Wisconsin Press, Madison, 1972.

Sewell, W.R. Derrick, "Broadening the Approach to Evaluation in Resources Management Decision-Making," 1 *Journal of Environmental Management* 33-60, 1973.

APPENDIX A

Physical Methods

The list of illustrative physical methods provided below is categorized by source activity and point(s) of introduction into the Residuals Generation/Discharge Process (See Figure V-1).

It is useful to visualize each source category as a "production process" having inputs and outputs. The outputs are goods and services desired and non-product outputs which include intermediate products and residuals. These residuals must be "disposed" or thrown away. Physical methods for reducing or eliminating the discharge of these residuals are the focus of this Appendix. Readers are encouraged to prepare their own list of physical methods for dealing with particular problems they face. The source activity categories used correspond with the standard systems for identifying and coding land use activities with the following exception.[1] For the purposes of this report, category 4—Transportation, Communication, and Utilities—has been divided into two categories: a) Transportation and b) Utilities and Communications. This modification was made because Transportation and Utilities are both major residual source categories. Further, the source activity of collective residuals handling and modification is included under Utilities and Communication.

The standard system has nine categories and the one- and two-digit levels are reproduced below.

TABLE A-1

Code	*Category*	*Code*	*Category*
1	Residential.	11	Household units.
		12	Group quarters.
		13	Residential hotels.
		14	Mobile home parks or courts.
		15	Transient lodgings.
		19	Other residential, NEC.[1]
2	Manufacturing.	21	Food and kindred products—manufacturing.
		22	Textile mill products—manufacturing.
		23	Apparel and other finished products made from fabrics, leather, and similar materials—manufacturing.
		24	Lumber and wood products (except furniture)—manufacturing.
		25	Furniture and fixtures—manufacturing.
		26	Paper and allied products—manufacturing.
		27	Printing, publishing, and allied industries.
		28	Chemicals and allied products—manufacturing.
		29	Petroleum refining and related industries.

3 Manufacturing (continued).	31 Rubber and miscellaneous plastic products—manufacturing.
	32 Stone, clay, and glass products—manufacturing.
	33 Primary metal industries.
	34 Fabricated metal products—manufacturing.
	35 Professional, scientific, and controlling instruments; photographic and optical goods; watches and clocks—manufacturing.
	39 Miscellaneous manufacturing, NEC.
4 Transportation, communication, and utilities.	41 Railroad, rapid rail transit, and street railway transportation.
	42 Motor vehicle transportation.
	43 Aircraft transportation.
	44 Marine craft transportation.
	45 Highway and street right-of-way.
	46 Automobile parking.
	47 Communication.
	48 Utilities.
	49 Other transportation, communication, and utilities, NEC.
5 Trade.	51 Wholesale trade.
	52 Retail trade—building materials, hardware, and farm equipment.
	53 Retail trade—general merchandise.
	54 Retail trade—food.
	55 Retail trade—automotive, marine craft, aircraft, and accessories.
	56 Retail trade—apparel and accessories.
	57 Retail trade—furniture, home furnishings, and equipment.
	58 Retail trade—eating and drinking.
	59 Other retail trade, NEC.
6 Services.	61 Finance, insurance, and real estate services.
	62 Personal services.
	63 Business services.
	64 Repair services.
	65 Professional services.
	66 Contract construction services.
	67 Governmental services.
	68 Educational services.
	69 Miscellaneous services.

7	Cultural, entertainment, and recreational.	71	Cultural activities and nature exhibitions.
		72	Public assembly.
		73	Amusements.
		74	Recreational activities.
		75	Resorts and group camps.
		76	Parks.
		79	Other Cultural, entertainment, and recreational, NEC.
8	Resource production and extraction.	81	Agriculture.
		82	Agricultural related activities.
		83	Forestry activities and related services.
		84	Fishing activities and related services.
		85	Mining activities and related services.
		89	Other resource production and extraction, NEC.
9	Undeveloped land and water areas.	91	Undeveloped and unused land area (excluding noncommercial forest development).
		92	Noncommercial forest development.
		93	Water areas.
		94	Vacant floor area.
		95	Under construction.
		99	Other undeveloped land and water areas, NEC.

[1]NEC—Not elsewhere coded.

Physical methods are provided for maintaining ambient water quality for suspended solids and ambient air quality for airborne particulates and hydrocarbons. These examples illustrate the procedure for relating physical methods with specific problems by source activity, media, and measure of quality.

Methods for Maintaining Ambient Water Quality for Suspended Solids

1. Residential

   A. *Physical Methods* to prevent erosion on construction sites:

   - Minimize areas stripped.
   - Conserve topsoil.
   - Straw bales.
   - Temporary mulching and seeding of all stripped areas to remain open for more than 6 months.
   - Conservation cultivation practices on all steep slopes.

- Traffic control on construction sites, berms and crushed stone on construction roads.
- Temporary diversions on sharply stopping sites.
- Temporary check dams on all waterways draining land under construction.

B. *Physical Methods* to entrap sediment from runoff prior to discharges from construction sites:

- Sediment basins, filter screens, etc.

C. *Physical Method* for final grading and establishing protective vegetative cover:

- Reduce slope length in critical areas with benches and terraces.

D. *Physical Method* to establish protective vegetative cover after final grading:

- Seeding techniques and ground cover for critical areas and steep slopes.
- Sodding of critical areas.
- Organic mulch on seeded areas.
- Hydroseeding and chemical stabilization of critical areas.

E. *Physical Method* for design and stabilize drainage channels to prevent erosion:

- Grass channels.
- Permanent diversions.
- Streambank protection with vegetation, stone, or concrete revetments.

F. *Physical Method* to reduce suspended solids land to treatment facilities:

- Discourage use of garbage disposals.

2. Manufacturing

A. *Physical Methods* to reduce suspended solids discharged from production processes:

- Reduce use of garbage disposal units in food processing.
- Utilize organic residuals for composting.
- Prevent sawdust and wood chips from washing into surface waters.
- Maximize use of savealls in paper making process.
(Note: Savealls are used to recover fiber for recycling because it is economical to do so. In response to pollution control requirements the saveall capacity may be increased to recover fiber beyond the point where it is economically justified from the point of view of paper making process, but is still the least cost way to achieve environmental standards.)
- Process whey (the watery milk solids that's left over from cheese making) into ingredient for animal feeds and as a powdered substitute for non-fat dry milk used in commercial baking. Deans Foods Co. is doing this at their Chemuny, Ill. facility. (See Chicago Sun-Times, Tuesday April 29, 1975, article by Financial Editor.) They are also working on a product made from whey for use in ice creams and puddings and as a vitamin and protein rich ingredient for baby foods.

3. Manufacturing (continued)

A. *Physical Methods* to reduce suspended solids discharged from production processes:

- Sedimentation of water from wet scrubbing of blast furnace flue gas to remove flue dust, followed by thickening of the clarifier overflow with lime to enhance flocculation. This procedure has been found most effective in removing iron oxide and silica. Ninety to 95 percent of the suspended material settles within 1 hour, with an effluent having less the 50 ppm suspended solids.
- Sedimentation to remove suspended solids from reclaimed rubber and synthetic

rubber processes. Suspended solids concentrations range from 1000-24,000 ppm for reclaimed rubber residuals and 60-2700 ppm for synthetic rubber residuals.
- Settling ponds and other appropriate structures for minimizing the suspended material carried away from stone and clay operations.

4. Transportation

Recent investigations by IIT Research Institute in Chicago show that much of the airborne particulate in the city of Chicago (often 70 percent or more) are minerals, mainly calcium carbonate (limestone).
Calcium carbonate comprises much of the soil in the metropolitan area and almost all of its asphalt streets. These mineral particles apparently become airborne by action of auto and truck tires on the pavement. (Ref. letters, Ronald G. Draftz, Senior Scientist IIT Research Institute, Chicago Magazine. May 1975 p. 5).

A. *Physical Methods* to control airborne suspended particulate:

- Improve street cleaning techniques (Note: American Public Works Association and Indiana University currently working on going project, NSF Grant).

4A. Utilities and Communication

A. *Physical Methods* for controlling suspended solids from fossil fuel burning power generation plants. The primary source of suspended solids is the effluent from wet scrubbers used to remove airborne particulates:

- On-site treatment facilities for removing suspended solids—settling basins, etc.
- Discharge wet scrubber effluent to municipal sewer.
  Note: Suspended solids after removal, become sludge (solid residual) that is usually disposed on the land. This is an example of an intermedia problem.

Air		*Water*		*Land*
Particulates	Wet scrubber →	Suspended Solids	Settling basin →	Sludge

5. Trade

N/A usually not a principal source of suspended solids.

6. Services

N/A usually not a principal source of suspended solids.

7. Cultural, Entertainment, and Recreational

This source category is not a major residuals generator. However, in particular situations some recreational activities may require the attention of residuals managers. For example, the control of off-the-road vehicles may be necessary in areas that are highly susceptible to erosion.

8. Resource Production and Extractions

A. *Physical Methods* for controlling water and wind erosion from agricultural activities:

- Tillage alternatives—such as no-tillage or zero tillage, ridge plant, till plant, strip tillage, sweep tillage, chisel planter, listing, plow plant, wheel-track plant.
- Terraces—generally applied to fields where contouring, stripcropping, and tillage operation do not offer adequate soil protection.
- Diversions—large, individually designed terraces, constructed across the slope to intercept and divert excess runoff to a stable outlet.

- Stripcropping—breaks length of the slope up into segments by laying out strips across natural slope of the land. Strips of close-growing crops or meadow grasses are planted between tilled row crop strips to serve as sediment filters or buffer strips.
- Contouring—tillage operations performed in a direction perpendicular to the slope of the land.
- Grassed waterways.
- Pipe outlets.
- Crop rotation.
- Cover crops.
- Other methods—trees, shrubs, grasses, and man-made structures may be required to deal with severe erosion problems.
  Structural measures include drop spillways, box inlet spillways, chute spillways, sod flumes, and debris basins. These structures supplement sound conservation methods, reduce grade in water courses, reduce velocity of flowing water, trap sediment and reduce peak water flows.
- Range and pasture management—methods such as rotation grazing, seasonal grazing and range revegetation.
- Establish and maintain vegetative or non-vegetative cover to protect the soil.
- Produce or bring to the soil surface, aggregates or clods large enough to resist the wind forces.
- Roughen the land surface to reduce wind velocity and trap drifting soils.
- Reduce field width along the prevailing wind direction by establishing wind barriers or traps strips at intervals to reduce wind velocity.
- Level or bench the land, where economically feasible, to reduce effective field widths and erosion rates on slopes and hilltops where wind forces are maximum.

B. *Physical Methods* to minimizing suspended solids from animal wastes:

- Maintain an adequate land-to-livestock ratio. Avoid concentration of animals that will create holding areas instead of grazing areas.
- Maintain a highly productive forage on the land to retard runoff, entrap animal wastes, and utilize nutrients.
- Plan a stocking density and rotation system of grazing to prevent overgrazing and erosion.
- Locate feeders and waterers a reasonable distance from surface waters. Move them frequently enough to prevent erodible paths.
- Provide adequate land absorption area downslope from feeding and watering sites, preferably with a filter strip of lush forage, growth between site and stream.
- Limit access to surface waters. Use fencing to keep livestock from entering critical stream reaches.
- Provide adequate shade to lessen need for animals to enter water for relief from heat.

C. *Physical Methods* for controlling sediments from silvicultural activities. Sediment can be most effectively controlled when all factors in the silviculture and harvest system are systematically planned with soil and water management to prevent soil erosion:

- Select harvest systems based on forest type and terrain.

D. *Physical Methods* for controlling sediment and erosion from mining activities:

9. Undeveloped Land and Water Areas

A. *Physical Methods* for erosion control from construction activity:

- Surface roughening such as scanfication and the use of serratal slopes.
- Interjection and diversion structures such as dikes, ditches, terraces and benches.
- Vegetative stabilization.

B. *Physical Methods* for sediment control from construction activity:

- Vegetation control practices such as natural buffers, installed vegetative buffer, contour strips, sod inlet filter.
- Structural control practices such as gravel inlet filter, sediment traps, sediment basins, and diversion structures. Specialized sediment control techniques such as channel relocation and water treatment.

Methods for Maintaining Ambient Air Quality for Airborne Particulate[2]

1. Residential

A. *Physical Methods* for controlling residential areas:

- Concentrate new development at densities which allow for measures to reduce emissions per capita—increasing multi-family housing (as opposed to detached units), and carefully locating new sources may result in reduced emissions per capita through economies of scale providing increased feasibility for new control equipment, as well as increased operating efficiencies.
- Exclude new sources from selected hot spots—areas which have been designated as high areas of pollution should be excluded from any consideration of new development that might further degrade the ambient air quality of the region.
- Control existing uses—control of particulate emissions from individual sources can still leave "hot spots" resulting from accumulated emissions from current activities. Zoning and land use controls afford only limited opportunity for removing such residuals.
- Orientation of buildings and windows—a modification of the designed building and window orientation can effectively reduce heating and air conditioning demand from 2 to 5 percent.

B. *Physical Methods* for controlling residential energy consumption:

- Increase fuel costs—higher cost of fuel would force consumers to conserve but the regressive nature of such costs to individuals with low incomes should be considered.
- Control room temperature for air conditioning and heating—central air conditioning represents over 25 percent of the annual residential electrical power consumption.

  Realizable savings from reduction of the thermostat set-point is about one to two percent for each degree of reduction. Hittman cites a Honeywell study showing that setting the thermostat back from 75^{0} to 68^{0} for eight hours each night would result in an 11 percent savings in heat requirements in the Baltimore region.
- Control room temperature for heating and air conditioning—see particulates, domestic and commercial heating.
- Ration electricity—growth plans for Baltimore Gas & Electric Company (BG & E), as filed with the FPC, show a substantial decline between 1973 and 1975 in electricity to be generated in the AQCR. After 1975, however, energy consumption for satisfying generation requirements is projected to increase from about 3 to over 10×10^{3} BTU by the 1985 date.

  As a last recourse, rationing of electricity could be employed on a scheduled diurnal basis or in periods of usage such as during the summer air conditioning season.

C. *Physical Methods* for improving residential energy consumption efficiency:

- Improve domestic building insulation—improving the building code specifications for insulation of domestic structures would bring about a substantial saving in BTU's.
- Reduce transmission losses—by improving transmission insulation and using higher voltage levels a greater percentage of generated electrical power would not be lost through transmission. This in turn would cause less demand on power generation.

- Improve efficiency of electrical appliances—appliances are becoming more energy consumptive. For example, "Frostless" refrigerators consume 30 percent more energy than do manual models. Surely the energy crisis has shown the need for energy efficient appliances.
- Diurnal room temperature—a substantial savings in fuel demand could be gained by introduction of diurnal room temperature.
- Improve furnace design—increasing the efficiency of furnace combustion by improving design specification could have an overall effectiveness of from 5 to 10 percent.
- Improve maintenance of heating system—building codes if amended to include more frequent inspections of heating systems to enforce a higher degree of efficiency could realize a 5 to 10 percent effectiveness.
- Modify pilot light—pilot lights in gas appliances annually use eight percent total gas consumed. Substituting electrical ignitors for pilot lights, together with better overinsulation, could save 20 to 30 percent of the energy consumption of a gas kitchen range.
- Design home heating and air conditioning system as a unit—a greater percentage of efficiency is obtained by use of a bi-modal climate control unit as a means of home temperature control. A 2 percent range of effectiveness is possible with such systems.

D. *Physical Methods* for improving residential energy particulate emissions:

- Reduce ash content of fuel—see particulate control, domestic and commercial heating.
- Convert to clean fuel—the simplistic approach is to convert all generation from coal and heavy oil to natural gas. However, because of the energy crisis, there is not enough gas or oil to meet today's energy requirements and utilities are requesting a change back to coal.

2. Manufacturing

A. *Physical Methods* for controlling manufacturing areas:

- Regulate timing of new development—a group of controls can be utilized to regulate this timing of new development. This becomes significant in its relationship to the scheduling of transportation and other public improvements and of the predicted time of effectiveness of other air quality maintenance measures.
- Limit use in areas or time to even out demand—See Ration electricity.
- Exclude high pollutant sources from AQMA—See Particulates, stationary sources.
- See Residential—Exclude new sources from selected hot spots.
- See Residential—Concentrate new development at densities which allow for measures to reduce emissions per unit.
- See Residential—Control existing uses.

B *Physical Methods* for controlling the manufacturing process:

- Improve collection efficiency—See Particulates, power plants.
- Install control devices on small combustion units—the effectiveness of implementing this program ranges from 50 to 100 percent depending on the degree to which it is enforced. Changing the design specifications to modify units with control equipment would be the most effective method of implementation. An alternate approach is the addition of a "black box" such as a high efficiency cyclone or main baghouse.
- Modify production hours—a decrease in the production hours per week through

local ordinances would force an industry to shorten work shifts to match output. The loss of income for the workers would probably outweigh the benefits derived through possible 2 percent effectiveness range.

- Modify raw material inputs—improving raw material specifications in industrial processing would have a potential range of effectiveness of from 2 to 5 percent. Selection of raw materials of high grade which will produce less residuals during process should be used.
- Recycle residuals back into production process—residuals which are a byproduct of the industrial process in many cases with the aid of control equipment can be recycled back into the industrial process for reuse. In some instances this represents a savings to the industry of raw materials that without recycling are lost in the process.

  An emission charge is one form of incentive for industry to recycle residuals.
- Improve product efficiencies—See Particulates, power plants.
- Modify production output—See Modify production hours.

C. *Physical Methods* for controlling manufacturing energy use:

- Increase electric rates for large users—restructuring the rate scale for large users could have an effectiveness rate of from 2 to 5 percent.
- Reduce ash content of fuel—processing of fuel to reduce the amount of ash content would reduce the amount emitted during ignition.
- Reduce demand for industrial products—by far, the most significant sources of particulates in the Baltimore AQMA are the industrial process emissions. Furthermore, additional industrial sources are not easy to identify, quantitate, or control. As discussed, the background levels of particulates ranges around 40 $\mu g/m^3$; therefore, only about 20 $\mu g/m^3$ of air quality are available to disperse and dilute emissions in the Baltimore metropolitan area.

  Assuming that the emission inventory missed some of the sources, or assuming that the pollution sources discharged more than is credited, the control measures may or may not achieve the goal of maintaining the NAAQS.

  Industrial sources accounted for 55 percent of the total particulate emissions in the Baltimore AQMA in 1973. In the study reported on herein, it was projected that in 1985 industrial sources would still account for 50 percent of the total. To further reduce these process emissions will require application of more stringent emission standards. The Environmental Protection Agency is developing New Source Performance Standards for various classes of industry which will require application of the best available control technology.

  To carry out a more thorough analysis of the potential control for industrial process emissions would require an analysis specific by industry class. In this AQMA, it also would be possible to look carefully at the major industrial sources when the final AQMP is prepared.
- See Residential—Increase fuel costs.
- See Residential—Improve efficiency of electrical appliances.
- See Residential—Ration electricity.
- See Residential—Convert to clean fuel.
- See Residential—Reduce transmission losses.

3. Manufacturing

A. *Physical Methods* for controlling manufacturing processes:

- See 2 Manufacturing—Reduce demand for industrial products.

B. *Physical Methods* for controlling manufacturing particulate emissions:

- Improve control equipment—The EPA has promulgated "New Source Performance Standards for Power Plants" above a certain size. In establishing the emission limits, EPA utilizes the best available control technology which can be demonstrated to the industry. Because any new plant of BG&E will have to comply with the NSPS, it would not appear that this control measure offers much hope of reducing emissions from power plant stacks below the limits now specified by EPA. The technology might be promoted to increase collector efficiencies even further; however, its application in the 1975-1985 time frame is doubtful.
- Improve collection—See Improve control equipment.
- Increase actual stack height—use of tall stacks tends to decrease ground level concentrations of suspended particulates. The effective height of the effluent plume from a power plant depends on physical stack height as well as the temperature and velocity of the exhaust gases. Generally not much improvement will be made to an existing plant to change stacks or stack conditions; however, design specifications on new plants can be useful in achieving the desired end result.
- Increase effective stack height—See Increase actual stack height.
- Utilize intermittent control with weather conditions—depending upon weather conditions further controls will be used when probable alerts are predicted or increasing concentrations are monitored.

Transportation

A. *Physical Methods* for controlling transportation:

- Utilize daylight savings time—Congress passed legislation this past winter which made daylight savings time mandatory year round until 1975. The percent range of effectiveness ranges from 1 to 2 percent.

  Congress recently passed legislation that will reinstate standard time on a limited basis. This action was taken due to the hazards to school children traveling in early morning darkness.
- See Residential—Increase fuel costs.
- See Residential—Exclude new sources from selected hot spots.
- See Residential—Concentrate development at densities which allow for measures to reduce emissions per unit.
- See Residential—Control existing uses.
- See 2 Manufacturing—Regulate timing of new development.
- See 2 Manufacturing—Reduce demand for transportation.

B. *Physical Methods* for controlling transportation particulates:

  Light duty vehicles, heavy duty vehicles—refer to measures to reduce emissions from light duty vehicles and heavy duty vehicles.
- Control unpaved streets—limiting access as well as speed would be an effective means of controlling unpaved streets which represent a major source of fugitive dust. By implementing a street control program a 25 to 50 percent rate of effectiveness could be obtained. Studies show that dust emissions increase at a rate approximately proportional to increase in vehicle speed and directly proportional to the number of vehicles.
- Limit speed on unpaved roads—See Control unpaved streets.
- Control open body vehicles—large open body vehicles (e.g., dump trucks) carrying full loads of dirt from pick up site to unloading, generate considerable amounts of fugitive dust while in transit. A simple method of curtailing this emission source is to

cover the load with a heavy cloth material such as canvas. Many states already require this by law. This simple inexpensive procedure can have an effectiveness range of 10 to 25 percent.

- Control deposition on roads—material collected on construction vehicles from project sites usually cause deposits to build up on streets as the traffic moves in and out. Automotive vehicles in turn cause a further dispersion of the material and the cycle continues until the deposited material is washed away by rain or the construction is complete. If ordinances were passed that would require these vehicles to be washed down upon leaving the sites a 10 to 25 percent range of effectiveness could be realized.
- See 2 Manufacturing—Limit use in areas or time to even out demand.
- See 2 Manufacturing—Reduce ash content of fuel.

C. *Physical Methods* to increase transportation efficiency:

- Modify tire and brake design wear—this measure requires the implementation of basic and applied research and development programs and should probably be sponsored by the Federal Government.
- See 2 Manufacturing—Install control devices on small combustion units.
- See 2 Manufacturing—Improve product efficiencies.
- See 3 Manufacturing—Improve control equipment.

4A. Utilities—Communication

A. *Physical Methods* to control location of utilities:

- Surround power plants with land use buffers—providing land use buffer zones around power plants would prevent sensitive receptors such as hospital, schools, convalescent homes, etc. from locating too close.
- Move power plants outside of region—the resulting decline of emissions from such a drastic course of action in cases other than those involving marginal operations makes this measure cost prohibitive.
- See Residential—Exclude new source from selected hot spots.
- See Residential—Concentrate new development at densities which allow for measures to reduce emissions per unit.

B. *Physical Methods* to control utility emissions:

- Utilize storage or peak shaving with clean fuel—having the potential to use a clean fuel during demand peaks would significantly alter emission rates. Using hydro electric power from pump storage facilities is one method that could be utilized.
- See Residential—Control existing uses.
- See 2 Manufacturing—Regulate timing of new development.
- See 3 Manufacturing—Generate more power in larger facilities.
- See 3 Manufacturing—Improve control equipment..

5. Trade

A. *Physical Methods* for controlling trade:

- Use total energy systems—utilization of individual electric power producing units for facilities such as shopping centers and utilize by-products such as waste heat for space heating.
- See Residential—Improve commercial building insulation.
- See Residential—Orientation of building and windows.
- See 2 Manufacturing—Reduce demand for trade activities.
- See 2 Manufacturing—Install control devices on small combustion units.

- See 2 Manufacturing—Modify production hours.
- See 2 Manufacturing—Recycle residuals back into produce process.
- See 2 Manufacturing—Modify production output.

6. Service

   A. *Physical Methods* for controlling services:

   - See 2 Manufacturing—Increase electric rates for large users.
   - See 2 Manufacturing—Modify production hours.
   - See 2 Manufacturing—Modify production output.

7. Cultural, Entertainment and Recreation

   A. *Physical Methods* for controlling cultural and entertainment areas:

   - See Residential—Ration-electricity.

   B. *Physical Methods* for controlling recreational areas:

   - See 2 Manufacturing—Limit use in areas or time to even out demand.

8. Resource Production and Extraction

   A. *Physical Methods* for controlling resource production and extraction:

   - Limit agricultural activities during dry weather—control of agricultural activities by local ordinances during dry weather would eliminate a significant amount of fugitive dust during dry warm weather months. The reduction in crop output during extended period of dry weather must be considered.
   - See 2 Manufacturing—Reduce demand for agriculture.
   - See 2 Manufacturing—Modify raw material inputs.
   - See 2 Manufacturing—Recycle residuals back into production process.

9. Undeveloped Land and Water Areas

   A. *Physical Methods* for controlling undeveloped land and water areas.

   - Limit activity on unvegetated lots—telling the local sand lot team they cannot use the ball field would be unrealistic and unpopular, but restriction of lots to off road vehicles should be considered if a 2 to 5 percent effectiveness is to be gained.
   - Eliminate unpaved parking lots—tax incentives would be the more effective program to eliminate unpaved parking lots as fugitive dust generation sites.
   - Plant cover on vacant lots—See Limit activity on unvegetated lots.
   - See Transportation—Limit speed on unpaved roads.
   - See Transportation—Control unpaved streets.

Methoas for Maintaining Ambient Air Quality for Hydrocarbons

1. Residential

   Usually not a significant source of hydrocarbons.

2. Manufacturing

   A. *Physical Methods* for controlling hydrocarbon emissions from printing operations:

   - A solvent recovery system, using activated carbon, can reduce hydrocarbon emissions from rotogravure printing. The hydrocarbons recovered are usually sold to solvent supplies for reprocessing and reuses.

     R.R. Donnelly, Lakeside Press, Chicago, Illinois completed a solvent recovery system in December 1974. Preliminary tests by Donnelly show system recovers about 97 percent of the hydrocarbons that would otherwise be emitted to atmosphere. The capital cost of this system was about $1.7 million dollars. Operating costs are not yet available. The cost of solvents used in the rotogravure process is currently about 50 cents per gallon. Assuming no emissions controls, calculations show that Donnelly would limit about 2.24 million gallons of hydrocarbon per year. If the recovery efficiency is 97 percent and the price of solvents remains 50 cents per gallon, then Donnelly can expect to save approximately $1 million per year. (Source: H.W. Poston, Commissioner, Department of Environmental Control, City of Chicago.)

     NOTE: The effect of rapidly increasing prices for petroleum products may be a major factor in the economics of these recovery systems.

   B. *Physical Methods* for controlling hydrocarbon emissions from chemical processes:

   - Activated carbon systems are used to reduce hydrocarbons emitted from processes producing paints, varnishes, lacquers, enamels, and allied products. Hydrocarbons are then recovered from the activated carbon for reuse.

     Sherwin-Williams Co., Chicago, Illinois installed an activated carbon system to control paracesol emissions from the sulfite oxidizes. A 2-stage jet condenser was installed to control paracesol emissions from vacuum steam jets. The emissions from paracesol manufacturing process created an odor problem. The system was installed in 1974. Tests show the activated carbon system to have an efficiency of 14 percent. And the jet condenses to have an efficiency of 99 percent.
     The capital cost of the system was about $250,000. Operating costs are about 10 cents per pound of paracesol recovered.
     Sherwin-Williams operates 7 days per week. Currently they are recovering approximately 1800 pounds of paracesol per day. Paracesol sold for 60 cents per pound in November 1974. Based on these data, Sherwin-Williams is recovering $6,300 per week or approximately $300,000 per year.
     (Source: H.W. Poston, Commissioner, Department of Environmental Control, City of Chicago.)

   C. *Physical Methods* for controlling hydrocarbon use in other manufacturing:

   - Reduce demand for reactive hydrocarbon solvents—through taxes and fees, a reduction in reactive hydrocarbon solvents could be initiated to reduce emissions from these sources from 25 to 50 percent.
   - Industrial process heating—three other sources of hydrocarbon emissions will, in 1985, produce 5.6 percent of the total hydrocarbon emissions inventory, i.e.,

industrial process heating (3.4 percent), miscellaneous gasoline engines (1.8 percent) and refuse incineration (0.4 percent). The first of these is most difficult to control; significant reduction would entail process changes for individual industrial operations, which could entail a long and difficult procedure with questionable effectiveness.

3. Manufacturing

   Usually not a major source of hydrocarbons.

4. Transportation

   A. *Physical Methods* for controlling hydrocarbons from mobile sources:

   - Methods to reduce emission rates include:

     Retrofit devices:

     Vacuum spark advance disconnect with low idle.
     Air bleed to intake system.
     Oxidation catalysts.

     Inspection/maintenance.

     Gaseous fuel conversion.

     Traffic flow improvements:

     Better highway and interchange design.
     Signal progression.
     One-way streets.
     Reversible lanes.
     Driver advisories.
     Loading regulations.
     Staggered work hours.

   - Methods to reduce vehicle miles travelled include:

     Traffic restrictions:

     Street closings.
     Traffic-free zones.
     Partial traffic restriction.
     Limited access zones.
     Idling restrictions.
     Gasoline rationing.

     Traffic avoidance:

     Restricted road building.
     Urban area bypasses.
     Control of urban development; e.g., strategic planning and planned unit development.
     Four-day work week.

     Mass transit improvement:

     Rapid rail.
     Community rail.
     Improved bus service.
     Reduced mass transit fares.
     Express bus lanes.

     Employee mass transit incentives.

- Measures to increase auto occupancy:
  (1) Parking incentives for car pools—in large employment centers with relatively large parking facilities, parking incentives can increase carpooling and auto occupancy. Parking incentives can take the form of reduced rates, reserved spaces or lots, late arrival or early departures, or a combination of all three.
  (2) Use of express lanes for carpools—express lanes, normally reserved exclusively for buses, can be opened to carpools. This incentive will greatly decrease the travel time for the carpool, thus encouraging higher auto occupancy rates.
  (3) Tax and insurance incentives for carpools—monetary incentives, such as tax reductions and insurance premium reductions act to increase auto occupancy.

Each of these measures can be expected to only have minimal effect on auto occupancy. Each taken separately would likely have an effectiveness of 0-2% reduction in VMT; collectively, they might reach as high as 2% reduction in LDV VMT. When combined with other measures to reduce VMT, a 1% effectiveness could be expected.

- Measures to reduce emissions per mile—episodic control on automobile travel. Enforcement of periodic bans on auto travel would reduce automobile travel during episodes of high pollution. This measure would be very effective although there are obvious economic problems and enforcement questions. Like other episodic measures, this is regarded as an available supplementary tool to be applied in the event that other measures are not adequate to solve the problem.
- A system of auto stickers which indicate the essential nature of travel based on occupation, family size, and other factors would assist in the enforcement of partial bans on driving. A truly arbitrary odd-even ban on driving could also be instituted during air pollution episodes.
  Emergency holidays for public employees. The use of emergency holidays for public employees would reduce the a.m. peak travel in direct proportion to the government employment. In areas of major public employment, such as Baltimore, this would be extremely effective. (There were an estimated 156,000 public employees in the region of a total employment of 869,800, or about 18% in 1970.)
  As with the public employees, provision of emergency holidays for private employees would directly decrease emissions during episodes.
- Optimize routes and schedules—care in the selection of truck routes and schedules for deliveries could eliminate wasted mileage and avoid congested, stop-and-go traffic. The responsibility for implementation of this measure lies chiefly on private business, but they could be assisted by better definition of truck routes on the part of local and regional agencies.

B. *Physical Methods* to reduce traffic congestion:

Cities presently employing the particular method are listed following the physical method.

• Traffic-free zones	Over 100 worldwide cities, including Tokyo, Vienna, Essen, Leeds, The Hague, Oldenburg, Munich, Athens, Bologna, Brussels, Florence, Ravenna, Rouen, Rome, and Verona

• Partial traffic restriction by *erecting physical barriers to* subdivide the center city	Approximately 24 U.S. cities, including New York City (temporary), Atchison, Fresno, Kalamazoo, Miami Beach, Minneapolis, and Providence
• Partial traffic restriction by *erecting physical barriers* to subdivide the center city	Bremen, Goteborg, Bologna, Liverpool
• Idling restrictions	Stockholm
• Parking ban in central city	Marseilles
• Parking supply management	Bologna, Newcastle, Hamburg, The Hague, London, and Glasgow
• Improved mass transit service	Seattle, Atlanta
• Reduced mass transit fares	Atlanta, St. Louis
• Exclusive bus/carpool lanes	Metropolitan New York (Long Island Expressway, I-495 in New Jersey), Boston (Southeast Freeway), Washington, D.C. (I-95), San Francisco (Bay Bridge toll booths)
• Entry tolls and permits for center city	London
• Urban area bypasses	Most major U.S. cities
• Staggered work hours	New York, Munich, Cologne, Bonn

C. *Physical Methods* to reduce motor vehicle emissions from individuals transportation controls:

Implementation time and estimated percentage reductions in motor vehicle emission follow the physical method listed.

• Inspection/ maintenance	2-5 years	4 to 15
• Retrofit	2-5 years	10 to 60 for those vehicles retrofitted
• Gaseous fuel systems	2-5 years	Less than 15
• Traffic flow techniques	2-5 years	Less than 20 in area affected
• Bypassing through traffic	5-10 years	Less than 5
• Improvements in public transportation	5-10 years	Less than 5
• Motor vehicle restraints	5-10 years	5 to 25 in area affected
• Work schedule change	10-20 years	Less than 3
• Control of urban development	10-20 years	Not estimated

Source: Institute of Public Administration, Teknekron, Inc., and TRW, Inc. Evaluating Transportation Controls to Reduce Motor Vehicle Emissions in Major Metropolitan Areas. Environmental Protection Agency. Research Triangle Park, North Carolina. Publication No. APTD-1364. November, 1972.

D. *Physical Methods* to control hydrocarbons from airplanes:

- Control aircraft emissions—measures for the reduction of hydrocarbon emissions from aircraft beyond the emission reductions proposed by EPA for 1979 and 1981 are limited. The most significant measures involve:
  (1) Reduction of flights.
  (2) Use of larger, cleaner aircraft.
  (3) Reduction of ground maneuvers.
  (4) Control of non-aircraft ground sources.
- Reduce low speed running of engines—changes in procedures to limit emissions resulting from ground maneuvers are currently being introduced in airports around the country. These changes involve such measures as taxiing on two or less engines, towing of aircraft by ground vehicles, reduction in engine "run-ups," elimination of non-essential taxiing operations and introduction of mobile lounges. It is estimated that these measures could result in a reduction of 10 percent in hydrocarbons emitted by aircraft on the ground, which is approximately 15 percent of the total emitted by aircraft at BWI.
- Reduction in emissions due to ground equipment—the ground equipment and airport-generated vehicular traffic together generate approximately 30 percent of all pollutants at the airport; this can be reduced by the following methods:
  (1) Installation of control devices on fuel-handling equipment at the airport to prevent spills and evaporation.
  (2) Limitation on movements of ground support vehicles.
  (3) Limitation on access to the airport by automobiles.

  Of these methods, the last could be substantially improved when the proposed rail transit connection to the airport comes on line. The effectiveness of these measures is estimated at 20 percent for this category.

E. *Physical Methods* to control hydrocarbons from diesels and shipping:

- Controls on diesel and shipping—See Heavy duty vehicles.
- Reduce demand on diesel and shipping—the growth of the trucking and shipping industries and the lack of controls on diesel engines accounts for the increased share of hydrocarbons emissions attributable to these sources (1.9 percent in 1972 to 5.5 percent in 1985) even though the increase in tons per three hour a.m. peak increases at a lesser rate (1.01 in 1972 to 1.35 tons in 1985). Any policy which would reduce the requirement for the transportation of goods to the region or within the region would in turn reduce the demand for the operation of diesel-powered engines and thereby reduce the hydrocarbon emissions.

  One means of furthering this objective is through land use controls which keep transportation terminals and industrial/commercial users of diesel transportation in proximity to each other. These are, of course, basic economic factors acting to bring this about—the concentration of industry and warehousing in the harbor area is an example—but proper provision in the land use plan can ensure that the market has no problems in finding optimum locations which will reduce diesel vehicle miles travelled. This measure can be expected to reduce hydrocarbon emissions by a small amount.

- Reduce emissions from diesel engines—during the past decade, diesel engines have not been subject to emission control devices in the same way as gasoline powered engines because of their rather small share of the total emissions. That share will become significant by 1985, as emissions from other sources are reduced. It is estimated that the introduction of new emission standards on all new diesel-powered trucks, and on other diesel engines in the Baltimore region (or any urban area), could reduce hydrocarbon emissions from those sources by up to 50 percent.
- Relocate truck traffic from region—diesel truck and bus movements through the region, while producing only a small part of the diesel and shipping emissions, could be reduced by the construction of a circumferential highway around the region. This factor is addressed under the transportation policies described for "automotive" sources. It is estimated that this measure, which could have significant side effects in terms of inducing more travel in areas adjacent to the region and which obviously presents some critical planning and cost questions, would have small impact on diesel VMT and it would not be justified on the basis of this scale of impact. This approach was, therefore, not considered in assessing the degree to which this category of emissions can be reduced.
- Episodic controls—while not considered viable as a strategy to reduce total emissions, episodic ban on non-essential truck travel has the potential to reduce the hydrocarbon emissions from diesel trucks by an estimated 80 percent during critical periods. A ban of this kind would exclude emergency and "essential" vehicles and would allow for travel through the region.

F. *Physical Methods* to reduce use of automobile:

- Measures to reduce automobile ownership—second and third car ownership is a variable in the determination of modal split and travel demand. If second and third car ownership can be curtailed, total VMT can also be reduced. Auto ownership could be made more expensive by applying additional tax on new vehicles, either in the form of an excise tax on purchases, a tax on registration through registration fees, or a tax directly on the ownership through personal property tax increases. Each of these methods, if on the order of $500 to $1000 per vehicle per year would discourage second car ownership and marginal car ownership. Assuming that this expense would induce a response similar to that forecast in the I-66 study in suburban Washington, D.C. through a $2.00 per day parking tax (a comparable additional annual levy on the automobile owner), a five to ten percent reduction in VMT could be expected.
- Measures to reduce total automobile travel—a prime means of reducing hydrocarbon emissions is to reduce the total amount of automobile travel occurring daily in the region. There is a range of measures and policy instruments available to contribute to such a reduction, some of which, it will be noted, result in a decrease in *all* vehicle travel, including heavy duty and diesel vehicle travel. Such measures include:
- Divert auto passengers to public transportation:

  (1) Major improvements in level of transit service—improvements to the level of transit service have been shown to be effective in increasing ridership. By

improving the reliability of the service, by increasing the frequency of operation, and by improving comfort and safety, increases in transit ridership may be attained. New lines (bus and rail), more vehicles and drivers, more comfortable vehicles, scheduling more responsive to the needs of the riding public, innovative scheduling techniques (such as Dial-a-Bus), new technologies, and other additions to the service provided can make the transit system more attractive than the automobile for certain types of travel. Busways and exclusive bus lanes can also help to make bus transit as fast as automobile travel.

Many cities have improved transit facilities by expanding service or by providing better facilities for that service. Washington's Shirley Highway busway has resulted in substantially more frequent, more rapid service which has resulted in increased ridership and reduced traffic in the Shirley Highway corridor. Busways in use in other cities have similarly helped to speed transit routes and increase ridership. The recent I-66 study, previously referred to, suggested a five to six percent increase in modal split in favor of transit. Baltimore has already programmed a large public investment in improved transit. The Phase I, 28-mile Metro system will begin operation some time during the period under study. A Phase II expansion tripling the size of the initial system is also under consideration. Plans are under study to orient the bus system around the rail lines to act as feeder collector-distributor lines. These improvements should increase regional transit usage. Other improvements are possible, including additional rapid rail lines and particularly, an extensive additional system of bus routes. New technologies may also be explored. Local distribution systems could be integrated with the rail rapid system in existing centers and in the new centers of activity which are proposed for the transit corridors.

Experiences in other cities indicate that improvements to bus systems of the type discussed above may result in increases in ridership of 10 to 25 percent. This reflects possible reductions in automobile VMT of five to ten percent. In order to determine more accurately the results of any massive changes in the Baltimore region transit system, existing BREIS-related transportation models should be used. By establishing a specific improved transit system in combination with other policies discussed in this report, an application of the BREIS models could determine the resulting increase in transit usage. Several alternative levels of improvement might be tested to determine the most effective program of improvements. For the present study, the five to ten percent reduction in VMT will be used as a measure of effectiveness.

(2) Reduce public transportation fares—Another method of attracting additional ridership to mass transit and hence away from the automobile is the reduction in the cost of the transit trip. By reducing the fare to some lower level, perhaps to zero, persons planning trips may be induced to make them by public transportation rather than by automobile.

The relationship between lower transit fares and ridership has not been well tested. In the past, information on fare increases was generally the only type of data available; thus studies of fare level drops were generally not possible. Few cities have reduced fares. Atlanta dropped fare levels from 35 to 15 cents and experienced a 19% increase in ridership. (A 30% increase in ridership was forecast for reduction to free fares.) Seattle has schieved large increases in ridership within the area served by its free downtown bus service. A further verification of these studies can be noted in the "I-66 Corridor Transportation

Alternates Study" which suggested a six to ten percent increase in the forecast transit modal split with a 50% reduction in transit fares. It should be noted that new riders attracted by fare reductions will not all be former automobile riders, but may to some degree include youths, senior citizens, and others who did not previously travel by automobile.

In Baltimore, transit ridership in the peak hour is forecast in the BREIS report at 20% of total travel. Thus, potential increases are conceivable in transit ridership. However, because of this low level, the reliance upon the automobile is fairly strong and large inducements would be necessary to change these conditions.

This measure would have its maximum effect in reducing VMT if transit fares were reduced to zero and if all new ridership represented individuals who formerly drove an automobile. Under these extreme conditions, if the 30% ridership increase forecast for Atlanta with free transit could be achieved in Baltimore, the percentage using transit during the peak hour would increase from 20% to approximately 26%. This would represent a six percent reduction in VMT if all new riders were former auto drivers. If fares were not eliminated totally, or if some of the new ridership were not auto drivers, the reduction in VMT would be smaller.

While this represents a reasonable estimate of the maximum potential effect of reducing transit fares to zero, this measure would be better tested through the application of more sophisticated transportation models. By applying the mode choice models developed for use in the BREIS study, the effect of this measure could be measured using data based on travel behavior in the Baltimore area. Further, other fare reduction policies could be tested and the specific effect of these policies could be better determined. For the purpose of this study, a two to five percent effectiveness will be used.

(3) Increase downtown parking costs—any increase in the cost of downtown parking will increase the out-of-pocket cost of automobile operation. This cost must be made sufficiently high if it is to have a large measure of effectiveness. Parking charges in downtown Baltimore today may reach $500 per year and, while this may deter many, there continues to be a large residual demand from those who consider this tolerable. It is estimated that taxes which increase the cost to around $1,000 per year would be required to bring about an appreciable reduction in VMT.

In the I-66 study forecast modal split increase of six to ten percent in favor of transit with the theoretical imposition of parking costs by $2.00 per day. Raising the cost above $1,200-1,500 per year would be expected to eliminate all but the truly auto-captive person.

- Measures to reduce the number of eligible drivers—reducing the number of eligible drivers by one or a combination of the methods described in the following paragraphs offers an additional opportunity to reduce auto travel. A policy of instituting more stringent and periodic driving tests would work in a number of ways. Periodic testing would have a nuisance factor which would discourage casual and occasional drivers from renewing their licenses. More stringent tests would reduce the number of persons able to drive. These methods have secondary safety implications, though it must be stated that the effectiveness of the measure in reducing automobile travel will be small, certainly in the zero to two percent category in the evaluation matrix.

A more liberal use of license revocation for multiple violations or selected types of violations, would reduce the number of licensed drivers on the road. This would result in an additional minor reduction in automobiles on the road, though it is more likely to be justified on the basis of safety than of air quality.

The current allowable age for drivers license is 16 years of age in Maryland. If the age limit were raised to 18, as in many states, the number of licensed drivers would be reduced in proportion to the number of 16 to 18 year old drivers, thus reducing the total VMT by a proportional amount. Estimates of the proportion of drivers in this age group is 6.2% assuming the drivers in the 16 to 18 to 62 age groups are equal to the total population on those age groups.

- Measures to make highway travel more expensive—introduction of new fees and taxes on travel and fuel can make highway travel more expensive. Any increase in costs associated with auto travel will tend to decrease the amount of auto travel. These charges can take the form of tolls and of taxes on fuel. The impact will be limited to a two to five percent increase in transit modal split resulting from a 50% increase in out of pocket expenses.
- Measures to reduce peak period automobile travel—the a.m. peak period is the most critical to the production of photo-chemical smog because hydrocarbons produced during those hours are subject to maximum exposure to sunlight. Furthermore, meteorological changes occurring at night tend to bring about air mixing and the introduction of clean air. Measures which result in the reduction of hydrocarbon emissions during this part of the day are critical to the maintenance of standards. These include:

  (1) Keep a proportion of vehicles off the road each day—institution of a 40-hour/four-day work week will result in a reduction in total VMT by reducing the total number of work trips per employee per week. Instead of the ten trips per week required under conventional scheduling, only eight per week would be necessary. If the program were implemented fully on a regionwide basis with full staggering of employee working days (the work week for each group being Monday-Thursday, Tuesday-Friday, Wednesday-Saturday, etc.) a reduction of 20% in work trips would occur each day. Because 40% of total peak hour VMT is accounted for by work trips, full implementation would result in a maximum VMT reduction of eight percent. However, it is unrealistic to expect that this maximum can be achieved. Some employers would be unwilling or unable to adopt such a schedule. Further, for those who did, there would be an increase in leisure and other non-work trips by employees such that the net reduction in VMT would be significantly less than eight percent. For Baltimore, the government activities in Towson and the Social Security Center are potential candidates for a four day work week.

  (2) Spread the peak period travel by staggering work hours—while the staggering of work hours itself will not result in a reduction in total daily VMT, changing of starting times such that employees would be making their working trip outside of the peak period could result in a substantial reduction in VMT during the 6:00-9:00 a.m. period. Presently, approximately equal amounts of traffic occur in each hour of the existing three hour period. Thus, about 30% of the work trip traffic could be shifted out of that period without resulting in a mere shifting of the peak period to a different period (7:00-10:00 a.m., for example). Because many of the trips will still occur in the 6:00-9:00 a.m. period, the reduction in work trip VMT would be at best about 25% during the peak period for the largest possible staggering. Because work trip VMT is approximately 40% of total peak period

travel, a reduction of approximately 10% in peak period VMT could occur, assuming full implementation.

This strategy has not to date been implemented for the express purpose of improving air quality, although, on a limited basis, it has been tried by large employers, most notably government agencies, to achieve some relief in peak hour traffic congestion. As in the case of the four day/40 hour work week, major government employers in Baltimore, accounting for about 10% of the regional labor force, would be the most likely leaders in undertaking staggered working hours. If this proportion of the labor force were involved, the maximum reduction in VMT would be approximately one percent, providing that no new non-work trips were undertaken in the peak period, and providing that any resultant relief in peak hour traffic congestion did not induce new automobile work trips to take place.

(3) Initiate centralized carpooling information system—during the winter of 1973-74, energy crisis centralized carpooling systems were instituted in most major cities. These systems matched potential drivers and riders via computer. Although this in and of itself is of small incentive to increase auto occupancy, when coupled with other incentives (parking and fast-leave incentives) and with disincentives, this facilitates carpooling and increases the probability that carpooling will occur. The estimates of effectiveness assume that these instruments are jointly applied.

- Measures to restrict travel in summer months:

(1) Coordinated vacations—it is a recorded fact that a.m. peak VMT drops slightly during the summer months as a result of the concentration of vacation time into this period of the year. If vacations could be restricted so that even more occurred in the 16 week summer period of maximum risk of air quality deterioration, an appreciable improvement can be achieved. Assuming a 40% work. 60% non-work split during peak period; two-week vacation; and 1/4 of the vacationers leave town then a six percent reduction in a.m. peak VMT could be achieved (12.5% x 40% = 5%; 25% x 12.5% = 1.875%; 5% + 1.875% = 6.875%).

(2) Seasonal rationing programs could be instituted to reduce hydrocarbon emissions during the summer months when the photo-chemical reaction is most likely to occur. All three types of rationing discussed above with the listed could be qualifications as to feasibility and effectiveness, applied as part of the program. Transit service should be improved in the summer if a rationing program were instituted. Currently, during the summer months, public transportation service is cut back because schools are closed, passengers are on vacation and because it is the transit employee vacation period. However, this is the period of the year when it is most critical that automobile utilization be reduced to a minimum. A method to encourage maximum use of public transportation would be to maintain and, if possible, enhance levels of service at this time of year.

- Measures to restrict travel year round—year-round fuel rationing may take different forms. Limitation of the amount purchased in a specific period by individual automobile owners is of questionable feasibility on a regional basis because it raises matters of equity with regard to other regions. Other forms of rationing may be more effective. The rationing of fuel to the retailer or wholesaler, similar to the 1973-74 winter allocation program, can do much to reduce travel. The third form of rationing, economic rationing could also reduce travel. This method is, of course, highly regressive because it would be in the form of major gasoline tax increases. Each of these rationing forms would require improvements in alternative modes of transportation if economic disruptions are to be avoided. Rationing will be relatively ineffective unless the rationed area is sufficiently large to discourage driving out of the region to obtain gasoline.

- Measures to make highway travel less convenient and less comfortable—by restricting highway construction and improvement, travel would become less convenient and less comfortable. The demand for travel generally would be lower by restricting the supply of highways within the region, and the amount of travel would be reduced. The traffic projections on which the calculations of air quality were based reflect large increases in the highway network. By reducing the amount of new highway from this level, less travel would result. While there are no data on the effect on travel of closing existing highways, other studies have indicated that the construction of new facilities leads to an increase in traffic over that which would occur without those facilities.

  Plans in the Baltimore region call for the construction of an extensive network of new freeways and major arterials. The "3A System" of Interstate Highways within Baltimore City and the General Development Plan system proposed by the Regional Planning Council represent a major increase in the supply of highways in the region. The effect on travel of nonconstructing either the 3A or GDP systems within the Baltimore Region has been measured as part of the travel simulations performed for the BREIS study. In 1995, four percent less traffic is forecast to occur in the peak hour if the 3A system is not constructed. Alternative 8—the 3A system but not the GDP system—has 12% less peak hour travel than the full network while Alternative 9, neither the 3A nor GDP systems, has 17.8% less travel in the peak period than the full network. Similar percentage decreases in travel would occur in 1985 for each Alternative if the systems are not constructed.

  In order to better measure the effect of a given highway system on regional travel in 1985 for the purposes of this study, the various models run as part of the BREIS study for 1980 and 1995 would have to be run for 1985 given the conditions in effect at that time. The level of transit service available, land use and population considerations, and other policies expected to be in effect at that time would have to be included. The scope and scheduling of the trial maintenance plan do not permit use of this preferred methodology; for the purposes of the current study, it has been assumed that similar percentage decreases in VMT will be attained in 1985 as in 1995. The shortcomings of this assumption are recognized; it may be a liberal estimate of the effectiveness of the measure.

- Measures to reduce gasoline consumption—the amount of fuel burned and the efficiency with which it is burned are both factors in hydrocarbon production. Measures to reduce gasoline consumption and increased efficiency will result in reduced emissions:

  (1) Decrease non-essential accessories—the institution of a heavy tax on accessories would reduce the number of auto accessories and increase the mileage of auto engines. Of prime importance is air conditioning. However, power brakes, power steering, and other secondary users of energy contribute to less effective gasoline use. Many of these luxuries have become regarded as essentials and, again, heavy taxes, perhaps of the order of $500 to $1000 per vehicle would be required to bring about any significant reduction in demand.

  (2) Modify engine type—when electric engined automobiles become a production

reality less energy will be used than gasoline powered automobiles by a factor of approximately 50%. Furthermore, only a portion of the electric power used will be generated by fossil fuel plants and this could well occur outside of the region. Therefore, less hydrocarbon emissions would be involved in powering electric automobiles and much less than this amount would occur in the Baltimore AWMA. One further advantage is that emissions generated per unit of energy at the stationary power plant are easier to control and easier to monitor than are emissions at the automobile exhaust pipe.

G. *Physical Methods* to reduce automobile emissions in hot spots:

- Measures to relocate travel outside of the region—some of the travel in the region is due to traffic originating from and destined for places outside of the region; a decrease in regional hydrocarbon emissions could be achieved by diverting this traffic around the region. Much of this traffic uses I-95. Significant diversion of this through traffic could be accomplished only by the construction of a major interstate roadway to allow total bypass of the AQM region. Although intercepting long trips and therefore, having a relatively large impact on VMT reduction per trip, the percent of through travel is so small during the a.m. peak that this measure would be expected to have minimal impact on total VMT reduction. In fact, it must be stated that the additional accessibility provided to parts of the outlying areas of the region could well result in additional development and additional travel above and beyond that which would otherwise occur. The extent of changes, both in reducing through traffic and in inducing additional travel must remain speculative without systematic testing.
- Measures to promote optimum traffic flow—through highway and signalization improvements, by increasing the average speed, and by reducing the amount of stop and go travel and other inefficiencies in the highway network, the rate of emissions per VMT may be reduced. Programs of this type include various improvements to signalization, intersection design, parking restrictions and roadway improvements and are especially applicable to arterial routes. Also available are various techniques for improving the flow of traffic on freeways such as driver information systems, ramp metering to allow only as many cars on a section of road as can be handled and various projects to improve the configuration of the highway. System-wide changes are also possible such that traffic is assigned to its optimum route by application of these techniques. In this way, a network may be modified to operate as efficiently as possible.

  Programs of this type have been proposed as parts of State Implementation Plans for various cities in the United States. Most cities are also undertaking traffic flow improvements under the TOPICS (Traffic Operations Program to Improve Capacity and Safety) Program. Small scale intersection or roadway improvements generally fall under this program. Cities with extensive freeway systems such as Chicago or Los Angeles have also applied freeway surveillance, driver information systems, and ramp metering in order to increase the efficiencies of these systems.

  In Baltimore, a large commitment to traffic flow improvements is already underway. The EPA-promulgated Transportation Control Plan calls for a decrease of emissions of hydrocarbons of 4.3% of the base year as a result of the application of TOPICS and other flow improvement measures. Considering the existing TCP, it would appear that no further improvements of this type are possible in Baltimore. Thus, the effectiveness of this strategy would be felt throughout the period under a study although as traffic increased, its effectiveness might be reduced.

Any improvement during the period under study could best be tested by a study of any possible areas within the region for improvements. Because of the spot nature of projects of this type, a survey of the region's highway system would be required to determine possible locations for these improvements and a detailed study of each site would be required to determine the amount of improvement that each project could individually accomplish.

H. *Physical Methods* to reduce truck travel:

Measures to reduce total truck travel—as with light duty vehicles, engine running time (therefore, total truck travel), is the prime determinant of hydrocarbon emissions.

- Measures to reduce truck ownership—private and corporate truck ownership can be restricted through the following measures:

  (1) Make truck ownership more expensive by applying additional tax on new vehicles. This may take the form of an excise tax on purchases, a tax on registration through registration fees, or a tax directly on the ownership through personal property tax increases. The level of taxation in mind is $500-$1000 per vehicle. Such charges could result in a small decrease in truck ownership as vehicles are used more efficiently by keeping them on the road for longer hours. The impact on VMT would be even less since most trips involve distribution of goods which must be moved anyway. The savings would be in elimination of less-than-essential trips, but would be marginal since the additional costs, as business expenses would be passed on to the consumer.

  (2) Reduce the number of eligible trucks by instituting a strict vehicle inspection system. This policy instrument would reduce the number of trucks which would be allowed to operate and it would also tend to eliminate older heavy duty vehicles from the inventory.

- Measures to reduce gasoline truck ownership—the application of fees and taxes to HDV would, as with light duty vehicles, increase the cost of owning and operating such vehicles. The impact of this measure would be limited, but it would certainly result in the elimination of some non-essential trips. Although the tendency would be to use trucks more intensively, there would not necessarily be a resulting reduction in VMT. The effect of this policy instrument could be minimal.

  If the taxes and fees imposed were applied to gasoline vehicles only, other types of engines (diesel and electric) would become more attractive. The amount of reduction in hydrocarbon emissions would depend on the type of replacement vehicle used.

- Reduce total HDV VMT—although relatively localized, the prohibition of truck movements in certain areas of the region will produce "truck-free" zones and result in small decreases in VMT and emissions.

  Public transit vehicles for the carriage and movement of goods could also be utilized in off-peak hours. Because buses and rapid transit carriers are not as fully occupied in the off-hours of the day, they could serve to transfer intracity or intracounty parcels, such as mail moving from one substation to another. This could reduce the number of truck trips made during the day in the region. This idea has been suggested in other cities; however, there is no record of its use as a technique to improve air quality. For Baltimore this measure could be applied to the intraregional movement of mail, government correspondence, and bulk newspaper delivery. Mail movement would, of course, require the use of a secure container or compartment on MTA vehicles.

This measure is limited in its potential effectiveness in reducing a.m. peak hour VMT for several reasons. Firstly, it deals with trips in the off-peak hours. Secondly, it deals only with a small part of all truck movements within the region. These measures can be expected to have only minimal effect on total HDV VMT.

I. *Physical Methods* to reduce truck emissions:

- Measures to reduce peak period truck travel—hydrocarbons produced by truck movement in the 6:00-9:00 a.m. peak hour are the prime concern, because this is the period in which hydrocarbons emitted have the longest exposure to sunlight and hence the greatest propensity for production of photo-chemical oxidants. Means of controlling these emissions include the prohibition of use of selected streets to truck traffic at selected times of the day. This type of prohibition would not only discourage a.m. peak truck travel, by creating inconvenience to the truckers, but if truck traffic were prohibited from congested thoroughfares in general and to delivery activities in particular, total truck VMT would be reduced during the a.m. peak and auto traffic would flow more easily, thus reducing hydrocarbon emissions. Baltimore currently has restricted loading zones. An attempt to further restrict truck movements results in considerable public reaction and caused special problems for the U.S. Postal Service. Any additional restriction can be expected to be politically controversial.
- Modify engine type and size—replacement of gasoline engines by electric engines, especially feasible in the case of light duty vehicles, could substantially reduce energy consumption and the emission of hydrocarbons. As noted above, however, technology has not advanced to the point of mass production of this type engine. Smaller engine size for many trucks could be implemented more readily and, given the over-powered nature of most heavy duty vehicles, this could be done without sacrificing the capability and utility of trucks. Smaller engined trucks would be encouraged through the use of a tax by engine displacement, thus replacing HDVs with LDVs.
- Measures to reduce emissions per mile—installation of pollution control devices will reduce emissions per mile. Heavy duty vehicles have not been subject to the same pollution control standards as light duty vehicles, and control of emissions has, as a result, been minimal. This is regarded as potentially the most productive new measure available for reduction of hydrocarbon because HDV's are a heavy source of pollution. In 1973, HDV's produced 12.61 tons (21.9% of the regional total) in the peak 6:00-9:00 a.m. period; by 1985, it is estimated that this will have decreased to 10.11 tons; however, by that year, this will represent 41.5% of the regional total. Any significant percentage reduction will be very important in reduction of regional totals. It is estimated that at least 50% of HDV hydrocarbons could be eliminated by this means, but only if state implementation of a retrofit program is instituted.

  Federal standards could be made more strict or Federal law could be changed to allow stricter state standards. This approach must be coupled with the installation of pollution control devices through the provision of legal requirement that such devices be installed.
- Measures to reduce truck travel during high pollution periods—a ban on non-essential truck travel similar to that suggested for automobiles during high pollution episodes would result in an effective reduction in truck movements and hence, of hydrocarbon emissions. In the evaluation of the matrix, this measure has been rated

at around 50% effective. This is, however, clearly an assumption as to the proportion of gasoline trucks which may reasonably be expected to be kept off the road for the few days in each year when pollution episodes are likely to occur. Also, a sticker system, as discussed previously, would produce proportional results during high pollution episodes.

Emergency holidays could also be designated for private and public employees. Such emergency holidays would not only reduce truck travel by giving drivers holidays but would reduce deliveries and other HDV activities.

It must also be noted that many of the measures will be effective only when parcelled with others. Perhaps the prime example of this is the combination of transportation and land use measures. The following paragraphs present an example of how the effectiveness of this coupling of measures may be estimated, a coupling which produces a land use pattern which is conducive to reduction of automotive travel and a transportation system to properly serve it.

Land use measures assumed to be available for the purpose include:

(1) Zoning.
(2) Agricultural/conservation zoning.
(3) Planning unit development and cluster zoning.
(4) Special use permits.
(5) Holding zones.
(6) Open space land requisition and landbanking.
(7) Floating zones.
(8) Discretionary taxation policies.

Land use and development controls have not been used to date for the exclusive purpose of achieving better air quality. However, many of these controls have been applied to achieve desired land use patterns which subsequently led to less traffic congestion and lower emission levels.

J. *Physical Methods* for transportation control proposed in plans:

Transportation control	*No. of State plans*	*No. of EPA plans*	*Total no. of plans**
Inspection/maintenance	15	25	31
Traffic flow improvements	7	18	24
Catalytic retrofit	6	15	16
Other retrofit	9	13	21
Parking restrictions	6	24	28
Pricing policies	5	3	8
Mass transit improvements	10	8	13
Additional stationary source controls	11	24	30
VMT reduction	4	4	8
Motor vehicle exclusion areas	2	2	4
Gaseous fuel conversion	2	0	2
Carpool locator	4	6	9
Gasoline limitations	0	11	11
Motorcycle restrictions	0	7	7
Idling limitations	0	1	1
Selective vehicle exclusion	1	9	10
Employer mass transit incentives	0	10	10

*In some AQCR's, the State and EPA have proposed separate or differing controls of the same type. These numbers are intended only to show the relative prevalence of the measures and may not reflect recent revisions in various transportation control plans.

Source: *State Air Pollution Implementation Plan Progress Report, January 1 to June 30, 1973.* U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. Publication EPA-450/2-73-005. September 1973.

4A. Utilities and Communication

A. *Physical Methods* for controlling utilities:

- Refuse incineration—in the development of the 1985 projections, it was assumed that no new sources of incineration would be permitted in the region. The reduction in emissions resulting from incineration of solid waste can be achieved by more complete incineration, however, this will produce only marginal improvements in what is already a minor source.
- Control power plant emissions—See Particulates, power plants.

5. Trade

A. *Physical Methods* for controlling hydrocarbon emissions from gasoline tanks, particularly bulk storage tanks located at service stations:

- Miscellaneous gasoline engines—several measures can be applied to reduce the hydrocarbon emissions from miscellaneous gasoline engines. These include the banning of gasoline powered mowers through implementation of a substantial fee, or the application of emissions control regulations to all gasoline engines. The periodic banning of gasoline-powered engines to attain episodic control is a feasible procedure.
- Improve methods of bulk storage—it should be noted that the measures discussed elsewhere which might be used to reduce automobile hydrocarbon emission through reduced travel and more efficient engines would directly affect the emissions from bulk storage. If less gasoline is used, less bulk storage requirements and a reduction in gasoline handling would result; therefore, fewer emissions would result. It will be assumed that the reduction in emissions attributable to bulk storage will decrease in proportion to the decrease in utilization of gasoline which results from other measures.

  One additional measure available to further reduce emissions from bulk storage sources comprises the reduction of gaseous leakage. New regulations for bulk storage coupled with frequent inspections could reduce the emissions. A floating roof or a vapor recovery system could be required on bulk storage facilities to accomplish this goal. All new bulk storage units of 65,000 gallons or greater capacity, in accordance with new source performance standards, are required to have such systems.
- Improve service station storage—as in the reduction of hydrocarbon emissions from bulk storage, the emissions from service station pumps and terminal loading would be reduced proportionately to the reduction in usage.

  Measures to reduce the number of fuel-handling operations can also be taken to further reduce emissions attributable to this source. The provision of larger gasoline tanks, tank trucks, and service station storage tanks would reduce the number of operations at the pumps and terminals. Coupled with this would be a requirement to produce a method of pressure feed or vacuum feed for the transfer of gasoline. This method would serve two purposes in that it would reduce the time of operation and would require a closed system which would reduce evaporation and spillages.

As with other gasoline storage and handling operations, the reduction in gasoline consumption will reduce the emissions from service station storage by way of the reduced number of storage facilities. Also, the introduction of vapor recovery devices and floating roof would reduce emissions from storage tanks. This could be accomplished through new state and local regulations coupled with frequent inspections.

- See 2 Manufacturing—Reduce demand for reactive hydrocarbon solvents.

6. Service

   A. *Physical Methods* for controlling hydrocarbon:

   - See 2 Manufacturing—Reduce demand for reactive hydrocarbon solvents.
   - See 4A. Utilities and Communication—Refuse incineration.

   B. *Physical Methods* for controlling hydrocarbons from commercial laundry and dry cleaning operations.

7. Cultural, Entertainment, and Recreation

   Usually not a major source of hydrocarbons.

8. Resource Production and Extraction

   Usually not a major source of hydrocarbons.

9. Undeveloped Land and Water Areas

   Usually not a major source of hydrocarbons.

APPENDIX A

NOTES

1. See Clawson, Marion, *Land Use Information: A Critical Survey of U.S. Statistics Including Possibilities for Greater Uniformity*, Division of Community Planning, Johns Hopkins Press, 1966.
2. See "Development of a Trial Air Quality Maintenance Plan Using the Baltimore Air Quality Control Region," EPA-450/3-74-050, September, 1974.

APPENDIX B

Implementation Measures

I. Regulatory

A. Effluent (Emission) Controls

1. New sources performance standards
2. Phase out existing sources
3. Prohibit new sources
4. Require fuel conversion
5. Combine emission sources
6. Special operating conditions/procedures
7. Require high stacks
8. Fugitive dust control requirements
9. More stringent standards for existing sources

B. Effluent (Emission) Load Allocations

1. To existing source
2. To new sources

C. Specifications on Raw Material and/or Energy Inputs

1. Limitation on sulfur content of fuels
2. Limitation on lead content of gasoline

D. Specifications on Product Outputs

1. Product packaging controls
2. Regulate composition of product on basis of environmental and health effects of products when they are disposed
3. Limitations on phosphorus in cleaning agents (detergents)
4. Limitations on noise for specified new equipment—motorcycles, etc.
5. Ban internal combustion engine

E. Specifications on Allowable Activities

1. Prohibit motorized vehicles in environmentally fragile areas
2. Prohibit passenger cars in central business districts
3. Prohibit trucks on specified routes
4. Parking bans
5. Control on temporary activities

F. Specifications on Intensity of Use

1. Limitations on number of users per period (e.g., campers/day; campers/season)
2. Limitations on number of users per unit area (e.g., boaters/sq. mi., cars/lineal mile)
3. Parking supply mgt.
4. Priority treatment for carpools

G. Specifications on Conditions for Use

1. Prohibit trail riding when wet
2. Prohibit use of recreational areas when excessively dry conditions prevail

H. Permits
   1. Construction
   2. Operating

I. Rationing

J. Licensing/Registration
   1. People
   2. Products
   3. Process

K. Land Use Growth Management
   1. Zoning
      a. Performance zoning—certain uses not permitted unless specified standards are met
      b. Flood plain zoning
      c. Open space zoning
      d. Specified use zones e.g.—zoning to protect natural resources agri/conserv. zones, protect critical areas
      e. Emission density zoning
      f. Conditional zoning
      g. Floating zones
      h. Holding zones
      i. Incentive zoning
      j. Interim zoning
      k. Large lot zoning
      l. Transitional zones
   2. Planned unit development—encourage use of multi-family residents, cluster dev., etc.
   3. Moratoria
   4. Development—construction (capital facilities) ordinances/regulations
      a. Erosion control
      b. Excavation (grading) control
      c. Wetlands protection
      d. Architectural appearance
      e. Historical preservation
      f. Tree preservation/planting requirements
      g. Sign regulations
      h. Dedication of land for public purposes by developers
      i. Installation/financing of public facilities by developers required
   5. Building costs
   6. Time phasing of development
   7. Permits—building; indirect sources review
   8. Land acquisition by public sector: ownership by easements (sources)
   9. Land banking

II. Economic

A. Effluent (Emission) Charges

B. User Charges: To recover cost of service
To finance pollution control agencies
To finance land agencies firms, etc.
To influence behavior of discharges

1. Water rates
2. Sewer charges based on quantity, quality, peak load price, timing surcharges for large contributors
3. Parking surcharges
4. Increased registration fees for cars, trucks;
Decreased registration bikes, multi-passenger vehicle
5. Charge per can of solid waste collected from residence (e.g., increase unit charges for more than 2 cans)

C. Taxes

1. Severance
2. Excise
3. Income
4. Capital gains
5. Property
   a. Differential property tax assessment
   b. Exemptions (e.g., Poll. Control Facilities, Soil Erosion Proj., Iowa sec. ER July/Aug. 1974 p. 256)
6. Depreciation schedules & tax credits
7. Exemptions for loans (bonds) to finance pollution abatement

D. Fees & Assessments

1. Rental for use of common property resource
2. Restoration fee
3. Service hook-on assessment
4. Permit & licensing fees

E. Bonds/Loans/Grants/Subsidies

1. Preferred interest rate for specified uses
2. Government grants, loans & subsidies for capital goods and operation

F. Markets for Rights to Common Property Resources

1. Land carrying capacity market—transferable development rights
2. Assimilative capacity market
   a. Pollution rights
   b. Discharge rights

G. Capital Improvement Programs

III. Administrative

A. Voluntary responses

1. Energy conservation in industry, commerce—specific and administrative order
2. Alter time phasing (scheduling) of activities
   a. Stagger working hours
   b. Industrial activities
3. Special operating conditions
   a. Combustion units to reduce emission

    4. Vehicle use restraints
    5. Carpooling
    6. Separations of solid residuals at point of origin
  - B. Purchasing Procedures

IV. Information Provision

  - A. Media advertising
  - B. Display and demonstrations
  - C. Forums/conferences
  - D. Research
  - E. Information dissemination
    1. Press releases
    2. Public identification of violators
    3. Continuing education programs
    4. Training programs

APPENDIX C

Illustrative Tables

The tables set forth in this appendix are by the general classifications of types of source categories, physical methods, implementation measures and institutional arrangements. They are illustrative and may be more detailed by subclassification as indicated on the tables.

TABLE C-1

Physical Methods and Source Activities

MEDIA: AIR RESIDUAL: PARICULATES PHYSICAL METHODS CLASSIFIED BY POINTS OF INTRODUCTION	SOURCE ACTIVITIES[1] 1. RESIDENTIAL	2. MANUFACTURING	3. MANUFACTURING (CONT'D)	4. TRANSPORTATION	4a. UTILITIES AND COMMUNICATION	5. TRADE	6. SERVICES	7. ENTERTAINMENT AND RECREATION	8. RESOURCE PRODUCTION AND EXTRACTION	9. UNDEVELOPED LAND AND WATER AREAS
A REDUCE/MODIFY "FINAL DEMAND"	●					●	●			
B REDUCING THE DISCHARGE OF RESIDUALS OR MODIFYING THEM										
1 REDUCING RESIDUALS GENERATION										
a. CHANGE RAW MATERIAL/ENERGY INPUTS		●	●		●					
b CHANGE PRODUCTION PROCESSES		●	●		●					
c CHANGE MIX OF PRODUCT OUTPUTS										
d. CHANGE PRODUCT OUTPUT SPECIFICATIONS										
2 MODIFYING RESIDUALS AFTER GENERATION										
a APPLYING RECOVERY TECHNOLOGY (INTERMEDIATE PRODUCT)										
b. APPLY WASTE TREATMENT (POLLUTION CONTROL) TECHNOLOGY		●	●		●					
c UTILIZE BY-PRODUCTS OF RESIDUALS MODIFICATION		●	●		●					
C IMPROVE THE ASSIMILATIVE CAPACITY										
1 MAKING BETTER USE OF THE EXISTING ASSIMILATIVE CAPACITY										
a CHANGE SPATIAL DISTRIBUTION OF SOURCE ACTIVITIES		●	●		●					
b CHANGE TIMING OF DISTRIBUTION FROM SOURCE ACTIVITIES										
c CHANGE SPATIAL DISTRIBUTION OF DISCHARGE		●	●		●					
d CHANGE TIMING OF DISTRIBUTION OF DISCHARGE										
2 INCREASE THE ASSIMILATIVE CAPACITY		●	●		●					
D. FINAL PROTECTIVE MEASURES										

[1]For more detailed breakdown, see classifications, including SIC, set forth in Land Use Information.

COMMENT: This Table is illustrative in general terms only to assist in identifying points at which physical methods may be introduced into the residuals generation and discharge process.

TABLE C-2

Physical Methods and Implementation Measures

MEDIA: AIR RESIDUAL: PARTICULATES SOURCES: POWER PLANTS; STEEL MILLS PHYSICAL METHODS CLASSIFIED BY POINTS OF INTRODUCTION	IMPLEMENTATION MEASURES 1. REGULATORY MEASURES	2. ECONOMIC MEASURES	3. ADMINISTRATIVE MEASURES	4. PROVISION OF INFORMATION
A. REDUCE/MODIFY "FINAL DEMAND"	●	●	●	●
B. REDUCING THE DISCHARGE OF RESIDUALS OR MODIFYING THEM				
1. REDUCING RESIDUALS GENERATION				
a. CHANGE RAW MATERIAL/ENERGY INPUTS	●			
b. CHANGE PRODUCTION PROCESSES				
c. CHANGE MIX OF PRODUCT OUTPUTS				
d. CHANGE PRODUCT OUTPUT SPECIFICATIONS	●			
2. MODIFYING RESIDUALS AFTER GENERATION				
a. APPLY RECOVERY TECHNOLOGY (INTERMEDIATE PRODUCT)		●		
b. UTILIZE BY-PRODUCTS OF RESIDUALS MODIFICATION		●		
c. APPLY WASTE TREATMENT (POLLUTION CONTROL) TECHNOLOGY	●	●		
C. IMPROVE THE ASSIMILATIVE CAPACITY				
1. MAKING BETTER USE OF THE EXISTING ASSIMILATIVE CAPACITY				
a. CHANGE SPATIAL DISTRIBUTION OF SOURCE ACTIVITIES	●	●	●	
b. CHANGE TEMPORAL DISTRIBUTION FROM SOURCE ACTIVITIES	●		●	
c. CHANGE SPATIAL DISTRIBUTION OF DISCHARGE	●	●		
d. CHANGE TIMING OF DISTRIBUTION OF DISCHARGE	●	●		
2. INCREASE THE ASSIMILATIVE CAPACITY	●	●		
D. FINAL PROTECTIVE MEASURES				●

COMMENT. This Table is illustrative in general terms to indicate the classes of implementation measures available to reduce or require implementation of certain classes of physical methods. See Appendix B for a detailed listing of implementation measures.

TABLE C-3

Institutional Arrangements and Implementation Measures

MEDIA: AIR RESIDUAL: PARTICULATES SOURCE ACTIVITIES: POWER PLANTS AND STEEL MILLS INSTITUTIONAL ARRANGEMENTS	IMPLEMENTATION MEASURES: 1. REGULATORY MEASURES	2. ECONOMIC MEASURES	3. ADMINISTRATIVE MEASURES	4. PROVISION OF INFORMATION
I. GENERAL JURISDICTION				
A. FEDERAL	●	●	●	●
B. STATE	●	●	●	●
C. LOCAL: CITY, COUNTY	●	●	●	●
II. LIMITED JURISDICTION[1]				
A. FEDERAL	●		●	●
B. STATE	●		●	●
C. LOCAL	●		●	●
III. INTERGOVERNMENTAL				
A. COOPERATIVE	●			●
B. MANDATED	●			●

[1]The limited jurisdiction classification may be subclassified by particular agency—e.g. Federal: EPA, HUD, Interior, etc.

COMMENT: This Table is illustrative in general terms only to indicate the broad range of implementation measures which each level of government (institutional arrangement) should consider. It can be made useful by subclassifying implementation measures. As an example: Economic Measures; Taxes; Income Tax; Tangibles Tax; Real Property Tax; User Charges; Effluent (Discharge) Charges; Subsidies. See Appendix B for a detailed listing of implementation measures.