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CLEAN WATER: AFFLUENCE, INFLUENCE, EFFLUENTS

1971 Summer Faculty Fellowship Program in Engineering Systems Design

Asee-Nasa Langley Research Center

CLEAN WATER: AFFLUENCE, INFLUENCE, EFFLUENTS

A DESIGN FOR WATER QUALITY MANAGEMENT

Editor-in-Chief: Albert E. Millar, Jr.
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1971 SUMMER
FACULTY FELLOWSHIP PROGRAM IN ENGINEERING SYSTEMS DESIGN

ASEE-NASA LANGLEY RESEARCH CENTER
OLD DOMINION UNIVERSITY RESEARCH FOUNDATION

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THE JAMES RIVER:

THE GOOD,

Headwaters
Near Covington, Virginia

THE BAD,

Industrial Use
Continental Can Company
Hopewell, Virginia

BEST REPRODUCIBLE

THE UGLY

A Portion of
The Estaury
Near Menchville, Virginia

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FOREWORD

This document summarizes the results of the 1971 ASEE-NASA Summer Faculty Program in Interdisciplinary Systems Design conducted at the NASA Langley Research Center during the period June 7 through August 20. The program was sponsored jointly by the National Aeronautics and Space Administration and the American Society for Engineering Education through a contract by NASA to the Old Dominion Research Foundation of Old Dominion University.

The objectives of this systems design program included the following:

(1) To provide a useful study of a broadly based problem of society that required the coordinated efforts of a multi-disciplinary team.

(2) To provide a framework for communication and collaboration between academic personnel and research engineers and scientists in governmental agencies and private industry

(3) To generate experience and foster interest in participation in and development of systems design activities and multi-disciplinary programs at the home institutions of the participants.

These three objectives were met by a group project directed toward a systems design approach to the problem of water quality and pollution abatement in rivers and estuaries with the James River Basin in Virginia used as a model The group study and design effort culminated in this report which is meant to communicate the problem of water quality degradation and its impact on society to the general public and decision makers for purposes of community planning and legislation. The report also outlines designs for water quality management systems and gives specific recommendations for effective water pollution abatement.

To be realistic, such a study must consider a wide range of social, political, technical, legal and economic questions. Therefore, in order to approach this study properly, a group of 23 investigators was assembled including faculty members representing 13 academic disciplines from 19 different universities and two law students The result was a multidisciplinary team well suited for the study of this most important problem, and it is felt that this report reflects the very broad background of these participants.

Chapters I, II, III, and IV present the general background for the problem of declining water quality and identify specific obstacles to effective water quality management. Chapter V outlines the design of a management system for water resources which can function within our society. Chapter VI is a case study of the James River and applies the general recommendations of the other chapters to this specific basin. Chapter VII presents specific recommendations that the authors of this report felt were essential to achieve the goals of improved water quality.

Having a multidisciplinary team has greatly aided the success of this study, but in addition the program has benefited from lecturers and consultants from a number of governmental agencies, universities, and private industries. These individuals, who are listed in Appendix C, were invaluable in providing needed data and information for the report.

Appreciation is expressed for the many courtesies and the comfortable atmosphere provided by the Co-Directors of the NASA-ASEE Summer Institute, Dr. John E. Duberg and Dr Gene L. Goglia The continuing excellent support and patience extended by Mr. Malcolm P. Clark and Mr. John Witherspoon of the NASA Training and Educational Services Branch are also warmly acknowledged.

Mr. Andrew R. Wineman, Head of the Earth Environments Section of the Langley Research Center, served as the technical advisor to the study program from its conception to its conclusion. For his constant encouragement, counsel, and cooperation during the entire program, the participants express their deepest appreciation.

J. Darrell Gibson
Project Director

Richard D. Klafter
Associate Director

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PROLOGUE:

THE AFFLUENCE OF OUR SOCIETY

One of America's first explorers, Captain John Smith, observed in 1607 when he sailed up Virginia's rivers that the country had "...the prerogative over the most pleasant places known." He also said that "...heaven and earth never agreed better to frame a place for man's habitation."* As recent as the seventeenth century, America was resplendant with the bounties of nature. Her innate affluence seemed limitless.

America in the current century has become rich in material possessions. Her apparent wealth still beckons to other nations. Nevertheless, learned men question the meaning of her technical/materialistic largess. Have we not sacrificed the vitality of our natural resources to gain such prestige? These resources sustained the first generation in the New World and contributed toward development of the most affluent society in history.

But the balance has shifted. America's recognized affluence, largely derived from exploitation of natural resources, stands as the most legitimate solution to pollution. The natural resources are fast moving toward dependancy on man. This ironical situation would have startled John Smith or even Thomas Jefferson. What will its effect be on our children? Clearly, we must develop a give-and-take relationship with our resources. The time for taking is over. One can only guess what the illustrious Captain Smith would say of these same rivers were he to sail them today.

The comparatively recent public adoption of the word ecology has more far-reaching effects than most people recognize. It is greatly more important than the semantic difference between conservation and ecology. The increasingly critical situation in America's resources has made the change in nomenclature more valid. Whereas "conservation" indicated preservation of the status quo, "ecology" refers to dynamic relationships between living organisms. The point here is that it is now quite late even to attempt preservation of certain resources; we must now move toward recovery.

Historically, Americans have been flagrantly guilty of the charge of resource expendability. Absence of foresight produced decimating effects upon our supply of topsoil or of buffalo herds; consequently, we recognize the destructive potential which could and will seriously threaten our finite supply of clean water. Excessive demands from an exponentially increasing population and expanding industry already have generated fearful pollution levels in lakes, rivers, and streams. With almost no regard for posterity, present-day polluters commit unnatural acts, the effect of which may be perceived now by any of the five natural senses near a typical body of water. However, the problems are so complex as to be legion. A great deal of verbiage has already been expended to convince the citizenry that something is dreadfully wrong with America's waters.

The purpose of this study is manifold. In the briefest possible manner, it reviews the contemporary state of the water pollution problem. One may peruse relevant facts and figures in order to gain more awareness of the immensity of the common situation facing all of us. The conditions of the rivers and streams and the variety of pollution sources demonstrate the wasting of a precious, yet exhaustible natural resource.

In additon to the general overview of water pollution, the report describes the magnitude and complexity of the remedies which have been formulated by governmental and private factions. Essentially, noble intentions have proved to fall far short of practical applications in the field of water quality management. Interestingly, the major legislative acts designed to improve water standards have exerted little beneficial influence over pollution. In fact, only the recent execution of the 1899 Refuse Act (July 1, 1971) has proved to accomplish something. Since July 1, 1971, all industrial dischargers

*Quoted from his True Travels, Adventures, and Observations ...1593-1629.

into public waters have been required to file forms with the Corps of Engineers which describe the nature of their effluents. However, there are loopholes for laggards to escape the retribution they deserve.

The primary (or only) advantage to the granting of permits to discharge (i.e , pollute) is that a formerly covert activity becomes overt. Fortunately, public outcry is still the most potent weapon for effecting change in our society Alexander Hamilton's words, "The people, sir, is a great beast," reveal themselves frequently as a rather apt description of an aroused populace The people will tolerate oppression, or bureaucratic collusion--but only to a degree and only on a temporary basis. The point is thatthe relatively recent concern over water pollution in America has created too little action. What there is seems too long overdue.

The precedence for the techniques used in this study derives from the view held by President Richard M. Nixon (July 9, 1970):

Despite its complexity, for pollution control purposes the environment must be perceived as a single, interrelated system.

Hence, an interdisciplinary system design approach to water pollution considers the diverse opinions relating to the overall matter. Hopefully, mutual exchange of ideas among several academic and professional disciplines fosters keener thinking and more generally applicable solutions. It is hoped as well that this coordinated approach will serve to diminish whatever proliferation has occurred due to bureaucraticoverlap. Certainly we must recognize that the time is right for incisive reappraisals of our thinking on water pollution and water quality management.

The report also demonstrates that a mathematical model of an estuarine system is necessary. Theidea here is that a reasonably-valid prediction of changes in a body of water may be viewed through data which may be collected preceding any controlled, i.e.,man-made, or natural alteration in a system Some of the factors included in a model are drawn from physical, biochemical, and economic characteristics of a given estuary. These variants can be examined at will in a mathematical model to produce a more accurate forecast of estuarine status in almost any situation. Thus, one of the most useful characteristics of the model is that it generates results which are usually counter to intuition. The benefits which such a model possesses are notable and may prove to be at least as effective in water quality management as current physical models are (such as the James River Model in Vicksburg, Mississippi). The latter is referred to below

Presented as a case study, the James River basin is examined as a specific, contemporary problem Thus, the report is required to delineate the major characteristics of the headwaters, the tributaries, and, most importantly, the James River estuary system. Major industrial, municipal, recreational, and navigational demands in the basin are also described. With established criteria, the James River basin can be approached within respective legal, social, economic, and technical jurisdictions. Truly, this is a particularly appropriate river system to examine systematically Its problems and their solutions offer extensive insights into those which confront other riverine communities.

In spite of the fact that the James River cradled this nation, its vast resources are seriously threatened by several polluting agents. Over three centuries of English-speaking residents have thrived from the several benefits which the river has afforded. No small portion of Virginia's affluence is attributed to the James. Yet, the salutary attributes of the river system are threatened by increasingly flagrant misuse. Industrial discharges are rivalled only by insufficiently treated municipal sewage as the primary pollutants which abound in the James River. Thus, the James is analyzed as contributing toward more pertinent knowledge in the field of interdisciplinary systems design applicable to pollution abatement.

The document serves to categorize the most vital needs in the field of water pollution. It attempts to induce simplicity from complexity, to extract order from chaos. Hence, the major approaches have been arranged in the following order:

1. Existing problems are annotated.
2. General criteria are established.
3. Implementation of solutions is described.

The most important phase of the entire study is the last, that which demands activation of immediate remedies. In this, the report most obviously reveals the diverse academic and professional expertise which the NASA-ASEE program retained at the Langley Research Center. Consequently, the most viable solutions to water pollution combine related legal, political, economic, social, and technical aspects.

The specific intent of the multidisciplinary design program is to offer legitimate

suggestions which can and should be implemented before water supplies cease their present potentially fatal alterations. The design offers a guideline; the ultimate solution lies in its utility. Our environment demands our keenest thoughts and our most immediate actions. Water pollution is a contemporary problem of utmost significance. One way or the other, it is unquestionably a temporary problem.

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SUMMARY AND RECOMMENDATIONS

The significance of this report can only be measured by the response it generates from those individuals who can make the biggest contribution to water pollution abatement—the American people and their elected officials. For this audience, many specific recommendations for water pollution control and abatement are presented in this study. (A complete list of these recommendations can be found in Chapter VII.) Some of these recommendations have appeared before; others have not. Some will evoke wide agreement; others wide controversy. Some of the measures recommended will require little expense; others are costly. But in the final analysis, it will be all citizens and not just the few who prepared this report who must decide the costs society is willing to bear. It is in the spirit of this report that we must warn short-sighted choices may incur costs none of us can bear. Therefore, WE RECOMMEND THAT:

- The Federal Government and cooperating nations immediately initiate studies to determine the rates of societal growth which can be sustained without unacceptable ecological deterioration.
- Officials at the highest levels of government commit themselves to the protection of the nation's waterways as a public trust. The concept of clean water in **all** America for **all** Americans should be adopted.
- Mandatory waiting periods in the present pollution abatement law be reduced to the absolute minimum necessary to provide discharges an equitable hearing.
- The discretion presently given to EPA officials for enforcement responsibility be drastically reduced.
- Public disclosure of effluent data be assured.
- Federal legislation shift the burden of proof to the discharger, requiring him to demonstrate that his discharge is non-polluting.
- Government funding of abatement facilities should not be a prerequisite to enforcement.
- Municipal water pollution programs focus on improving the quality of urban life for **all** residents.
- Industry be required to repay that proportion of federal grants associated with costs of industrial waste treatment, monitoring, and enforcement.
- The Environmental Protection Agency insist on efficient use of water pollution control grant funds—including the consolidation of small treatment districts where it is economical.
- All water pollution abatement activities of the federal government be centralized in EPA.
- The authority to review "Section 102" statements be transferred from the Council on Environmental Quality to EPA.
- Immediate, comprehensive studies to ascertain the impact of economic development on wetlands be initiated and supported at the federal level.
- A moratorium be declared on conversion of wetlands to other uses, while policy is being formulated.
- Contingency plans for **all** oil and hazardous chemical spills be developed.
- Run-off, erosion and resulting sedimentation affecting water quality be identified and controlled.
- Industrial plants unable to economically afford pollution abatement be allowed to close down.
- Congress assure itself of qualified professional staff by underwriting fellowships for competent scientific and engineering aides.

- Legislation be modified to permit the private citizen to take definitive legal action against recalcitrant polluters and negligent pollution abatement officials

- Every major river basin have a river basin authority (or its functional equivalent) with full power to plan, implement and enforce water quality programs.

- Federal legislation specifically require development of comprehensive basin plans that meet national planning standards in nationally developed water planning regions. This requirement should be independent of requests for federal aid grants.

- Water pollution abatement plans be reviewed by authorities responsible for air pollution and land use planning.

- Waste treatment for most dischargers to interstate and intrastate watercourses including all major dischargers, be required to incorporate at least 90 percent removal of biochemical oxygen demand (BOD).

- Qualified, licensed operators and maintenance staff be required in all sewage treatment plants.

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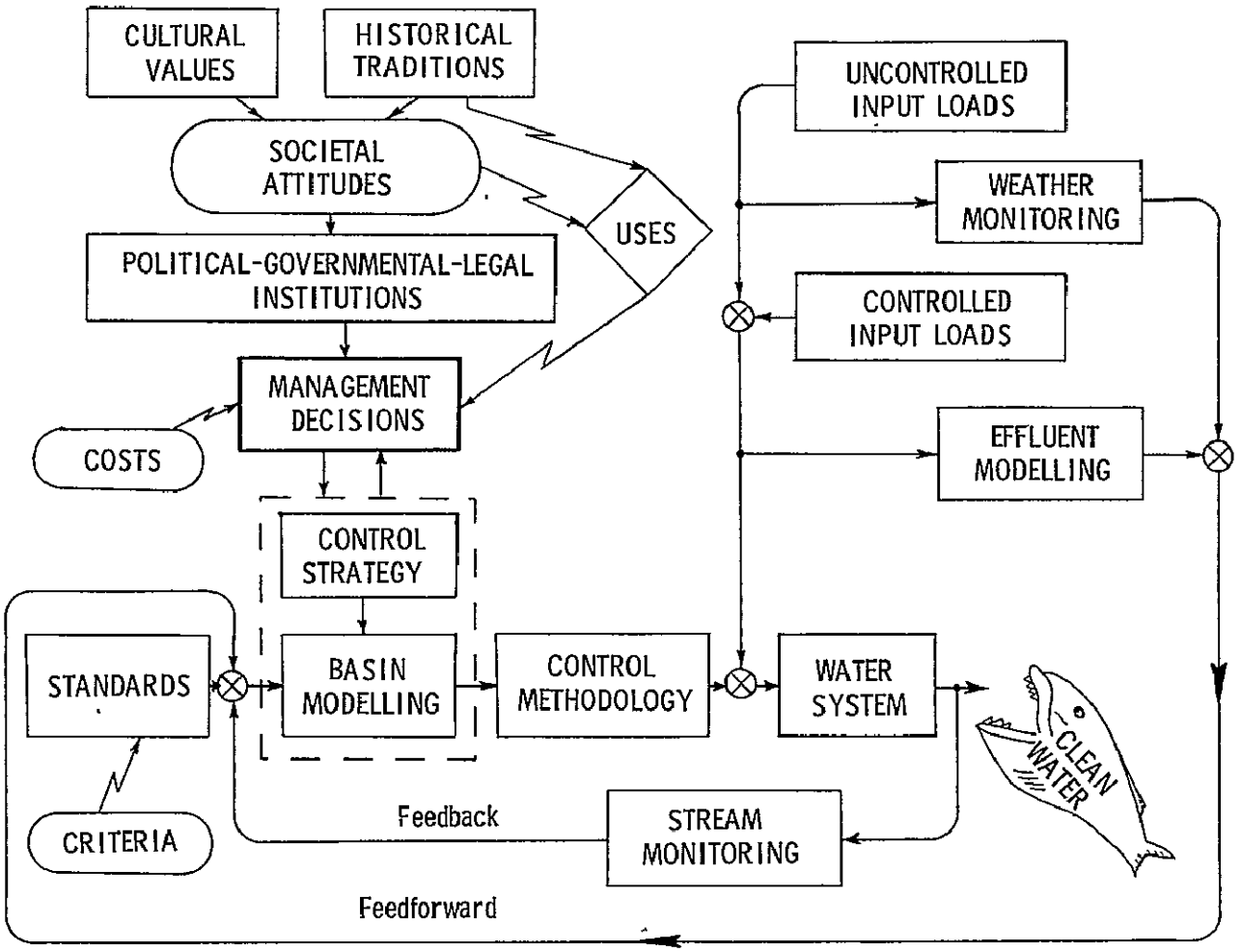
WATER QUALITY MANAGEMENT, THE APPROACH TO CLEAN WATER



Clean Water: A Retreat From Biological Brinkmanship

The time has long since passed when man could safely ignore his stewardship of the earth. His responsibility as a guardian is no longer a matter of choice; it is a matter of survival In ancient times, man's neglect of conservation or misuse of the earth only helped to lead to the collapse of empires. Now, with a population growth rate that staggers one's imagination, the pressure on existing aquatic ecosystems is so great that planetary disaster may be imminently close. Make no mistake about this. The possiblity of ecosystem collapse is probably as much of a danger as thermonuclear war. Application of common sense by able leaders can avert the latter; but destruction of aquatic ecosystems can be avoided only by complex community cooperation, some of which must be on a global scale.

For strong evidence of impending ecosystem pressures, one need only read a few of the many sets of demographic projections that have been prepared during the last several years. For example, consult the four-volume **James River Basin: Comprehensive Water Resources Plan** (1) and note the many figures, graphs, and charts of data showing projected water system uses up through the year 2020. Bear in mind that these calculations were based on best estimates of probable trends and somewhat reduced population growth rates. The impact of these data is hard to miss. Within the next fifty years, supply and use demands in the James River Basin are projected to increase about five times, by conservative estimate, over those of 1968. Since the James and virtually all other U. S. rivers are already misused, polluted, and over-stressed by our rather lax 1970 standards, one fact is inescapably clear. There must not be a fivefold increase; there is no evidence that the ecosystem has that much flexibility within a margin of safety.

Should drastic biological catastrophes occur, the James will have long ceased to be

a living system before 2020. Instead, it will more likely be a dead sea of brine and refuse sloshing back and forth with the tides, watched only by a stark and barren landscape.

We can not allow this to happen. It is not our right. The earth belongs just as much to future generations as it does to those living today. It is our trust soley by circumstances of time. No selfish or immediate demands which create additional stresses, unwise uses, or destructive development must have precedence over the rights of the future.

The waters of all aquatic ecosystems are part of the commons. Like fresh air or streaming sunlight, clean water is inherently vital to all life. If man is to lord the earth, his duty to protect its waters becomes unequivocal. To wilfully violate this trust is unthinkable. We must act immediately as all our waters may be in grave danger. An intensive cleanup effort is mandatory, for little time appears to be left before the damage becomes irreparable. If we act now, our generation's record of river insult can just possibly make one of the blackest marks in history. If we fail to act, our deeds may not be entered.

Life, Liberty, and the Pursuit of Happiness

The current ecological dilemma demonstrates the demand for the resource of water. From Biblical times to the present, civilization has flourished due to waters which transported vessels, nourished crops, and slaked thirsts. From Nomadic tribesmen who employed thirst-resistant camels to the Phoenicians who sailed to verge on the known world, water provided the earliest pattern of human discovery and development. As navigational paths, water routes opened the Western Hemisphere in the fifteenth century to succeeding migrations. The commercial possibilities of rivers and seas have been of great significance to economic development. Likewise, man's health has always been dependent on reasonably pure water

Of prime concern to all of us is the current status of our water resources. Winds, currents, rainfall, temperature changes, and sedimentation cause constant transformation in water systems. Normally, products of environmental interaction fulfill the vital needs of water organisms as they thrive in the ecological chain. Our concern here is with the startling possibility that a natural balance is more finite than even imagined possible. Our thoughts immediately turn to the present conditions, manmade and otherwise, of our water resources.

Pollution basically is a misuse of natural resources. When waters become overtaxed by demands which are in violation of their natural capacities, they lose beneficial effects once vonsidered infinite. Assimilative qualities of a water system are restricted by flow rates, temperature, and the quantity of incoming discharges. As a result of excessive unnatural effluents. Water quickly assumes a limited utility to all sectors Realization that clean water supplies are rapidly shrinking has recently brought considerably more interest in water quality management to several academic, political, and professional groups. Some of this has been generated from a mere passing interest in a noble sounding fad; however, many people are displaying an increasing awareness of the crisis which we face regarding water quality today. And the primary reason for the concern is that without changing the current trends in our fresh water supply, life as we know it will soon be lost.

We ask, "What is right?" Is it "right" that conflicting interests have caused havoc in most major American river systems? One of the emptiest arguments is that whatever exists is correct or adequate by virture of its mere presence. Just as empty is the assumption that a negative direction in water quality will mystically change to the better with no effort on the part of anyone. The rightness of recovering our water resources seems essentail to the fullness of our existence. For it is the inherent right of anyone to have access to clean water; and if we need to expand upon the reasons for this assumption, three precepts will be presented and examined in regard to water quality.

Americans are granted three basic rights from Thomas Jefferson's penning of the Declaration of Independence. His guarantee to **life** can be corroborated with the necessity of high standards of water quality. Whether for quenching thirst or cooling a drink, one's water supply must be of an acceptable level. Any one of us sorely misses the loss of confidence in any staple; and this is especially true in reference to clean water. Water and life are directly proportional. Thus, water quality management is logically an inalienable function of our society.

Secondly, Jefferson spoke of **liberty**. Relating this to water quality, we must consider posterity. Since the earliest days of our republic, individuals have sensed encroach-

ment of freedom of choice in many matters. At no time more than the present has the average American believed that he has lost this freedom. This current feeling of alienation in our society stems from reduced access to individual freedoms, including encroachment by special interest organizations. What primarily should be considered here is that succeeding generations deserve the right to use water of the highest possible quality. This generation acting in an enlightened present must provide choice for water uses in the next.

Jefferson finally considered the **pursuit of happiness**. By this he could have indicated emotional stability and absence of excessive tension. Americans have since taken for granted the idea that water will continue to offer excellent recreational outlets. Boating and swimming provide millions of vacationers with needed diversion from occupational fatigue each year. However, more and more people are aghast at the stench and visually polluted scenes now present in many of America's leading watering spots. With this recognition of impending loss, interested parties have raised editorial and journalistic outcries in mostly a heretofore vain attempt at reducing public apathy.

The Complexity of Water Quality Management

True water quality management required input from social, economic, political, legal, and scientific sources. The impact of the former groups is not as well understood as the scientific interactions, and even the latter is not understood well enough to allow man to have complete control of the environment.

One complicating factor is the close dependancy of any major pollution action upon public acceptance and consent. Bond issues, stronger laws, manpower to enforce the law, public education campaigns, environmental education all involve the "man on the street" Elected officials have become very sensitive to the growing chorus of voices on all topics. Where the public has demonstrated emphatically its concern, elected officials are responding. The critical task now remains, however, of carrying the intentions, funds, and laws through to practical accomplishments. Water quality management is complex, needs public support and vigilence, and as currently structured, must function through many layers of government.

Motley Assemblage

In order to provide management organization for water quality control, each level of government has independently assumed responsibility within its jurisdiction. The result is a many-layered cake of overlapping and conflicting responsibilities and organization. Each governmental agency has taken only that portion of the responsibility pertinent to its mandated area of operation. The Corps of Engineers, by court decisions, considered the navigational hazard involved when judging permit applications; the Department of Agriculture, the soil and sediment runoff; Public Health agencies the health hazard, and so on. Fortunately, this conflict has been recognized, and an attempt has been made to correct the situation by formation of the federal Environmental Protection Agency (EPA). Unfortunately, the coordination of environmental protective practices has not yet proceeded very far.

As man learned to walk by placing one foot in front of the other, so will the correct government structure emerge. The first step has been taken with the formation of EPA. Now the other foot must move ahead.

The lower levels of government are almost oversupplied with environmentally concerned agencies. Scattered as they are, rapid progress is stymied. Most progress often seems mired in the endless shuffle of papers from one agency to another. For example, Virginia Watermen (those who make their living by harvesting the marine life of Chesapeake Bay) had a particular problem which they took to the Virginia Institute of Marine Sciences which in turn referred them to the State Water Control Board which in turn referred them to the Virginia Marine Resources Commission.

Hence, a typical list of government structure, by category, includes but is not limited to, State Pollution Control Agencies, State Planning Agencies, other State Agencies, Interstate Agencies, River Development Agencies, Waste Treatment Authorities, County Government, Citizen Groups, Advisory Councils, Industrial Councils, and Municipal goverment. This is in addition to the Federal Government and international groups such as the World Health Organization (WHO) and Red Cross. In the Federal Government structure some of the agencies that are concerned with environmental matters include the Department of the Interior, Environmental Protection Agency, Department of Commerce, Civil

works portion of the U.S. Army Corps of Engineers, Department of Transportation, Department of Agriculture, Atomic Energy Commission, National Aeronautics and Space Administration, Department of Housing and Urban Development, Department of Health, Education, and Welfare and the various subdivisions within each of the above. each of the above.

Therefore, it is readily apparent that some form of streamlining to condense the efforts is necessary. The major reason for the existence of the environmentally oriented governmental units is to provide the environment with a just voice in the many competing uses to which it is subject. They certainly were not created to perpetuate environmental decay via bureaucratic entanglement.

Uses and Competition

Thus, there are many uses for water. The boat enthusiast seeks reasonably clean, low silt water with a minimum of debris. The industrialist seeks water of a specific oxygen content with low chemical concentration and in sufficient volume to cool his factory or process a product. The farmer needs low cost, high volume water. Wildlife need water for all their life processes. The shipowner needs deep water. Mankind needs water.

Some of these users degrade water to the point where reprocessing is necessary before further use. Some uses degrade but do not require reprocessing. Some uses actually remove water from the local water basin, others do not degrade. In most situations certain uses will conflict with other uses Priorities and standards assist in determining which uses predominate and at whose expense.

Whether irrigating, cooling, flushing, transporting, generating power, carrying waste, floating boats, levitating water skiiers, cooling, or sustaining life, water is at the same time the most abundant and the most critical single feature on this planet. While having demonstrated the fiber of America's heritage, we also have recognized how basic waters are to the kind of life most of us seek to retain (or regain). Avoiding the accusation of being crusaders or fatalists, we accept the demonstable premise that high water quality standards must become the prime objective of all individuals Therefore, to aid in achieving high quality water standards, the authors adopted the following objective:

Determine the interaction of technological, social, economic, and political forces necessary to produce clean water.

The Water Basin System

The Water Basin System is described by four components (Figure 1.1). They are air, land, cultural, and water. These components interact with each other and with similar components exterior to the Water Basin System.

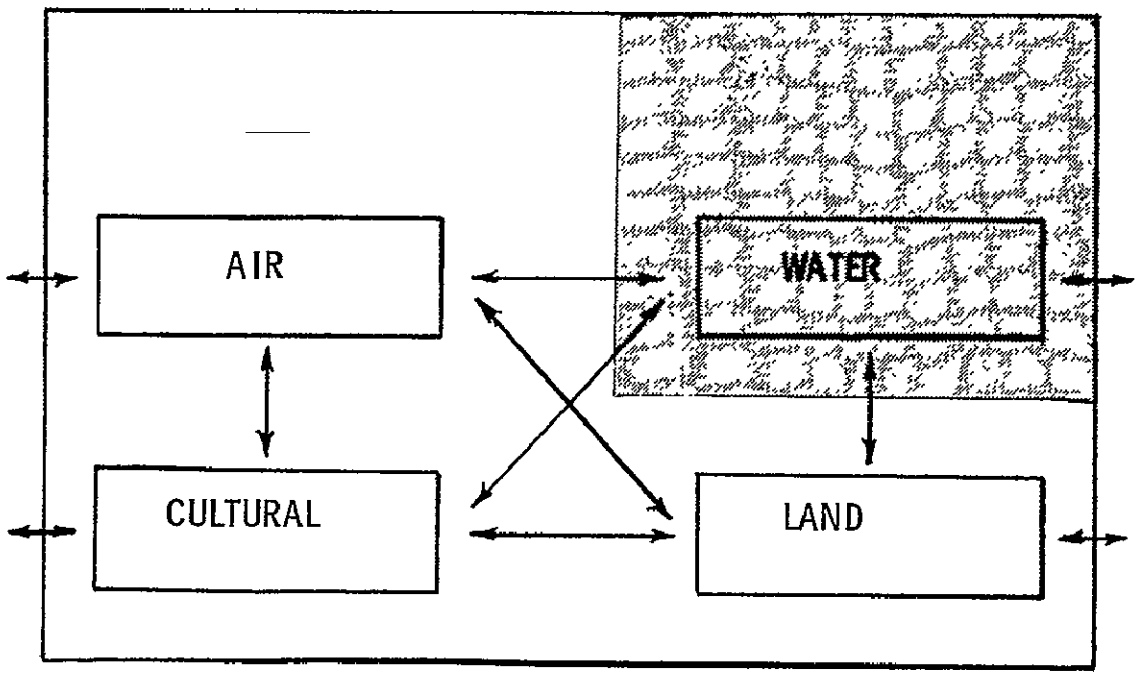


FIGURE 1.1 THE WATER BASIN SYSTEM

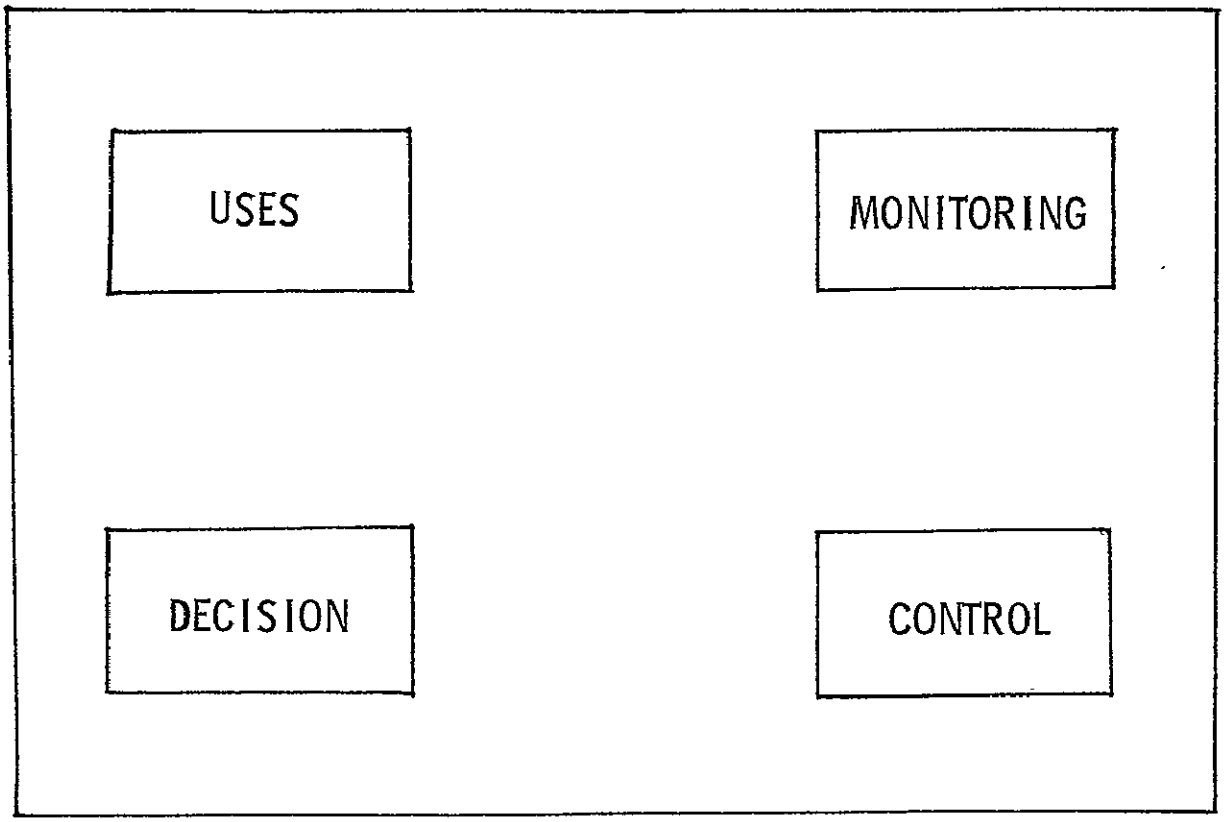


FIGURE 1.2 THE WATER SUBSYSTEM

The following study premises, or ground rules, assist in meeting the objective stated above:

1. Focus on the water component or subsystem.
2. The other components would be considered only insofar as they interact with the water subsystem.
3. Any solution for clean water could not degrade the other components.
4. The James River is the case study area.

The Water Subsystem

The Water Subsystem of the Water Basin System is further broken down into four functional elements (Figure 1.2). These are Uses, Monitoring, Control, and Decision.

Uses: Multiple utilization of a Water System.

Monitoring: Collection and dissemination of suitable information for surveillance, prediction, and control.

Control: Strategy and process by which optimum use is achieved.

Decision: Policy and direction as promulgated by the Water Basin Management.

The Systems Design for Clean Water

The Systems Design for Clean Water shown in Figure 1.3, describes the societal, technical, and managerial interactions within the Water Subsystem. (This system design if consistent with five control system plans discussed later in Chapter V.) In this context, the following chapters present the basic right to high water quality, the greatest wrongs committed in opposition to it, and the remedial plan for recovery of this vital resource.

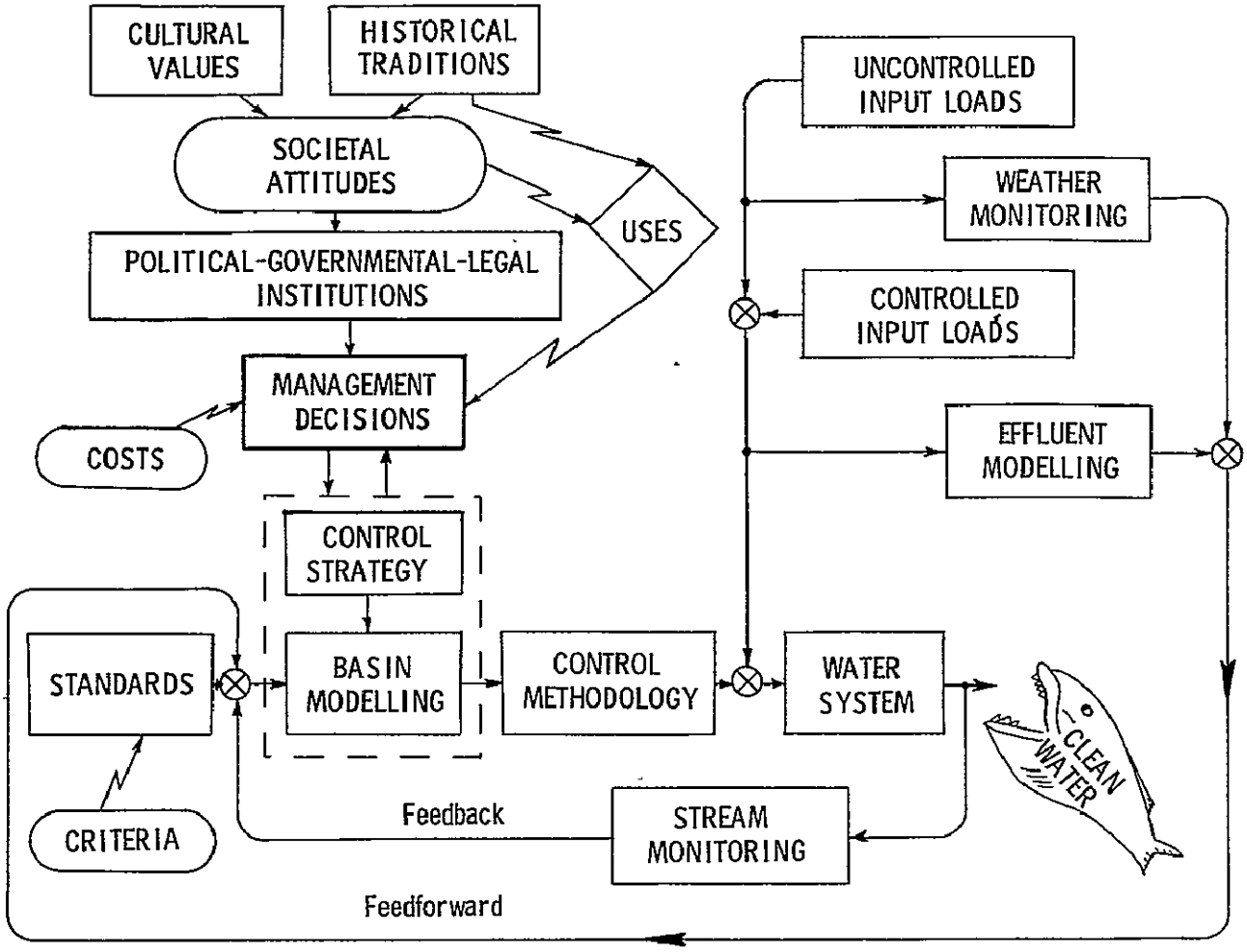


FIGURE 1.3 SYSTEMS DESIGN FOR CLEAN WATER

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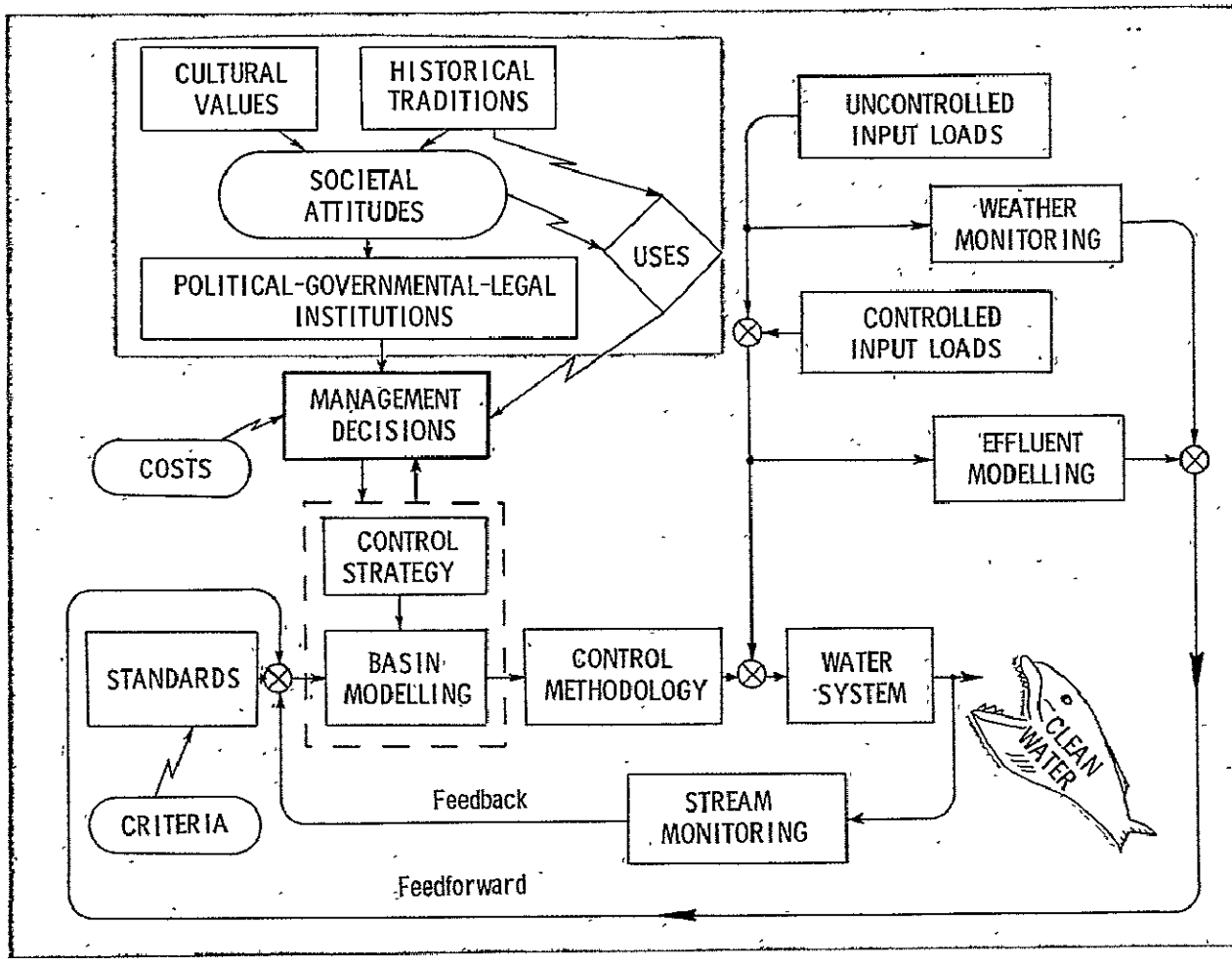
THE SOCIETAL INFLUENCE ON CLEAN WATER



Synopsis

The main purpose of this chapter will be to demonstrate that the problem of clean water is much deeper than one which can be solved by adjustments on the level of political, governmental, or legal institutions. Rather, it is one which involves a more fundamental issue—**viz.**, that of our societal attitudes toward the allocation and use of natural resources.

It will be asserted in this chapter that our political, governmental, and legal structures are merely institutional embodiments of societal attitudes, which in turn are a product of our historical traditions and cultural values. These latter are important, for in the area of natural resources use and allocation, there are very deep historical, cultural, and societal values which place definite limitations on our freedom to bring about changes in the area of water resources management (i.e., to bring about clean water); thus, any recommended adjustments of a political or legal nature must be worked out within the constraints of these more fundamental attitudinal determinants. We suggest that the reader who needs to get the essence of the discussion pursue only this synopsis. The reader who requires additional details should concentrate on the remaining sections of this chapter.

Let us look a little closer at the socio-political input branch of our design for clean water. We would assert that our political, governmental, and legal structures are merely institutional embodiments of societal attitudes, which in turn are a product of our historical traditions and cultural values. In the area of natural resource use and allocation, there are some very deep historical, cultural, and societal values which place definite limitations on our freedom to bring about changes in the area of water resources management (i.e., to bring about clean water); thus, any recommended adjustments of a

political or legal nature must be worked out within the constraints of these more fundamental attitudinal determinants.

The historical traditions of this country have instilled among most Americans a value orientation based upon their frontier heritage in which nature was regarded as a vast open frontier to be tamed, conquered, and used by the pioneering Americans. The attitude toward water and other natural resources was one of exploitation and laissez-faire individualism; and by "individuals" we mean primarily independent entrepreneurs and owners of private businesses and corporations. Typical of the legal doctrine which reflected this societal value was the tradition of "appropriation" established in the Western states which said, roughly, that "anyone could do almost anything he wanted with water resources, so long as he got there first." Neither this doctrine, nor its less radical counterpart in the East, the riparian doctrine, contained much room for any sort of overall cooperative or comprehensive approach to planning for the use of water resources.

The cultural values of Americans, also, reinforced these historical traditions, and were of the type that militated against long-range comprehensive approaches to water resource allocation. Among the values most pertinent to the use of natural resources were those involving:

1) man's attitude toward nature—embodying western European civilization's traditional faith in man's reason, and the influence of Darwin in the late 19th century; the American attitude was that man should use and dominate nature, rather than live in harmony with it.

2) man's attitude toward productivity and progress—reflective of European liberal thought from the Age of Enlightenment up through the Industrial Revolution, progress was most often equated with increased productivity, and was held to be a positive good to be sought after.

3) man's attitude toward cooperation and competition—typical of the laissez-faire economic theories of the age where the goal involved was increased productivity, unfettered competition was considered to be the optimum form of societal and economic interaction. And, this doctrine of free markets or private enterprise in the business sector fit in perfectly with American attitudes toward independence and individualism in the social and international political sphere.

Now, one result of these underlying historical traditions and cultural values is that, where the use of natural resources is concerned, this is a country which has never had a tradition of cooperation in its political and legal institutions. On the contrary, the political environment in the United States has traditionally been one of "bargaining, negotiation, and compromise," rather than one of "cooperation" or "compliance to authority." Political changes which have occurred have generally been ones which did not involve obvious changes in basic philosophy; we have been "pragmatic" rather than "ideological" in our political approach.

Just as our approach then toward the allocation of natural resources has been characterized by exploitation, individualism, competition and fragmentation, so too have there been similar divisions in the legal and political structures established in which to resolve conflicts in these areas. Thus, the various power interests which grew out of amassing control over natural resources inevitably found their corresponding numbers in the governmental and societal institutions of the country. The result is that governmental and political structures have not been created with an eye to cooperation, coordination, rationalization, or systematic planning. Rather they have been established to protect, or at least to reflect the interests of, the power centers within the culture.

While this situation may have been tolerable during eras of shared national values, it is unlikely to be satisfactory in a period of value change. In short, it will be very difficult to effect basic changes in institutional approaches to water management without corresponding fundamental changes in the values of society's power elites.

But the success of these elites has generally been the result of excelling in those particular values which stressed competition and independence; logically enough, members of these power groups now have the greatest stake in the perpetuation of those values. And, since these same power entities are the ones with the greatest access to the sources of mass communications, they are also able to reinforce societal allegiance to the same values—thus creating, in this time of increasing environmental inter-dependence, today's dilemma.

Some understanding of how this societal fragmentation of major power interests is reflected in the political-legal sphere might be realized if we note that in the entire history of

this nation, the only attempts at national legislation on water resources before World War II, came about as reactions to crises situations—generally floods and droughts. Since 1948, there has been an increased governmental concern with water quality on both the federal and state levels. But even here the scattershot ad hoc approach persists.

The most obvious fragmentation is that which occurs in the division of political jurisdictions between federal, state, and local levels. Congress, for example, is divided to reflect powerful state interests in its Senate, and local interests in the House of Representatives.

The great influence of these states and localities has resulted in a retention over the years of the primary authority regarding water resources in the hands of the states. Thus, in all the major Federal legislation water pollution is still generally considered "a uniquely local problem." There are very few long-range, comprehensive, regional, or river-basin solutions to the major problems of water quality. The norm is a fragmented, ad hoc approach to the management of water divided between the competing federal, state, and municipal authorities In addition, there is also a fragmentation within each of these levels of government.

On the Federal level, for example, despite recent attempts at consolidation within one Environmental Protection Agency, there persist many Federal agencies involved in water resources and water programs. These agencies are spread throughout the Departments of Interior, Commerce, Transportation, Agriculture, and Housing and Urban Development.

At the state level, too, the typical State Water Control Board is only one of the many state agencies with jurisdiction over water problems, and must contend as a rule with State Health Departments, Marine Resources Commissions, Sanitation Districts, Fisheries, and Wildlife Federations, and—in the state of Virginia—that department whose very name is a philosophical contradiction in terms—the Department of Conservation and Economic Development.

On the legislative level, the committee structures of the Congress and the State Assemblies are similarly fragmented, with jurisdiction over the funding and policies of the several agencies mentioned being determined by any number of legislative philosophies—each of which is motivated by the fragmented power interests which the particular senior legislators might represent, and which are worked out in a political climate of bargain and compromise.

However, it should be pointed out that these divisions, between and within levels and branches of government, existed in many instances long before clean water became an issue. They are only the external manifestations of what is essentially a lack of political commitment on the part of a society that is composed of divided and countervailing power interests. The point is that there is within this type of society no political will to cooperate toward a long-term "rationalization" of the management of water resources. This lack of political will to cooperate toward a solution is most obvious in the numerous "loopholes" consciously worked into the laws which have been passed, on the state and federal levels, since water quality became a political issue in the post-war years.

For examples of what might be called "inherent deficiencies" written into the law, we might cite:

—Laws which give wide discretionary judgments to the Administrators of the water agencies so that the legal authority to move becomes interpreted as a bureaucratic justification to procrastinate;

—Laws which place the burden of proof for proving pollution exists in a discharge, upon the governmental authorities rather than the polluter;

—Laws which stipulate numerous mandatory time delays for compliance worked into the procedures for enforcement.

In short, we find laws which are the product of compromise and negotiation between power groups—but NOT laws written on the basis of comprehensive rational planning for water resources management.

In addition, there is an almost complete lack of enthusiasm for enforcing what weak legal machinery finally results from the legislative process. We can cite many instances, all of which reflect bureaucracy. Some of the related perennial problems are:

—Legislative cutting-back in the funding for enforcement of anti-pollution legislation; especially in those few areas where administrative machinery gives evidence of moving with vigor. The recent Virginia House Bill No. 192 is an example of this;

—The Justice Department's establishing of cumbersome ground rules in an effort to dissuade its U.S. attorneys in the field from

prosecuting violators of the 1899 Refuse Act;

—Finally, the constant and repeated underfunding of agencies devoted to anti-pollution activities. Despite periodic campaign oratory, budgeting in the area of water pollution abatement activity—even in this day of supposed heightened ecological consciousness—still represents at both the federal and state levels less than 2% of all governmental spending.

The explanation for the loopholes and the lack of political commitment to enforce is that this attitude is endemic to a society which stresses and rewards private competition as the optimal solution to problems of resource allocation. The President, the legislators and the administrators of the law are NOT somehow outside of society and its values, but are parts of it; they share its cultural attitudes The entire governmental and political structure—divided as it is both between and within levels of jurisdiction—is the way it is because it reflects society divisions and its fragmented centers of powers.

There is little evidence that society has changed its attitude toward the allocation of natural resources simply because a few terms like "ecology" and "pollution" have come into the vernacular in recent years; for the basic values which created and sustain the current ad hoc approach to resource management persist, indeed, reinforce the existing political and social framework. Unlike our major governmental endeavors which proceeded without significant financial disruption in the 1960's—the Space program and the Vietnam War—there are powerful vested interests would be seriously hurt if the fragmented approach to the problem of water resources were to be changed and would, naturally, oppose any attempt at "rationalization" of the water management problem.

In short, to solve the problem of water pollution, adjustments in institutions will not strike at the root of the problem unless there is a corresponding re-orientation of basic cultural attitudes toward the environment. In the past, only natural disasters brought about even the minor political adjustments which were necessary as stop-gap measures; never has there been a confrontation with basic cultural and societal determinants. Thus, public relations programs, "educating" the mass populace in new attitudes toward water resources are doomed to fall short unless accompanied by fundamental changes in values among the power elites with the greatest stakes in the existing system.

Social and Cultural Factors Affecting Water Use And Quality Standards

The Emergency of Water Institutions

During the formative stages in the development of our nation there was little concern for water rules and rights of use except those pertaining to navigational right-of-ways and related matters. This neglect can be understood in light of a number of basic facts of life at the time. First, the territory was sparsely populated, and the pressure on water resources was minimal. Second, in view of the fact there was very little competition for the use of water, it was generally assumed that the supply was unlimited. Few formal rules were stated. People relied on informal agreements and common law borrowed from the Old World. After the nation gained independence and moved into the agricultural economy of the 18th and 19th centuries, the expanding farm community increased pressure on water resources for livestock consumption and irrigation purposes. In the East, competition increasingly engendered conflicts, eventually bringing water questions to the attention of town meetings and the circuit court. The prevailing rules continued to be primarily the customs of common law adopted from England and practiced in many regions, since Colonial days.

Apparently, because of convenience and the habit of tradition, the most familiar rules were seized upon as applicable to the demands of farming and navigation. Among the most significant was the riparian principle which states "that a riparian owner has the right to the natural stream of water flowing by or through his land in its ordinary, natural state, both as to quantity and quality, as incident to the right to the land on or through which the water-course runs . . " (1) Even at the pre-industrial stage of American society the riparian doctrine was not wholly suitable to eastern America, and for that matter it had not been an ideal guideline for many years in the expanding communities of "mother" England. In eastern American there was a relative abundance of water resources throughout most of the 18th and 19th centuries. Human and livestock wastes were frequently discharged directly into the water.

However, there is little recorded evidence that any one recognized the danger of this practice much less objecting to it on aesthetic grounds. In fact, since pressure on water resources was light, it is likely that little reflection was ever devoted to the appropriateness or strength of the riparian doctrine. Thus, like other doctrines of common law the rules were institutionalized aspects of the existing culture and persisted with great resilience.

In contrast to those circumstances suitable for the inheritance of a riparian doctrine, the settlement of the largely arid Western states placed great pressure on the limited water resources. The climatic conditions, and the force of an opportunistic cultural orientation, contributed to the widespread development of an alternate set of rules for water use referred to as the appropriation doctrine. In a widely quoted account of the development of American water institutions, Wells A. Hutchins describes and analyzes the appropriation doctrine as one that "accords priorities pursuant to the maxim that the one who is first in time is the first in right, regardless of whether the water is used upon land contiguous to the source of supply or far removed from it." [2]

According to Hutchins, there is some evidence that appropriation was a cultural practice transferred by the Spanish from the Mediterranean region to Mexico and the American Southwest. Upon entering Utah in 1847, the Mormons independently developed the same doctrine for irrigation purposes. Slightly later, in 1849, miners of the gold rush communities in California developed an identical doctrine to expedite competitive enterprise in mining and for supportive milling and agricultural uses [2]

Eventually, "the customs of the miners formed the basis of a number of early appropriation statutes in the western states and territories. They were probably most influential in the spread of the appropriation doctrine throughout the west." [2]

As in the case of the eastern riparian principle, the appropriation doctrine of the West grew from practices consistent with the individualistic competitive themes that stimulated the settlement of this nation Moreover these practices persisted throughout the 19th century and influenced the development of the formal legislative phases of American water institutions which began in the 20th century.

Cultural Conditions Underlying the Development of Water Institutions

Water institution, like other aspects of our culture, have emerged through the convergence of a number of forces including ethnic traditions governing water use, circumstances in the natural environment, plus a most basic feature of our culture—the ethos defining man's relationship to nature.*[3] The problematic ethos of western civilization that has been adopted in American culture is a secular philosophy that Paul Ehrlich has noted "sees man's proper role as dominating nature, rather than living in harmony with it." [4] This philosophy, coupled with a major cultural commitment to a competitive progress yields a powerful and pervasive ideology that fashions emerging ideas in a manner consistent with further societal exploitation of the natural resources. In short, the roots of American water institutions are very deep, and under these circumstances the process of change is very difficult to perceive. Indeed, water rules do not appear simply as a matter of snap decision, by accident, by deliberate rational process or by the force of tradition, but rather out of a convergency of all these forces. It is a gradual process, and one that is undergoing constant change.

There are two very critical aspects of the process of change that need further explanation. First, any new idea for water use must meet not only the test of utility, but it also must fit or complement the existing culture In other words, the existing culture operates very much like an "idea filter." New ideas that are in conflict with existing water use rights and practices may also be in conflict with more basic cultural themes. Dissonant ideas will, therefore, generally be filtered out or ignored by the actors of that society [5] [6] [7].

Thus, a proposed change that represents a relatively narrow alteration in means, procedures, or techniques will proceed with relative ease. However, a change that is confused with or involves restating basic philosophies or goals will be intensely resisted. Change will also be resisted to the extent that it involves an item of culture that has strong interdependence with other levels

*The ethos of a society refers to ideas that prevail the culture, providing a basic "flavor" that lends direction to the development of all its institutions and core value themes

or systems of ideas within that culture. This is due to the fact that a change affecting only one aspect of social activity will distrub the life patterns of less people in fewer areas of life than those that have implications for activity in many areas, e.g., if the change affects family life and religious activity as well as one's occupational activity [8] [9]. Since there can be little doubt that many current solutions for water problems have met the negative form of these conditional statements, proposed solutions to the problem continue to encounter resistance.

The operation of these limiting conditions can be illustrated lucidly by examining some of the basic adjustments to water rules that have taken place since the mid-19th century. During this era the country witnessed the first serious challenge to the agrarian life style as the industrial revolution of the European continent spread to large American ports. By the late 19th century the industrial capacity of the eastern U.S. grew to the point that it placed a noticeable competitive pressure on water use. Nevertheless, little legislation was created at either a state or federal level. Changes in water rules were still a matter of judicial review. (Common law) A number of cases in the East dealt with the apparent violation by industrial users of the riparian principle that entitled one to the "ordinary use of the water including the right to apply it in a reasonably way to purposes of trade and manufacture . ." [1]. For example, a Maryland court interpreted the common law in favor of an alleged polluting manufacturer utilizing this "reasonable use" principle as follows:

> What nature and extent of pollution will call for active interference of the court is not in all cases easy to define. It is not every impurity imparted to the water, however small in degree, that will be the subject of an injunction. **All running streams are, to a certain extent, polluted**; and especially are they so when they flow through **populous regions of country and the waters are utilized for mechanical and manufacturing purposes**. The wasting of the manured and cultivated fields, and the natural drainage of the country, of necessity bring many impurities to the stream; but **these and the like sources of pollution, cannot ordinarily, be restrained by the court**. Therefore, when we speak of the right of each riparian proprietor to have the water of a natural stream flow through his land in its natural purity, those descriptive terms must be understood in a **comparative sense**; as **no proprietor** does receive, nor **can he reasonably expect to receive, the water in a state of entire purity**. (Bold supplied) [1]

As a result of these cases, an individual's legal right to protect water-related resources is largely restricted by the nature of his property interest. Under the appropriation doctrine, a water owner can legally attack another's unreasonable use of water through a nuisance action only if his **own** property is unreasonably affected. [10] In riparian states, the government is considered the proprietor of public waters as well as the primary regulator of water quality by use of the state's police power In practice, this means that a public nuisance (e.g., lowered water quality which affects all riparian owners equally) can be enjoined by state legal action, but not by the private suit of an owner. [10]

Under the riparian doctrine the public at large has had even less recourse where abuses occur. The state as proprietor holds ownership of public water-related resources as trustee for the general public. However, the common law imposes only limited restrictions on the state's ability to degrade or dispose of public resources. A private citizen does not have a constitutional right to a non-degraded environment since the state's role as proprietor supervenes its role as trustee. A citizen can challenge a state government's decision to sell wetlands or allow lowered water quality only when the action of the government is corrupt or a flagrant violation of designated state responsibility. The notion of a "public trust" does not define a citizen's property right in or constitutional right to a viable environment. [11] Under these conditions it has become a fairly simple matter for private investors and municipalities to gain access to this property for any type of development.

Twentieth-Century Problems

By the time we had moved into the twentieth century, the combined pressure on the forests and grasslands from industry, agriculture and urbanization had divested the land in many regions of the East and Midwest of its absorbent properties. These conditions presented the country with alternating threats

of drought and flood. Once again the societal reaction to these problems was completely consistent with the major cultural orientations discussed above. The tradition of free enterprise in light of the success of a growing industrial empire provided tremendous impetus to seek a solution that would not challenge or threaten "progress."

These forces contribute significantly to an explanation of what political scientist Henry C. Hart refers to as the "crisis oriented," piecemeal approach to water problems followed by governmental control at all levels. [12]

It is apparent that long range comprehensive planning is required to solve our water resource problems. However, Byland has demonstrated that people have a fear of water resource development projects which may bring many unanticipated changes in their living arrangements, standards of living, or occupational activities [13], [14] In the American context progress connotates economic and technical changes that will tangibly improve our way of life in the here and now. And tangible progress spells changes in our material standards of life—our consumer capacities.

That people are predisposed to solutions with consequences that are highly predictable is understandable in light of our predominate social investments in a sacrosanct philosophy that stresses individual comfort and competitive gain. Long range, comprehensive planning very definitely implies making choices now that will have unknown extensive consequences for choices later. That is, growth and economic expansion in certain directions may be precluded now.

Under these conditions there is little willingness to plan and provide the sanction and societal commitment necessary to change direction until it is too late and too expensive to solve the problem in fashion that would provide the greatest satisfaction to the most people. Citing data from the President's 1950 Water Resources Policy Commission report, Hart shows the telltale relationship between the crisis of flooding and legislative action: "The first great flood of the century, in 1901, brought no legislative response. Floods were still acts of God." [12] The multiple effects of the destruction of forest and indigenous grasses were being felt in many ways.

Gradually, a conservation movement rose to meet the occasion. By the time of the second great flood, in 1903, President Theodore Roosevelt, had provided a human input into the problem through his conservation crusade which was well underway. Congress was stimulated to modify the Rivers and Harbors Act to include data collection and planning for flood control purposes. From there until 1950, Hart shows that flood crisis continued to stimulate legislation and the appropriation of government funds for water resource development. Furthermore, most of the 26 pieces of major legislations enacted from 1903-1950 took the form of water storage and flow control action While some of the acts included provisions for several uses of water resources, most relied on the concept of the "multi-purpose reservoir." They were multi-purpose reservoirs to be sure, but their alternate purposes were generally those that could be adapted to flood control dam programs. [12]

However, several acts were passed outside of the atmosphere of immediate disaster. They have contributed to water policy, but again they were isolated pieces of legislation which added to the fragmentation of the development of a comprehensive water policy. These acts included: the 1911 Weeks Act authorizing national forests for watershed protection, the 1920 Federal Power Act, the 1937 Water Facilities Act (USDA Pond Building Fund), and the 1948 Water Pollution Control Act. [12]

Two other acts of a more comprehensive nature, the Boulder Canyon Project Act of 1928, and the Creation of TVA in 1933, were also erected outside the atmosphere of flood crisis. However, their attractiveness lay in their potentiality not only to control floods, but to provide a self-supportive saleable product in the form of hydroelectric power. [12] Also, there can be little doubt that depression economics provided sustenance to the progress of these two projects.

It is unfortunate that most efforts to create policies for broad planning failed to get off the ground. The plans certainly had merit, but we must agree with Hart who listed these plans as failures. According to Hart the major efforts include:

> Theodore Roosevelt's national conservation commission of 1908, Congress' National Waterways Commission of 1908-1911, Senator Newland's abortive Waterways Commission in 1917, Franklin Roosevelt's Committee on Water Flow and National Resource Board in 1934, his National Resource Committee in

1935, and George Norris' proposal for Seven Regional authorities in 1937—all were nationwide in scope, policies of reorganization, or plans for study; none called for specific water-control works. Accordingly, put forward during or on the eve of serious floods, they could not compete for congressional support with lists of dams and levies in the stricken river valleys. [12]

The attitude of Congress and other governmental entities is apparent here, but this proclivity in water action policy has continued to manifest itself throughout the 1950's and 60's despite the fact the national water problem has broadened in definition to include various forms of pollution. In these two decades (and up through the early 70's), population and industrial pressures have reached a point wherein poor water quality is a visible national reality. Public thinking and legislative action have to an extent reflected a growing sensitivity to the problem as witnessed by the fact that most of the legislation directed at pollution has been enacted in the last two decades. However, once again the filter action of our cultural orientation and the supporting societal commitments have resulted in a very slow almost negligible progress Once again our approach has been to enact legislation which has the effect of protecting vested interests and value orientations inconsistent with the realities of twentieth-century life.

Exploitive Orientation in Modern Societal Actors

Between 1966 and 1970 only about 1.2% of the funds available to EPA for water quality control went into enforcement while better than 87% went into municipal treatment plant construction subsidies. To compound matters, indications are that most of the construction grant proposals submitted by local agencies are approved. Seldom do EPA officials interfere with local and state government prerogative even if combined facilities for contiguous municipalities or other adjustments would be more efficient than proposed separate systems. [15. Ch. 16-17]* The distribution of funds within the program is directed toward construction which maintains the waste production pattern consistent with dominant interest and value orientations. [16] Deference to "local approaches" is an acknowledged rule of administration, and in this respect, treatment plant construction follows the line of least resistance.

It is clear that the concept of "local control" is given deference at every turn in the law and administrative practices Local control is a concept that developed as a safety mechanism, designed and built into our political system to preserve individualism and competitive achievement. However, with the growth and complexity of communities in the modern era, local control provides increasing opportunities for special interest groups to thrive behind the shelter of fragmentation that characterizes government and modern life in all spheres. To the average citizen, city hall or the state house may seem to be just two more links in the astounding maze of rules, procedures, subterfuge, and other characteristics he finds so typical of government. The resulting alienation produces a sense of powerlessness [17], [18]

Taxpayers at all levels of American society support the efforts of state and municipal officials to minimize all costs for the benefits of all public services It is the view of the common man that pollution control is just one more attempt of government to impose unwanted values on him and to reduce his margin of affluence [19], [20]. The result of this trade off is more contaminated effluents.

The Nader Task Force report pinpoints the problem as one of powerful interest. Private interests and elites have experienced success under the existing scheme of priorities and rewards, and are therefore understandably committed to maintaining the status quo. At the same time these are also the interests possessing the necessary wealth and communication resources to reinforce and perpetuate the existing system [21], [22], [23], [24] One manifestation of powerful private investment interests is the use of lobby and advisory councils representing business interests. Money and communication technology is brought to bear on many aspects of policy formulation, but one of the most noticeable demonstrations of this facility has been evident in the inability of Congress to provide EPA with the administrative backbone necessary to identify and regulate pollutants discharged by industry. Most difficult is the task of keeping up with changes

*In addition to the cited reference, several project staff fellows ascertained these facts in interviews with EPA officials in Washington, July 1971

in the manufacturing processes. To do this most successfully "monitors" need access to plants themselves and to knowledge of the particular manufacturing process—an authority almost impossible to obtain. There is no federal antipollution law which gives the government authority to inspect industrial plants or their waste treatment facilities.

The permit issuing authority of some state pollution control boards has provided this right, but in practice authorities seldom inspect operations without providing industries with at least a few days' warning—effectively allowing them to tidy up their operation in the course of investigating pollution complaints and under the same strict ground rules federal authorities have also occasionally inspected plant processes on the site. Because of the restrictions generally put upon these investigators, one regional EPA Water Quality Office has reported that it spent roughly one-third of its meagre enforcement budget gathering information independently which could have been saved if direct access to industrial plants were possible. [15· Ch. 12]

One method of gathering such information which is used at the Federal level is the permit-issuing authority expanded from the Army Corps of Engineers to the OWP of EPA on July 1, 1971. This requires the disclosure of effluent data—not of manufacturing processes—by industrial polluters as a pre-requisite for a discharge permit. However, this information still reveals only the end product being dumped into the river. It will be several years before it is known whether the information to be provided by the industries applying for these permits is detailed enough to yield the kind of data desired.

Michigan recently passed a law (April, 1971) requiring industries to list all raw materials used in any manufacturing process likely to have an effect upon the environment. [15: Ch. 12] However, industry has been traditionally successful in preventing the creation of any governmental authority which would threaten to impinge upon the hallowed ground of "trade secrets." Comprehensive national inventories of wastes from municipalities and federal facilities have been taken for several years. However, the one short-lived attempt by Congress to set up a National Industrial Waste Inventory was quashed by the **Business Advisory Council on Federal Reports**, a counselling body to the Office of Management and Budget. Thus, the prospects for a Michigan-type law at the federal level, or in other states, is not very likely. [15: Ch. 12]

Similarly, Anderson and Geersten have documented the noteworthy facility with which corporate interest groups dominate the media, skillfully manipulating sacred cultural symbols ("well chosen patriotic expressions"), in order to inflame public anxiety, stemming from proposed water resource development projects, to their advantage. [13], [25] The Nader Task Force also documents the recent corporate practice of issuing veiled economic threats and innuendoes based on the contentions that "we can have employment or environment but not both." [15: Ch. 7-10]. These threats could not be so effective were it not for the fact that the public is receptive, i.e., they place creature comforts at the top of their priority scale and lack political consciousness of environmental crises. The small pieces of evidence available at this point regarding public attitude indicate that concern over and even awareness of the problem, despite the high level of media exposure, is an elite pleasure at best. It is a problem of little concern to the lower-middle and lower socioeconomic classes in America. [19]

The lower strata are in some cases struggling with serious subsistence problems or, on the other hand, are concerned with making the "system" pay off with at least a modicum of success and the material luxuries of "the good life." This is an experience their parents missed, but one in which they have invested their faith and savings for their children. [26], [30]* Water quality is a remote problem from their point of view.

Summary

At this point let us review our analysis and sharpen our focus on the main socio-cultural forces that have generated and reinforced our water management problem. The first impediment lies at the very base of Western and some Eastern cultures, e.g., the U.S.S.R. It is a universally shared expectation that man should dominate rather than live in harmony with nature. The corollary to this is an expectation that man should turn nature to his own ends and prosper from her abundant resources. The attitude that has prevailed in other countries—notably the U.S.S.R.—is that

*For the hard-core poor there may be a complete rejection of main stream values and political concerns of the affluent

the resources, particularly air and water, are there for the taking. [4], [27] They are free for society to use as it pleases. The appropriate societal unit-level at which the direct or indirect benefits of a natural resource are distributed varies—between societies sharing this attitude. In America the benefits are acquired and/or set up for distributers to individual or private interests whereas in Russia the benefits are set up and distributed by the state, for the state.

A second basic problem is our belief that growth in community size and industrial productivity is synonymous with progress and prosperity. We share this ailment with many industrial societies including Russia. In both cases progress and prosperity are rooted in an exaggerated equation of materialism with human well-being In Russia the concern is for the wealth and power productivity accruing to the state—collective prosperity is enhanced as the state makes gains in the international market and political arena. In America, of course, the benefits of productivity accrue directly to private interests. Prosperity is defined as individual success and corporate wealth

The most critical cultural aspect of the problem is difficult to identify. Some have argued, upon observing that Russia has a serious pollution problem, that capitalism and the free enterprise tradition cannot be at fault since Russia is a communist nation. [27] The problem, it is agreed, must lie in the urbanization-industrialization processes. This argument ignores the fact that forces of the international competition have modified American and other capitalistic countries until they are hardly recognizable as free enterprise systems. Relationships between the Defense Department, AEC, and NASA contractors, e.g., Lockheed, are perhaps the most obvious examples of this point. [28] Through similar processes of international interaction, Russia has hardly become the Marxian model of collectivistic finance. It would be more accurate to say Russia operates under a form of state capitalism. Is it then a problem of some form of capitalistic financial-reward system or is it industrialization-urbanization?

We think it is none of these processes; rather, it is a fundamental normatic outlook in values that underlies each of these processes. In fact, pollution is quite evidently a growing problem in many urban industrial areas of Southeast Asia such as New Delhi and particularly in Far Eastern cities like Hong Kong. Here, despite a good deal of industrial development (and in some cases, development that much precedes our own.) they have never managed the consistent growth and expansion characterizing our own economic development. Economic perspectives have not developed within a highly rational-systematic evaluative context that provided the West cultural mooring for capitalistic modes or production. [29] Although Far Eastern areas lack the economics of capitalism (and their industrialization process reveals many other differences), they certainly have a growing pollution problem. What then is the answer?

The value orientation we have eluded to above is a shared attitude common in several areas of the world—but excessively characteristic of the U.S. and now Russia—that say **competition** is the optimum form of interaction for distributing resources and the benefits that are the yield of production. In Russia this competitive orientation has applied primarily to its external relations, but now on the domestic scene interregional and even individual **competition** is increasingly apparent. [27] The entrenched belief is that competition is the most efficient relation between productive units of any size for maximizing the rewards of production—monetary profit and power. This places a premium of course **on production volume and cost minimization.**

When these key values are persistently defended and reinforced at most levels of society, by those who have obtained the very rewards that the culture has taught them to need, it is small wonder that there is little inclination to internalize the social costs of production and growth. In short, the water quality point of view faces a severe test. The values of those with interest in a quality environment stand in stark contrast to both the dominant values of affluent societies and the interests that epitomize these values. This then is an ideal context within which to maintain a fragmented approach to water policy.

Fragmentation Between Governmental Jurisdictions

If, as has been previously noted, ours is a culture that denies planning and relies upon a fragmented approach to the solution of problems so that the predominant major interests can control processes of societal change, then this is most evident in the Federal-state structure of our governmental institutions. The protection of local and state prerogatives is guaranteed in the division of

the national legislature into a House of Representatives (where local interests are protected) and a Senate (where state jurisdiction is enhanced). It is because of an acute awareness of state and local government prerogatives that the federal government historically has hesitated in moving in areas of primary concern to these lower jurisdictions unless overwhelming national interest in the specific problem could be demonstrated.

Traditionally, regulation of the use of natural resources has been a state responsibility. However, the Constitution grants to Congress the power to exercise full and complete regulatory authority over interstate commerce. Therefore, Congress, if it so chooses, may pre-empt any portion of this regulatory field and deny the states any concurrent powers [31] . Also, the nature of such regulable "commerce" and methods of regulation have been very broadly defined. For instance, the movement of pollutants through waters which cross state lines is in itself "commerce" and subject to federal control. Interstate waters are defined as "...all rivers, lakes and other waters that flow across or form a part of state boundaries, including coastal waters." [32:sec. 23(e)] Congress may also regulate all navigable waters to regulate matters, such as water pollution, which may have no demonstrated effect on navigation and which have been traditional concerns of the states' Police powers. [33] The Supreme Court has extended the definition of navigable waters from those which ". . .are used, or are susceptible of being used, in their ordinary condition, as highways of commerce . ." to: [34]

----the entire stretch of a stream which is navigable only in part,

----those which are "potentially susceptible of navigation," [35]
(i.e., the Corps can channelize it);

----non-navigable tributaries of navigable streams, if navigability or interstate commerce is affected. [36]

Beyond this uncontested reach of federal jurisdiction, a strong legal argument can be made that subsurface waters and non-navigable, intrastate streams are federally regulable, (e g., on the grounds that regulations of other waters gives polluters of sub-surface waters an unfair competitive advantage.) [37] [38] .

Thus, in theory there is strong constitutional jurisdiction for a very broad federal role in water quality management. In fact, the present Federal Water Pollution Control Act severely limits the constitutionally permissible reach of federal action. Sec. 1 (b) declares the intent of Congress to "recognize, reserve, and protect the primary responsibility of the states" [32: sec. 16] in this field. Thus, despite federal interest in water quality since 1948, every piece of national legislation since that time has been written to retain primary authority--not just flexibility in implementation--at the state level. The jurisdiction of the national government--the one level of political activity strong enough to withstand the pressures of local special interests--in the area of water pollution abatement has been circumscribed very carefully.

Section 10 (a) allows federal enforcement only on interstate or navigable waters. Even this conservative assertion of jurisdiction is a practical fiction, for EPA may begin abatement action on its own initiative in only two situations:

--when "substantial economic injury" results from damage to shellfish;

--when pollution caused in one state endangers the health or welfare of persons in another.

Note that it is the pollution, not the waters, which is required to be demonstrably "interstate" before Federal jurisdiction can be invoked; and even this limited authority is narrowed by stipulating that the pollution has to flow "into" a second state, and not merely "from" or "over" a state's boundaries, thus effectively eliminating from federal jurisdiction rivers flowing seaward in 22 coastal states.

In any other circumstances, EPA can act only with the consent of a Governor of a state. This has not been readily forthcoming in most instances because the same pressures working upon state governors not to enforce their own water pollution laws vigorously (e.g., dependency upon major industries for employment and a tax base) would also work against a Governor's calling in the Federal authorities. In addition, there is the normal desire for good relations with a neighboring state and the persisting penchant of most governors for the protection of states' rights. Indeed eight of the eleven times the Federal Government has been requested by a Governor to hold an enforcement conference have occurred during an outgoing Governor's last year in office. [15: p. 7]

More importantly, when the Federal Government moves without a Governor's request, it must have not only the state's tac

acquiescence, but also its active cooperation for Section 10 (b) stipulates that the states are the primary enforcement agents of the recommendations of the enforcement conference and, if the case goes to the second stage of the proceedings, of the hearing board. It is only at the seldom invoked third state of judicial acton that the Federal government would move into the enforcement role. Consequently, the states are still the critical link in the enforcement of federal water pollution control laws.

This particular set of federal-state relations which places primary responsibility upon the state has, unfortunately, not resulted in any significant observable successes in the efforts of government to improve water quality on the nation's streams and rivers. The shortcomings in the existing arrangement are generally of two types: (1) the disparity of power between the enforcing authority and the polluter; and (2) the lack of clarity of jurisdiction among the various policing authorities. A clarification of existing jurisdictional arrangements in the establishment and enforcement of water quality criteria would seem to be in order.

It seems that the level of government within the actual river basin would be the jurisdiction most familiar with the unique local problems of water supply, demand and quality. However, it is at precisely this local level that societal and political dependency upon the good will of major polluters (e.g., the largest employer in a one-industry town) is most extreme and so the power of the enforcing governmental authority is often not equal to the task. More important, however, a river basin, includes a number of political jurisdictions; and what measures may be appropriate for river use in one locale, may be very inappropriate for river quality elsewhere downstream. Consequently, some authority encompassing the totality of the river's watershed, and which could be responsible for the total effect of environmental interaction with the river, would be more commensurate to the task. Such a regional authority, however, seldom corresponds to existing political subdivisions or commands the primary political loyalties of citizens and thus would be hard pressed to assume the taxing or enforcing authority necessary to manage the total system of waters in the river basin. Consequently, the existing supra-levels of governmental jurisdiction have to be employed.

For river basins contained entirely within one state, this would appear to be the level of state government. However, there has been a distinct unwillingness to commit funds on the state level adequate to the job of properly managing river quality. Most state water pollution control boards command less that 1 percent of a state's budgetary allocations. In Virginia the operating budget of the State Water Control Board is about $15 million out of a total annual state budget of $3.8 billion. Even such meagre totals as these have been attained only as the result of federal programs of research, technical assistance, training, enforcement, and construction as were initiated in 1953, 1961, and 1965 in order to provide the "catalyst" to spur state agencies to action with matching funds An analysis of the Virginia State Water Control Board's annual budgetary expenditures for the 25 years of its existence since 1946 shows precisely such dramatic increases in activity following the initiation of federal programs in 1958, 1961, and 1965. (See figure 2.1)

A precise analysis of the breakdown of state versus federal funds in these total annual appropriations (see Chapter VI) shows that the Federal funding alone did not account for the increase in spending following the years 1956, 1961, and 1965. Indeed, the state component of the total has in the case of Virginia consistently been greater than the federal. However, the initiation of movement on the federal level (e.g., the standards program, the enforcement program, the construction grant programs, etc.) is often sufficient impetus for the state water agency to justify increased funding support on the state level in order that it may be able fully to qualify for and participate in the new federal programs.

In addition to the spur toward activity which the injection of federal money has for a state's water pollution control program it's also true that federal enforcement on water quality standards would represent the strongest level of authority which might be applied to a polluting situation. Given the power of some of the targets against whom the laws must be invoked, it would hardly be a case of overkill to rely upon Federal instruments. Indeed there are many instances of states and municipalities actually having stronger water quality standards, but being unable or unwilling (i e., reluctant to enforce them after considering the nature of the violater, or e.g , a large municipality or the major employer in a one-industry town).

However, because of our Constitutional structure, and the preferred reliance upon

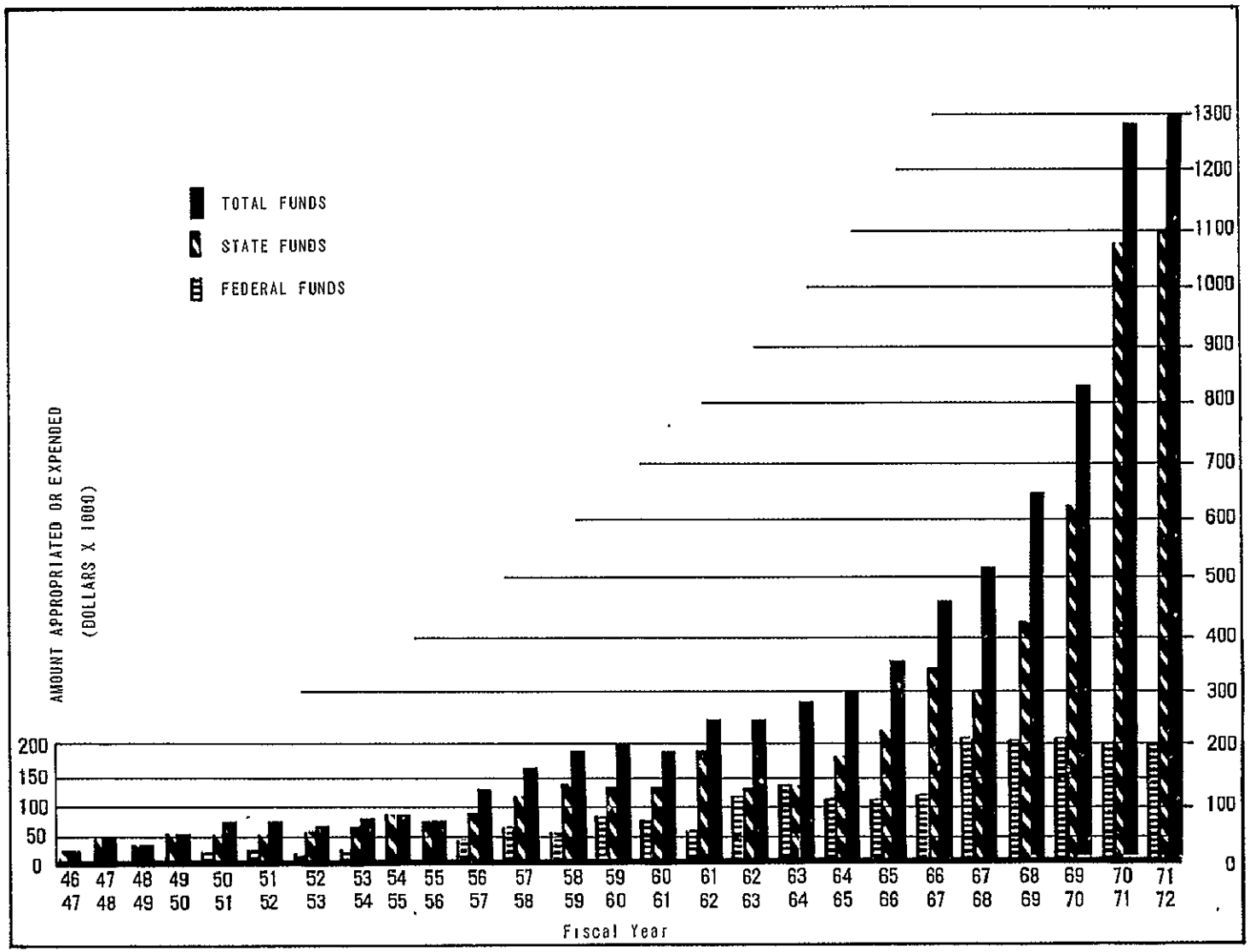


FIGURE 2.1 OPERATING BUDGET — VIRGINIA STATE WATER BOARD

state authorities for the primary enforcement of federal anti-pollution laws since 1956, there has not been any vigorous enforcement activity by the one level of government equal to the task. For all intents and purposes, the philosophy the "pollution is a uniquely local problem" (i e., the laws must be interpreted and implemented at the lowest possible level of jurisdiction) has been successfully used to keep the Federal presence to a minimum. The Federal laws since 1956 have been effectively emasculated by keeping enforcement at a weak enough level (i.e., the state) that the major targets of pollution enforcement action can often dominate.

The attitude of state administration toward industry is generally protective with temporary preferential tax treatment, and promises of freedom from tough pollution control requirements often written into advertisements and solicitations enticing industry to locate in the state. Quite often the state water pollution control boards have seats allowed to industry representatives. Thirty two of 50 states have this representation explicitly alloted; in others it happens more informally (see Appendix E). As a result, even though states frequently have strong antipollution laws on the books, there is a reluctance to enforce them

It is even more difficult to get vigorous action at the local level. For example, several municipalities--such as Akron, Chicago, New York, and Detroit--have drafted legislation to ban phosphorus from detergents sold in their areas. In additon to the fact that residents can go across city lines to buy the detergents, such low-level legislation is relatively easy for a major industry to challenge on the local level. The detergent industry, for example, has successfully enjoined the city of Akron, Ohio, from enforcing its regulation. Suffice it to say, the city of Akron is less formidable target than the Federal Government, and for many such municipalities the effort to withstand court challenges and enforce might cost more than the benefits to be derived.

Since few major watersheds are entirely intrastate, some form of inter-or suprastate coordination is necessary for comprehensive management. Informal arrangements between states are inherently inadequate since compliance with such agreements is completely voluntary. One state's recalcitrance on any essential point means the collapse of an integrated plan.

The interstate compact provides a more sturdy framework for river basin management Although some forty compacts dealing at least in part with water quality management have been approved, the cumbersome approval process has ensured that none of them provides the tools necessary for an entirely adequate approach. Each formal compact must be approved verbatim by each state legislature, the Congress and the President. Not only has the approval process averaged nearly nine years, but the provisions of a compact typically conform to the concessions granted by the most reluctant state. Most commissions established by compact can merely collect data and submit planning suggestions to the states involved. As a result, most are simply advisory boards without enforcement power. [37]

Only the Delaware and Ohio river basin presently have reasonably successful independent commissions established by compact The Delaware River Basin Commission is governed by a board composed of representatives from the four member states and the federal government. Each of the five members has an equal vote with a majority necessary for Commission action. The Commission has sufficient authority to allocate river flow and assimilative capacity to water users and waste dischargers. While the Commission has the power to seek injunctions against violaters, its present policy favors cooperation to coercion. Enforcement action is left to the state agencies. This policy is probably necessary since DRBC is financially dependent on contributions from members. The Commission also lacks any direct control over land use. Nevertheless, the Commission has begun to implement a promising abatement program for the most heavily polluted reach of the Delaware. [39]

The Ohio River Valley Water Sanitation Commission (ORSANCO) has more limited powers. The eight member states contribute a total of less than $200,000 yearly for the Commission's operations. ORSANCO's telemetered stream monitoring system is one of the best in the country, but abatement is accomplished entirely by persuasion since each state can veto any enforcement of the standards set by the Commission. [40]

The inherent weaknesses of these independent basin commissions cast doubt on their ability to successfully carry out long range pollution control plans. ORSANCO is essentially a data collecting body which enforces only by persuasion. It is very susceptible to the political pressures which a less cooperative policy would create. DRBC

promises to be relatively much more effective, but its financial dependency forces it into a cooperative posture Since DRBC has no authority to manage land use and does not have the present financial capability to own and manage treatment works, its waste allocation plan may collapse under the pressure of industrial and population growth.

One recent compact has created an independent agency with the board powers necessary for comprehensive management. The Tahoe Regional Planning Agency has the authority to implement a plan for the lake region. The Agency regulates all waste discharges, operates a regional treatment plant, enacts zoning ordinances to effect land use planning, and has primary regulatory control over all natural resources in the area.[41] Of course, the successful approval of this compact is directly related to the unique situation at Lake Tahoe and does not portend similar compacts elsewhere. There is no analogy between an isolated mountain resort area and a heavily populated and diverse river basin.

Given the inherent problems of weakness of power and vagueness of jurisdiction which are present in an exclusively local, state, or regional machinery would appear to be a possible corrective. This would not involve the complete elimination of the lower authorities, and indeed could utilize the valuable existing machinery at these levels of jurisdiction for the implementing of federal enforcement and federal standards. An increased federal role would, however, bring about a greater uniformity of national water pollution standards, so that industries could not threaten to leave one locality for fear of "strict" enforcement, for another locale where they might expect more "tolerance."

Fragmentation Within Levels of Government

The fragmented, ad hoc approach by which our society responds to comprehensive problems such as the management of water resources is evident not only in the division of jurisdiction between the federal and state layers of government, but also within the administration at each level. At the Federal level, despite the creation of the Environmental Protection Agency in 1970, there are still many functional and jurisdictional matters pursuant to the management of water-related activities rightly claimed and exercised by other significant governmental entities such as the Army Corps of Engineers, the Office of Management and Budget, and the Departments of Justice, Agriculture, HUD, HEW, and Interior.

On the state level, despite the existence of water control boards or commissions in most states, there is still overlapping authority with the various departments of health, economic or industrial development, and fisheries or marine resources, as well as port authorities, and states attorneys generals' offices which might interfere with a water quality board's exclusive and unfettered action. Chapter VI, "A Case Study: Clean Water for the James River," gives a detailed look at such divisions of authority in one state--Virginia. The remainder of this section will be devoted to a look at such conflicts of jurisdiction at the federal level.

Since December 2, 1970, the major federal agency charged with water quality control has been the **Environmental Protection Agency** (EPA). Responsibility for water quality has been spread throughout the functional subdivisions of EPA since April 1971, with the central coordinating agency being the Office of Water Programs (OWP).

Previously this responsibility was centralized in the Water Quality Office (WQO) of EPA (from December 1970 to April 1971); and in its predecessor organizations such as the Federal Water Quality Administration (FWQA) when it was in the Dept. of Interior (1966-1970); and the Federal Water Pollution Control Administration (FWPCA) when it was in the Dept. of HEW (1961-1965). In terms of functional duties, however, OWP, WQO, FWQA, and FWPCA generally refer to the same agency with proper allowance being made for the correct time period.

The evolution of EPA as the primary federal agency concerned with water quality began with the National Environmental Policy Act of 1969 (NEPA) which had three major purposes: to declare a national environmental policy; to force federal agencies to consider fully the environmental consequences of their proposed actions; and to establish a Council on Environmental Quality which would formulate and directly advise the President on environmental policy.

Sec. 101 of the Act stated general policy objectives in sweeping language. The federal government should use "all practicable means" to assure "safe, healthful, productive, and aesthetically and culturally pleasing surroundings" for all Americans; to expand beneficial uses without degradation or undesirable and unintended consequences;

and to act as "trustee of the environment for succeeding generations." [42]

While these policy statements do not create a judicially enforceable right to a non-degraded environment, they do provide the basis for courts to recognize a "paramount national interest" or "overriding federal policy" in environmental cases. In practice, this means that courts should give more weight to environmental factors when reviewing the actions of state or federal administrative agencies or when adjudicating disputes between private parties. The scales should tip more in favor of environmental protection than traditional legal theory allows. In addition, these broad considerations should be a factor in federal agency planning and action.

The most important section of the act for our purposes was the establishment,on January 1, 1971, of a national **Council on Environmental Quality**-- a three-member panel (appointed by the President), whose chief function was to assist and advise the President in the preparation of a yearly Environmental Quality Report for Congress. The Council was also enjoined to coordinate all Federal programs related to environmental quality. On April 3, 1970, pursuant to the Environmental Quality Improvement Act of 1970, the **Office of Environmental Quality** was established to provide the professional and administrative staff and support for the Council of Environmental Quality.

Upon the recommendations of the bodies, on July 9, 1970, President Nixon issued Reorganization Plan No. 3, establishing the Environmental Protection Agency whose general purpose was to combine "into one agency a variety of research, monitoring, standard-setting, and enforcement activities" for the purpose of making a "coordinated attack on the pollutants which debase the air we breathe, the water we drink, and the land that grows our food." [43: pp.294-25]

The EPA is independent of any other Cabinet Department, similar in status to NASA or the AEC. Its main role it to "establish and enforce standards, monitor and analyze the environment, conduct research and demonstrations, and assist State and Local government pollution control programs."[43: p. 25] Its total budget for its first year of operation (FY1971) was 1.4 billion.

In the field of water quality control, the new EPA had transferred under its jurisdiction the following agencies and bureaus, from existing Cabinet departments·

--from the Department of Interior, the Federal Water Quality Administration;

--from the Department of Health, Education and Welfare, the Bureau of Solid Waste Management and the Bureau of Water Hygiene. (These two bureaus were in HEW's Environmental Control Administration.)

In addition to these agency transfers, certain functions and authority pertaining to water resources previously delegated to offices throughout other government departments were also transferred to the EPA, including activities pertaining to radiological health in the Atomic Energy Commission and the Bureau of Radiological Health in HEW, and some functions relating to pesticides being performed by the Department of Agriculture and the Department of Interior.

Since the internal reorganization of EPA of April 30, 1971, responsibilities for water quality have been spread throughout the major functional subdivisions of EPA (See Figure 2.2). For example:

--water quality enforcement activities, along with other environmental enforcement activities, are coordinated by the Assistant Administrator for Enforcement and General Counsel;

--research in pollution sources and effects, pollution control technology, direct supervision of EPA laboratories and planning for environmental quality monitoring programs are the responsibility of the Assistant Administrator for Research and Monitoring;

—collateral programs that impinge on water quality (pesticides, radiation, and solid waste) fall under the Assistant Administrator for Categorical Programs.

However, the most important part of EPA involved in water quality is the **Office of Water Programs** (OWP) under the Assistant Administrator for Media Programs. Its most significant activities include the water qualities standards management program, which in cooperation with states, cities, and industry, has been, since 1966, setting criteria for sections of river basins and watersheds on a regional basis; the administration of the program of federal grants for the construction of municipal waste treatment facilities, preferably when they conform to a basinwide, or regional plan; manpower development and training in the field of water quality control; and selected demonstration programs.

Despite the effort at consolidating federal

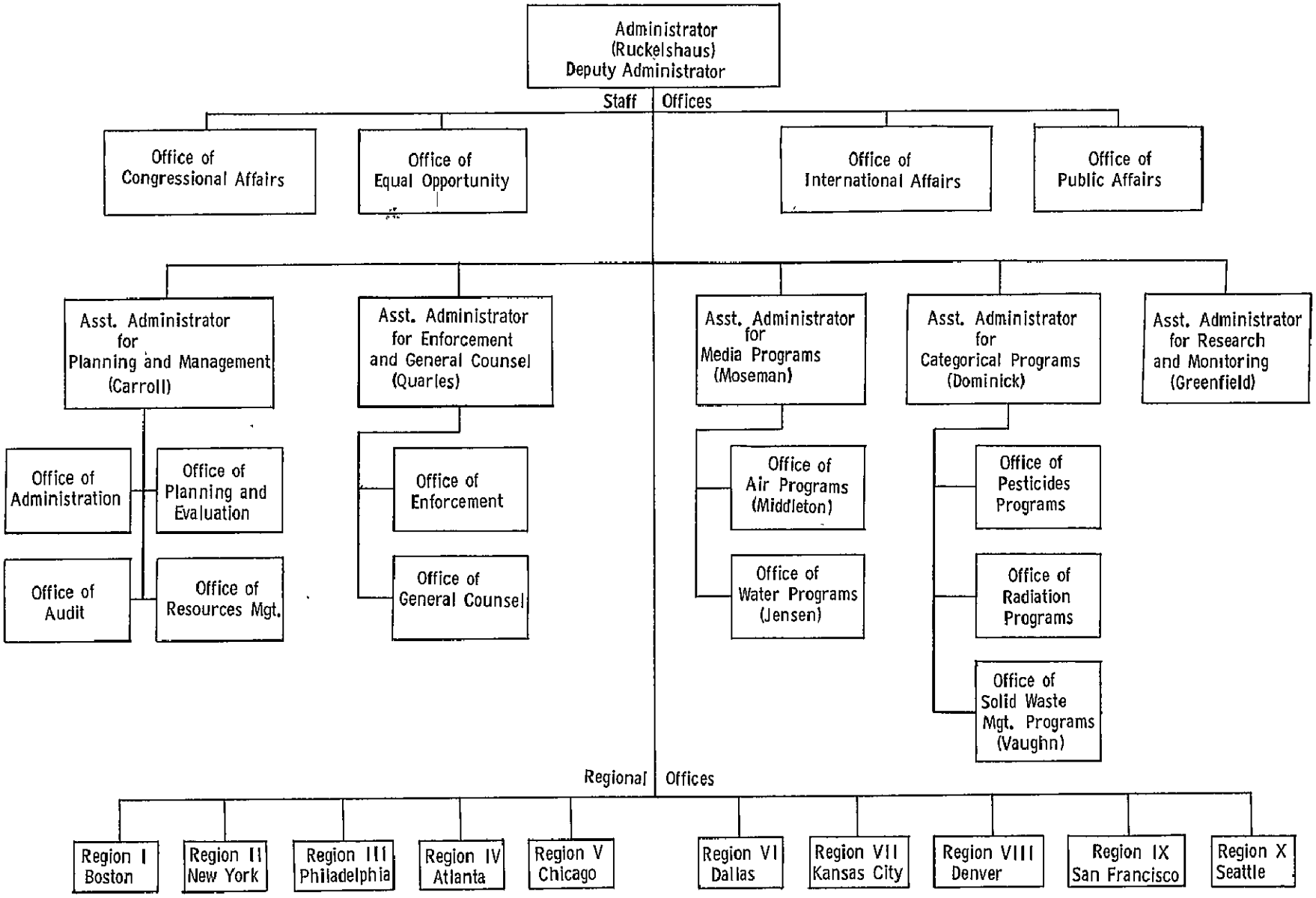


FIGURE 2.2 ORGANIZATION OF THE ENVIRONMENTAL PROTECTION AGENCY

agencies with environmental concerns within the Environmental Protection Agency, there remains at the Federal level a formidable array of agencies which retain primary authority and control over other aspects of water resources and development. Among the many federal agencies which still exercise control over programs having **direct, significant** operational effects upon the nation's river basins and estuaries are the following:

—within the Department of Interior
Bureau of Commercial Fisheries
Bureau of Sport Fisheries and Wildlife
Bureau of Outdoor Recreation
The Geological Survey
Office of Water Resources Research

—within the Department of Commerce
The Maritime Administration
Environmental Science Services Administration
(formerly the Weather Bureau and the (Coast and Geodetic Survey)
Economic Development Administration
National Industrial Pollution Control Council

—within the Department of Transportation
Coast Guard

—within the Department of Defense
Department of the Army's Corps of Engineers* [44: pp. 345-351]

The National Estuarine Pollution Study Report of the Secretary of the Interior of March 25, 1970, also lists a number of agencies—chiefly within the Departments of HEW, Agriculture, and HUD—with the authority for programs having "indirect or related effects" on river basins. It also notes the National Science Foundation, the Smithsonian Institution, the National Academy of Sciences, and the National Academy of Engineering as Federal agencies "involved in research and study" of the waters; and the Water Resources Council, the National Council on Marine Resources and Engineering Development, the Atomic Energy Commission, and the Federal Power Commission as "agencies involved in planning, coordinating, and licensing activities on river basins."

The division of authority is most pronounced in the exercise of certain functions wherein the EPA and other agencies' jurisdiction overlaps with a resulting detrimental effect upon the goal of high water quality.

The most important division of authority is that which is caused by the retention of important and potentially lucrative water programs in the departments of Agriculture, Interior, HUD, and Commerce.

The Farmers Home Administration of the Department of Agriculture has three programs—a grant-in-aid program, a direct loan program, and an insurance of loans program—to assist in the improvement of domestic water systems in rural areas of under 5500 population. Each of these programs averages about $100 million per year, for a total of more than $300 million, in Federal appropriations annually.

The Department of Housing and Urban Development has a grant program to finance up to 50% of cost (up to 90% for towns of less than 10,000 population) of local municipal basic water and sewer facilities other than treatment works. Admittedly this program leaves the major effort in the direction of waste treatment facilities in the hands of EPA. However, the price tag of typical appropriations in the early 1970's—about $350 million per year—for these pipes and ducts indicates that a significant part of the effort (about one-fourth) in this water related activity is still outside the management span of OWP. As a result, considerable negotiation is necessary to assure that treatment plants supported by EPA will be funded on the same time scale as the HUD-supported sewers that feed them. If not, it is not inconceivable that money which could be earmarked for the pipes of a EPA-aided sewage treatment plant in New York might go to an HUD-aided municipality in California.

Finally, the Economic Development Administration of the Department of Commerce has a program to provide grants up to 50% (up to 80% in particularly depressed areas) for projects—including water and sewer projects—in areas of the country designated as "economic redevelopment areas." In FY 71, more than $100 million—some 70% of the total appropriation went to water and sewer projects.

The total of these three water-related programs, only the largest of several that might be cited, approaches some $750 million in annual appropriations—more than half the total budget of OWP of EPA. This represents a power, which if brought within the general umbrella of one central water agency would

add immeasurably to its strength and reputation within the federal bureaucracy

A weak attempt was made to coordinate governmental activities affecting the water and other environmental resources in Section 102 of the 1969 National Environmental Protection Act which compelled federal agencies to give full consideration to adverse environmental effects of proposed legislation and "major Federal actions." [42] If adverse effects are likely, the agency must make a substantiated finding that other and overriding national objectives justify the project.

Section 103 indicates how this stipulation is to be carried out by requiring each agency to set up an internal review mechanism. In the course of this review, the agency must consult with other state and federal agencies which have any legal jurisdiction or special expertise as to the environmental impact of the project. Comments from these other agencies must accompany a draft statement which must be made public 15 days before public hearings are held. Draft statements (but not public hearings) are required for every project. After such consultation, the final statement must be submitted to the Council on Environmental Quality which makes its own review but does not have an actual veto power.

Unfortunately, in practice there has been no uniform understanding of **what** major federal actions require 102 statements. Each agency has made its own decision and CEQ has not set firm guidelines. For instance, the Forest Service has decided that timber sales (clear cutting) do not require statements. Neither the CEQ, nor the Office of Management and Budget (which has broad authority in legislative clearance and coordination of federal activities) has issued any clarifying statement to date [45].

Section 103 also requires the agency involved with a project it suspects will have environmental impact to make the "fullest practicable" public disclosure of information related to the project [45]. Since each agency typically defines its own procedures, there is presently a great diversity in the timing and extent of public disclosure. There is no uniform policy on the type or timing of information given to the public. Some agencies bury adverse comments and do not make draft statements public. The NEPA gives each agency the final decision on whether to proceed with its own projects.

A similar situation exists with respect to legislative action which might affect the environment. Section 102 of the NEPA requires statements on proposed legislation to be referred to the concerned agencies for environmental impact statements. In 1970, only seven such statements were prepared for an estimated 800 bills. [45: p. 23] The implications here are even more profound than the agencies' laxity, for environmental legislation is likely to have a much greater effect than any single agency project.

There is some basis for optimism concerning the procedures inserted into the 1969 NEPA, however, for although they are being sloppily followed they do provide the basis for judicial review of proposed projects.

Federal agencies can no longer plead ignorance of adverse environmental effects. If an agency does not provide substantial evidence of adequate consideration of adverse effects, courts will find agency approval of a project to be "arbitrary and capricious" and enjoin its progress. However, judicial review is probably limited to the satisfaction of procedural requirements. If the agency has gone through its formal bureaucratic paces and provides a plausible justification for the project, the courts will probably not question the agency's judgment.

The major problem with the environmental impact statement procedure, however, is that the job of consolidation is presently in the hands of the Council of Environmental Quality which has a budget about one-tenth as large as the EPA. Its $1.5 million annual appropriation supports a professional staff of less than 25, with only four with Ph.D's in sciences. As a result it is able to process only a few Section 102 statements per day. A more logical arrangement would be to transfer coordinating control over the environment impact statement program to EPA which has the nucleus of the staff and funding strength to do it effectively.

A more significant division of authority within the federal government concerns not those agencies which have an overlapping jurisdiction in promoting water programs, but those agencies whose vested interest is not in the promotion of water resources at all. The continuing important role of the Department of Commerce as "industry's spokesman" within the Cabinet is the most obvious example In April, 1970, at the same time as President Nixon issued the Executive Order setting up the Environmental Protection Agency he established the National Industrial Pollution Control Council within the Com-

merce Department, a body composed of some 60 executives of the major polluting industries in the country. Nominally intended to provide an input to the government concerning "environmental programs affecting industry," the NIPCC in effect has used its Commerce Department office space and staff to lobby within the government against such EPA and conservationist-sponsored programs as a national industrial waste inventory and a ban on the use of phosphates in detergents. [15: Ch. XII, p 25, and Ch. IV, p. 13]

Another example is EPA's dependency upon the Justice Department for its ultimate enforcement tool—the court hearing and injunction. The "resurrection" of the Refuse Act of 1899 (actually Section 13 of the broader Rivers and Harbor Act of 1899) in late 1969, with its attendant revelation that only about 400 industries (out of some 40,000 industrial plants discharging directly into U.S. navigable waters) actually had CORPS permits, meant that practically 99% of the industries in the country were technically committing a crime when they dumped anything but pure water into navigable streams. [15· Ch. XV, p.2] The lack of vigor with which the Justice Department moved in enforcing the 1899 Refuse Act showed that its priorities were hardly in the field of environmental protection.

Less than one-tenth of the more than 100 lawyers in Justice's Land and Natural Resources Division were assigned to work on prosecutions of all water pollution cases. Even more significantly, the Department issued guidelines for U.S. Attorneys in the field of July 10, 1970, which severely curtailed their authority to seek prosecutions under the Act of 1899 by enunciating a general philosophy of deferring application of the law to the weaker federal and state criteria enacted since that time Specifically, the Justice Dept guidelines permitted its regional attorneys to prosecute under the 1899 Act only those discharges which were "accidental or infrequent." They were prohibited from prosecuting, without clearance from Washington, discharges "of a continuing nature resulting from the ordinary operations of a manufacturing plant." [15· Ch. XV, p. 7]

Justice's guidelines also provided for freedom from prosecution any industries which were in "substantial compliance" (i e., not in compliance, but ostensibly trying) with state standards and timetables, and industries which were being "subjected to an enforcement proceeding" of OWP or a state, (i.e., generally, the worst offenders in the first place.) As a result of these restrictive guidelines, during the first fifteen months since the resurrection of the 1899 Act, the government moved against only 28 industrial polluters—and ten of these came in July, 1970, during the period of the widely publicized mercury pollution scare. [15: Ch. XV, p. 6]

While the situation described is not a traditional division of authority problem (for violation of any federal criminal statute ultimately requires its prosecution by the Justice Department), such interdepartmental lack of appreciation of the purposes of agency mission might be avoided if EPA had sufficient authority to assess civil fines against polluters found in violation of standards. Another way to eliminate dependency upon excessive involvement by the Department of Justice for prosecutions would be to shift the burden of proving pollution so that the government would not have to demonstrate daily separate instances of a continuing violation in order to award a penalty for each day. [15: Ch. XV, p. 15a]

In any case, the major problems of divided authority in prosecution of the 1899 Act are not those between EPA and the Justice Department—this relationship simply points out starkly the lack of political commitment to enforce stiff laws against polluters. The division of authority entanglements which will emerge upon implementation of the law, and which incidentally will provide a convenient mask for the demonstrated unwillingness simply to enforce, are those which exist between EPA and the Army Corps of Engineers, and between EPA and the state water control authorities Under the original 1899 Refuse Act—which prohibited the discharge into any navigable water of "any refuse matter of any kind or description whatever other than that flowing from streets and sewers" [46] —and intended primarily for the protection of navigation routes, the Army Corps of Engineers has primary authority. However, the courts in *Zabel* vs *Tabb* (F. 2d, 5th Cir. July 16, 1970(have affirmed the right of the Corps to deny a dredge and fill permit solely on environmental grounds, [47] noting in addition that the 1958 Fish and Wildlife Coordination Act required consultation with the Department of the Interior before granting permits, and that the National Environmental Policy Act of 1969 required all federal agencies before acting in any ecological matters, to seek the recommendations of all other federal agencies having environmental exper-

tise. Thus, the EPA has assumed a prominent role in a technical advisory capacity to the Army Corps

This role assumed greater potential importance after December 23, 1970, when a Presidential order clarifying procedures to be followed in implementing the 1899 Act required every industrial polluter to make application for a discharge permit before July 1, 1971. Pursuant to this order, the Army Corps of Engineers and the EPA agreed in a memorandum of understanding January 12, 1971, that the actual task of handling the paperwork and issuing the permit would be performed by the Corps as had traditionally been the practice. The OWP of EPA, however, would have final authority concerning each permit's terms regarding water quality matters.

While at first glance this might appear to give great potential for expanding EPA's role in the field of national water quality management, it should be realized that the Army retains "primary responsibility for enforcement of the Refuse Act." [48: p.2] This effectively puts the burden of responsibility upon an agency whose primary mission (not to mention its past history) is hardly one involving great concern for the environment However, this retention of authority within the Department of the Army does not in truth represent a usurpation of any authority the EPA was eager to assume. In testimony before Congress in February, 1971, the EPA's General Counsel said that rather than expanding into its new-found jurisdiction of "navigable" waters within states, the EPA was prepared to administer the permit program on intrastate waters through the pollution control systems of the respective states in any case. [15: XV, pp. 13-14] This in all likelihood means that the permits which are issued may be relatively weak and may represent little more than "licenses to pollute." If so the industrial polluters who have been dumping in violation of the law up to now will henceforth be dumping with the government's official permission.

Finally within the federal establishment itself EPA should have unchallenged authority in the setting of priorities for anti-pollution projects involving Federal facilities. Under existing executive procedures, however, it is the Office of Management and Budget (OMB) which possesses the coordinating role for all federal anti-pollution efforts. OWP's role is that of a passive technical counsultant which arranges, for OMB, in a priority listing, the totality of federal anti-pollution projects contemplated. OMB thereupon typically eliminates the lower one-third of this listing, and then returns the requests remaining approved to the respective departments. These then have complete flexibility to rearrange or eliminate projects at their own initiative—sometimes after further consultation with OMB over fiscal guidelines, never with another reference to OWP. [15· XVIII, pp. 31-32] Thus, the one agency in the Federal Government which should be the main voice in determining where available clean-up funds for Federal installations should be distributed, EPA, has little control over the allocation of these funds. The agency which should be first to receive information about a pollution problem violation within federal agencies and which should have the expertise to remedy such a situation should also have control over the funds which can be employed to this purpose. EPA does not, and this is typical of the divisions of authority endemic to the federal effort to control water pollution.

In conclusion, it should be noted that this division of authority within the executive branch of the federal government is similarly reflected within the legislative branch. There are approximately twenty different House and Senate committees—and a plethora of respective subcommittees—which have jurisdiction over the various sections of the executive branch which administer water programs. Each of these legislative pockets of power—as well as the fiefdoms within the executive branch over which they exercise control—came into being for reasons having little, or nothing, to do with high standards of water quality management The major determinants were the vagaries of the seniority system and which committee chairmen were in respective positions at the time the particular executive agency in question was established or reorganized. The following chart gives some indication of the overlapping of interests at the legislative level. (See figure 2.4)

In addition to these conflicts of authority and interest, there is also the perennial problem of Congress' inability to compete with the executive branch in the obtaining of scientific and technical expertise necessary to exercise knowledgeable direction over the bureaucratic branch it nominally controls. This problem reaches its classic proportions in the area of Congressional overviews of major weapons systems programs such as the

CONGRESSIONAL COMMITTEE JURISDICTION OVER EXECUTIVE AGENCIES IN MARINE SCIENCE

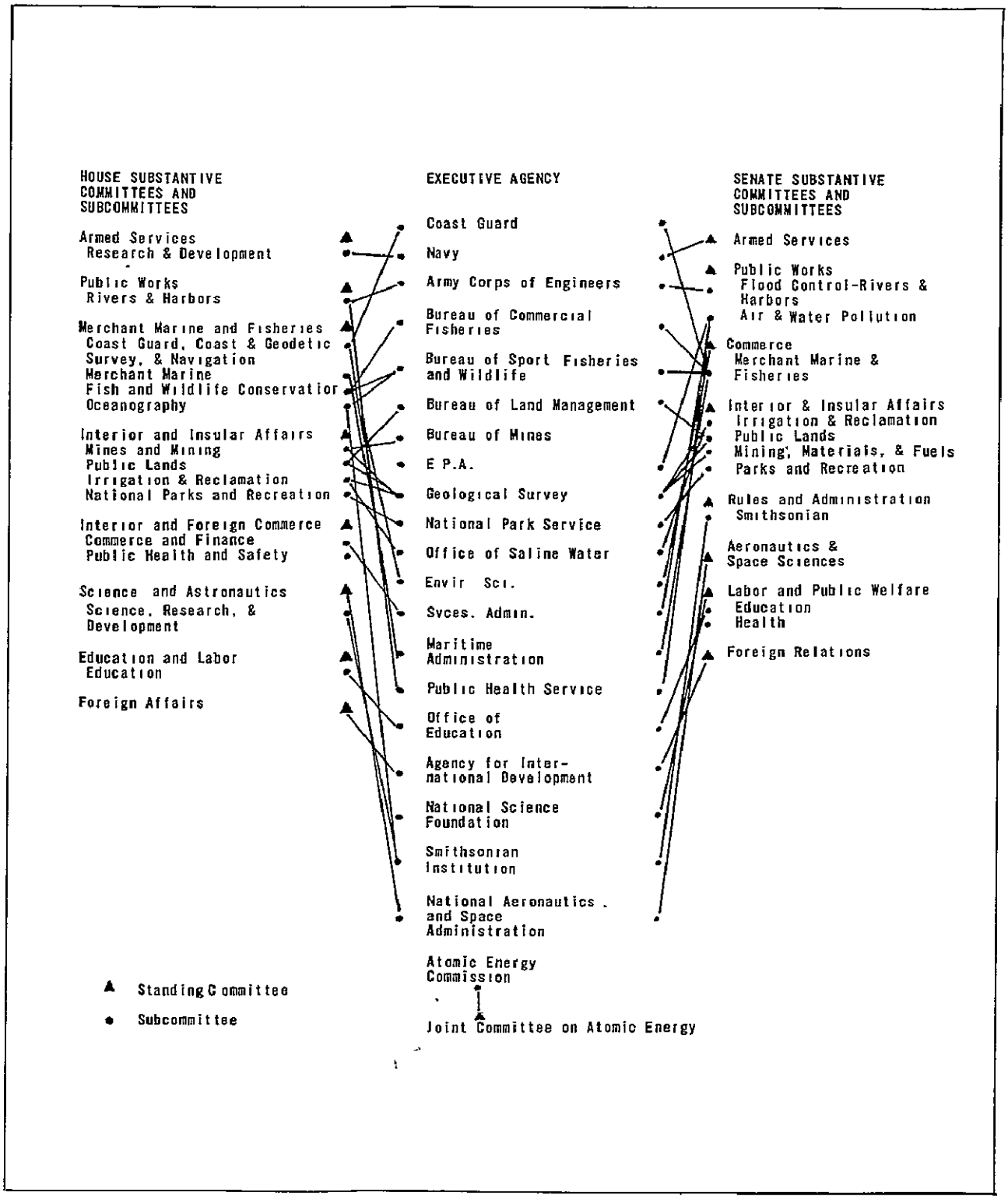


FIGURE 2.3

Anti-Ballistic Missile. The lack of Congressional ability to pass upon the programs presented by the executive branch has been expressed very cogently by Senator William Proxmire:

> . . . the Congress cannot . . . establish proper national priorities, cannot improve the quality of their decisions, cannot properly scrutinize the executive budget unless it equips itself to ask the right question . . . Currently, we do not have the staff either to interpret or to evaluate the analysis done by the executive branch were it presented to us, nor does Congress have a staff to do policy analysis of its own. [49]

In the field of water quality management, it is only in recent years that the House and Senate Committees on Public Works have each added to their respective staffs on a full-time basis one scientist. So strapped are the Congressional committees for this type of scientific advice, however, that the salaries for these scientists are being substantially underwritten by the American Political Science Association through its Congressional Fellowship Program. Because the stipend is nominal, the scientists attracted to these Congressional staff positions are generally young men without extensive practical experience, and in general hardly and equal match in quantity or quality to the comparable expertise available to agencies within the executive branch.

To establish the information machinery that would enable Congress to fight the battle of Pennsylvania Avenue on more equal terms, a dramatic increase in the funding of Congressional committee staffs would be necessary. This is a need which is generally recognized and draws wide bipartisan support. As Maine's Republican Senator Margaret Chase Smith urged in 1969,

> If we need independent expertise we should proceed to obtain it by recruiting consultants. If we need more in-house capability in the Congress and in our committees, let us expand the staffs. [50]

Such a move might possibly attract university professors on sabbatical, industrial scientists on leave, or independent consultants. However, it would only go a small step toward righting the balance between the executive and legislative branches.

Manifestations of Fragmentation in Administration Enforcement

It will be shown elsewhere in this report that the technological and scientific expertise to effect clean waters in the rivers and streams of this nation is presently available in the form of advanced (i e., up to and including tertiary), sewage treatment systems. The major obstacle to the attainment of high water quality standards is the lack of a political commitment to employ such techniques. This normally takes the form of not requiring dischargers of pollutants to adapt such solutions—either by not enforcing the laws which would require them to do so, or by not providing the incentive which would motivate them to do so. Budgetary allocations are an ideal starting point to consider evidences of lack of political commitment for the budget is a highly political document. At the Federal level, despite the periodic flurry of campaign oratory the fact remains that since the national government first became involved in water pollution programs with the passage of the Water Pollution Control Act of 1948, only $4 billion has been appropriated towards the effort. As small as this sum is, it is more than the totality of all state expenditures in the comparable period.

Even today, where there is more evidence than ever of a national commitment (in the form of appropriated funds) to serious antipollution efforts in the area of water quality, the $1.1 billion representing the total federal effort exerted by the Office of Water Programs of the EPA—the chief Federal agency involved in water programs—is but a fraction of 1% of the total Federal budget. Water quality control—when balanced against national defense, health, education, welfare, urban problems and other needs of the country—is still a very low priority item, and this hard political fact of life must be admitted. Similarly on the state level, in Virginia, for example, out of a total budget of almost $3.8 billion, approximately $15 million is all that is expended by the state water control board.

Equally significant, when total appropriations in the antipollution effort are analyzed, it can be seen that the greater part of the effort is devoted to providing industries and municipalities positive incentives to adopt adequate technological solutions to the problem. This generally takes the form of federal and state participation in the grant-in-aid program for the construction of waste

'You Know Something, Officer? You're Right!

Carton by L. D. Warren for **TIMES-HERALD**
Newport News, Virginia, August 9, 1971
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treatment plants. A much smaller percentage of governmental effort is devoted to bringing about a similar solution by enforcement of existing administrative machinery. This situation is indicative, at base, of a lack of political commitment to effect a complete solution to the problem of polluted water

Indicative of the manner in which government has moved into the field of water quality management is the experience of the original

national Water Pollution Control Act of 1948—it went totally unfunded for eight years. After the passage of the 1956 Amendments to the Water Pollution Control Act, a permanent federal presence, with financing, was ensured thanks to the establishment of the construction grant program which especially since the increase in expenditures following the 1961 amendments, has effectively "carried" the total federal effort in the field of water pollution abatement. While this has ensured the continuance of the necessary federal funds for water quality management filtering down to the local level, it has at the same time essentially relegated the cure to the problem of water pollution to the level of a massive public works program with all the attendant atmosphere of "pork-barrel politics" having become part of the remedy.

However beneficial the effects of a construction grants program in terms of ensuring the acceptance of a Federal role in fighting water pollution, it results in a massive diversion of funds into an area which is essentially no more than a symptom of the problem. The heavy funding of a construction grants program implies that the solution to the water pollution problem is simply to build sewage treatment plants. This begs the hard political question of who is to pay for the effort. Localities are increasingly unable to pass bond issues to finance the construction of waste treatment facilities on a local level. To the extent that they do, this generally represents a passing on of the remedy to local citizenry and taxpayers while ignoring the real sources of most damaging pollution discharges.

A more direct way of attacking the problem—and getting at the nub of the political issue involved (i.e., who is to pay)—is to enforce strict pollution control laws against individual polluters thereby motivating them to treat their own wastes with the construction of appropriate on-site facilities. In the case of industrial polluters the cost of this solution may, of course, ultimately be passed on to the public in the form of higher prices to apply for the new procedures in the manufacturing process. But this will be a cost which the public will have to absorb (if the product is a necessity or strongly desired) through its continued purchase of the product in the marketplace. The public will not be able to reject the product (if it is truly desired) as it can cavalierly reject municipal bond issues for waste treatment plants. Meanwhile, and this is the crucial point, the waste is being treated.

However, because the thrust of the federal effort has been solely to construct municipal treatment plants and to ignore (i.e., leave to the local level) the sticky political question of who is to pay (i.e., with matching funds) and how the money is to be raised, all levels of government have deferred from any serious action on the enforcement front which would put pressure on industries to clean up their waste before it is put into the rivers and streams.

This complete absence of any will to enforce existing water quality standards and legislation is at the root of the failure to achieve any real progress in the area of water pollution abatement. It is a reflection of the political realities that the government—at all levels—has consistently decided **not** to lay the responsibility for solution at the steps of those most immediately involved. The behavior of the Justice Department in the years following the discovery of the applicability of the Refuse Act in 1969 is illustrative of this singular lack of the political will to enforce. An analysis of what little remains of anti-water-pollution funds after appropriations for construction grants are expended will also give some indication of the dimensions of this situation.

The budget for federal water programs for the most recent three-year period has approximate average annual line-item entries for major functional categories similar to the following. (See Figure 2.4)

The most telling figure in this breakdown is the relative de-emphasis given to the enforcement of water quality standards Ever since the establishment of enforcement conference machinery under the 1958 act, less than 2% of the federal effort in the water pollution field has gone into this activity. In the 15 years since 1956, only 56 enforcement conferences have been held to enforce water quality standards, an average of less than four per year. Only a small percentage of these ever resulted in follow-up conferences. Four went to the second stage of federal machinery—the hearing board—and only once has the Federal government moved to the third stage of action and taken a polluter to court. Since the act inclusion of the "shellfish" clause which theoretically enlarged the federal jurisdiction to include 427 new areas of the country in some 22 coastal states where, according to the Public Health Service, 1,750,000 acres of shellfish beds have been completely closed to shellfishing in recent years, the enforcement

FIGURE 2.4

BUDGET FOR OFFICE OF WATER PROGRAMS, ENVIRONMENTAL PROTECTION AGENCY

Construction Grants Program & its Admin.	$214 million	$800 million	$1,000 million
Research and Development	44 million	37 million	44 million
State Grants Programs & its Administration	10 million	10 million	10 million
Comprehensive Planning Programs	6.1 million	6.9 million	8 million
Training and Education	5.2 million	6.1 million	7 million
Enforcement	4.0 million	4.3 million	5.2 million
Pollution Surveillance	2.7 million	4.0 million	4.3 million
Other (Executive Direction and Support Control of Pollutants Federal Actions Technical Support Public Information, Etc.)	11.7 million	12.6 million	12.8 million
TOTALS	$300.7 million	$886.1 million	$1,098.0 million
(Total of Programs other than Construction Grants	($ 86.7 million)	($ 86.1 million)	($ 98.1 million)

procedure has been invoked only five times. [15 Ch. VI, p. 16]

In short, ever since the establishment of federal enforcement conferences procedure in 1956, there has been a considered effort not to invoke the machinery. Where conferences have been called, they have typically been started against relatively small-time violators—for example, against Mobile Bay, Alabama, where the losses to the shellfish industry were an estimated $200,000 per year—while major sources of pollution (e.g., Houston Ship Channel where $11.6 million is lost annually to the shellfish industry) are ignored. [15: Ch. VI, p. 33]

On the state level the situation is similar. Generally, the enforcement battle is lost before it even begins with the initial instituting of relatively low water quality standards as terms of the permit to discharge. When there is suspicion that a discharger is in violation of his discharge permit terms, legislation normally provides for notice to all interested parties to attend an open hearing. As with Federal enforcement machinery, such proceedings on the state level are also time-consuming and costly. More often than not, a large industrial polluter is more adequately prepared financially to withstand the rigors of the conference machinery than is the state agency with its meagre enforcement funds.

If it can be established that a discharger is in violation of the law or of his permit, or has failed to report completely, a penalty can be imposed. Most states have provisions which include permit revocation or modification, fines, imprisonment, and cease and desist orders. Needless to say, the "enforcement" machinery hardly ever reaches the stage of fines, prison, or injunctions to stop. Frequently, the standards stipulated in the permit are modified, but downward in the favor of the discharger so that he may continue to dump his waste at the same load, but now he does it in accordance with the law.

The reason most frequently offered for this hesitancy on the part of governmental authorities to emphasize enforcement is the preference for a "cooperative" solution to the problem with industries and municipalities. In fact, permeating the entire atmosphere between governmental anti-pollution officials and the industries and municipalities they are supposed to monitor is the attitude that compliance is a cooperative venture. The expressed explanation for this attitude generally echoes the lines of the philosophy that "you can bring a horse to water, but you can't make him drink,"—that concern for curbing pollution is not something that can be forced upon someone, but the sort of thing that

demands willing collaboration to be successful. The underlying reason, however, is that the control agency is stripped of any real powers to enforce due to budgetary limitations which reflect the expressed lack of political will to work a total solution on the part of the legislatures which give the agency its operating mandate. The State Water Control Board, in Virginia, for example, does not even have a separate enforcement section and nowhere does it budget specifically for this function. When in 1971, the Board began to move with unaccustomed vigor in the area of enforcing standards by warning municipalities that it would refuse to grant permits for discharge to new industrial construction in their localities, the state assembly responded by drafting legislation which curtailed the Board's authority to act in this manner unless it was able to provide the necessary funds to assist the target city in meeting such standards. [64]

As a result, because the average state water control board typically lacks any significant enforcement authority or funding, it dearly depends upon the polluting industries and municipalities to provide it with information about their discharge processes and products. Because of the dependence of the enforcement agencies upon the polluters for the gathering, or confirmation, of much of the data needed to enforce programs of abatement, a cozy marriage of convenience has generally become necessary in order for any pollution control agency to make a pretence of doing its job. Only by cultivating relationships of trust and confidence with the polluters they regulate can governmental authorities get the information they need without going through the frustation of continued confrontations and extended negotiations as required in the enforcement conference machinery [15: Ch. XII, p. 11] Pollution control officials thus become dependent for the information they need on the polluter's good will, and so become intimidated from pushing too hard.

It is because of this type of situation that governmental enforcement officials such as the chief federal enforcement officer, Murray Stein, will typically cite as examples of their "success" how few times they have had to invoke enforcement machinery, or to go to court. [15: Ch. XV, p. 19] Examples of "cooperative successes"—such as the "Hopewell solution" on the James River—have frequently meant little more than industries blandly assuring the water control board officials that they were doing all they could, while delaying until machinery obsolescence or plans for new expansion provided a normal business opportunity for improving production and treatment methods. Only then—sometimes years after the initial discovery of the polluting situation—is the "compliance action" voluntarily initiated by the polluters.

One variation of the dependency of the regulators upon the regulated is penchant for excessive public "complimenting" of those industries which finally come around to compliance, sometimes several years behind schedule, in the vain hope that malingering municipalities and manufacturers will be motivated to follow suit. It is a testimony to the weakness of enforcement procedures that the hope placed in this technique of persuasion by citing the example of "leaders" in the anti-pollution field is regarded as one of the strongest tools in motivating recalcitrant industries to take anti-pollution action [15: Ch. X, p. 37]

Reliance upon cooperative solution obtains not only in situations involving confrontation between governmental authorities and private polluters or polluters in another governmental jurisdiction, but even between pollution control authorities and other agencies within the same level of government. OWP or EPA, and state water control boards are supposed to be the vigorous advocates of the anti-pollution cause within their respective levels of government. Most often the tools given them to carry out this job are not equal to the task Within OWP of EPA, the Federal Activities Division has traditionally occupied the lowest organizational status within the agency. The reason is that the agency's statutory authority to move against pollution activity within the federal government is purely advisory, and depends for success upon the willing cooperation of the agencies who do the polluting. In the most recent executive order on water pollution at federal facilities, OWP of EPA was specifically excluded from any independent power of surveillance over other agencies by the stipulation that only the respective "heads of agencies" were to "maintain review and surveillance" to ensure that standards were met. The agency heads retain complete discretion over whether to submit performance specifications for proposed abatement to the EPA. There is no mention of what happens to whom if performance does not meet EPA's water quality standards. In fact, it is most

unlikely that EPA would even learn if there was a violation of standards.

Thus, in addition to a lack of any say over how federal activities spend their budgetary allotments in the field of pollution abatement, the OWP (EPA) has to rely on amicable relations with other agencies even to discover information about what pollution problems an agency may consider that it has. The lack of such fundamental powers as even to be able to determine its own information base is typical of why the EPA and state pollution control authorities are unable to enforce clean water standards in their own jurisdiction before moving against municipalities or industries.

The connection between funding and enforcement is sometimes cited even in areas where extensive federal money has been forthcoming—e.g., in the construction grants program. Here the complaint of underfunding—e.g., in the fiscal years 1968 and 1969—has been used as an excuse not to move on the enforcement front. Under the 1965 law, deadlines for states to be in compliance with federal standards were allowed to slide in some cases roughly to the years 1970 through 1972. However, the enforcement of even these standards has been less than vigorous because of the "lack" of construction funds Of the $3 4 billion authorized by Congress in 1966 for the four-year period 1968-71 to help the states begin implementing the standards requirements of the 1965 Act, only $2.2 billion has actually been appropriated. The understanding has been allowed to exist at the state level that the deadlines for compliance were based on the assumption of full appropriations of the FY 67 four-year package. Since the construction grants package was not totally funded, the enforcement of the 1965 standards program has been dealyed.

A similar situation pointing up the connection between funding and enforcement can be cited in the state of Virginia, where in April, 1971, House Bill 192 was passed prohibiting the State Water Control Board from certain phases of its enforcement activity against municipalities unless it could also guarantee to a municipality adequate funding for the construction of the treatment plants needed to come into compliance with the standards the Board was invoking. [64]

Another example of how the lack of an adequate enforcement budget hurts the effort toward cleaner waters is in the area of follow-up to ensure that the monies spent in construction grants programs are utilized well. Many of the plants which have been built under the grants program do not, after they are put into operation, treat waste sewage well. Among the reasons are bad plant design, understaffing or staffing by ill-trained or negligent operators, and running the plant to treat industrial wastes it was never designed for (and not charging the industry anything extra for so doing.) The OWP or EPA has within its grants authority the power to police the use of its construction grants program more efficiently; all applicants for a grant have to assure "proper and efficient operation and maintenance" of the plant. [32: Sec 8] In practice, however, because of the low enforcement budget, few follow-up inspections are made by the EPA. Recent new regulations now require the regional office of the EPA to inspect annually during the first three years of operation. However, more is needed in order to assure the plants, when constructed, are operated properly. The "assurance of efficient operation and maintenance" clause could be interpreted to establish penalties, to require the posting of performance bonds, to demand the certification of plant operators, or to stipulate continuous monitoring and periodic reporting on behalf of the municipality. All of this, however, would require an increased enforcement budget.

Finally, the funding in the area of research and development is often used as an excuse to defer enforcement. Oftentimes when OWP of EPA is confronted with a pollution situation by an industry, rather than resort to enforcement machinery, a grant or contract for development and demonstration in advanced treatment technology is given directly to industry under Section 6 (b) of the Act. The R&D budget of EPA is roughly five times the enforcement budget, and more than one half of it goes directly to industry ($10.1 of $19.1 million in the FWQA in FY 69). [15· Ch XIX, p. 41] A cheaper way to attain the solution might be vigorously to enforce the water quality laws and let industry pay for whatever innovation it takes to comply. Very often research into new technology is simply not initiated by an industry until outside pressure makes it necessary. Finally, as another indication of how the R&D budget is sometimes used to perpetuate the lack of commitment to enforcement, there have been some examples of QWP (EPA) actually diverting some of its in-house research away from enforcement oriented research and into the direction of more theoretical long-range

laboratory water studies. [15: Ch. VII, pp. 28-32]

Manifestations of the Fragmented Approach as Reflected in Inherent Deficiencies in the Law

As noted above, the effectiveness of federal enforcement under the Federal Water Pollution Control Act is severely limited by jurisdictional restrictions. Even when EPA can act under those restrictions, the two enforcement pathways described in the Act involve proof problems, mandatory delays, wide administrative decisions, and severe difficulties with the rules of decision to be applied by the court.

One of these procedures deals with enforcement of water quality standards. The 1965 amendments to the Act required each state to adopt a plan to create and implement standards only for the stretches of interstate waters within its boundaries. This requirement did not create uniform federal standards even for interstate waters since each state was allowed some latitude in determining applicable scientific criteria and permissible use (e.g , industrial discharges) for the waters. By August, 1971, the standards suggested by 40 states had received full federal approval. The authors of the Act specified 1967 as the deadline date.

This proscrastination has had little practical effect, on the federal level, since the provisions of the Act hamstring standards enforcement anyway. EPA must give a standards violator 180 days notice before filing suit. At trial, EPA must prove not only that the standards are being violated, but also that the violation endangers "the health or welfare of persons." This two-fold burden would be very difficult to carry (theoretically, since no cases have yet gone to judgment). EPA must show that lowered stream quality is specifically due to the alleged violator's discharge. Since the act does not allow inspection of a discharger's facility and since the standards do not contain effluent limitations, any but the most flagrant cases would degenerate into battles between hydrological experts.

Even if EPA could carry its double burden, the court must give "due consideration to the practicability and to the physical and economic feasibility of complying with the standards." The court can even review the standards themselves In other words, the court may require the polluter to do very little or nothing at all if the cost of abatement to the polluter is too high.

An older, even more cumbersome, procedure has been used more than fifty times in the last fifteen years. This "ad hoc" procedure requires only that "danger to health or welfare" be deomonstrated. But before a case can come to trial, an informal conference and a formal hearing must be held. The mandatory delays involved total slightly more than one year. Bureaucratic delays and gestures toward compliance can be expected to extend this period. The results of these pre-trial proceedings would have little effect on the issues at trial since even the findings of the formal hearing would have only evidenciary weight. As with the standards procedure, EPA cannot force the defendant to divulge more than minimal effluent data and the court may consider the "economic feasibility" of abatement.

Of the more than fifty conferences convened under this procedure, five resulted in formal hearings and one actually went to trial. That case resulted in a consent decree and a fourteen-year abatement schedule. It seems that the greatest practical deficiency in the Act is the discretion given to the Administration of EPA, who is required to take any action in only one situation When the governor of an affected state requests, the EPA **must** convene an informal conference. However, further federal action is mandatory only if the Administrator of EPA "believes" that "effective progress toward abatement" is not being made. If a governor requests federal action on intrastate waters, EPA need call a conference only if in its "judgment" the pollution is of "sufficient significance." The shellfish clause, which allows the EPA to intervene on its own initiative in a purely intrastate situation, mandates federal action only when the Administrator "has reason to believe" that "substantial economic injury is resulting from shellfish destruction." If events ever proceed to the point when court action is permissible under the Act, EPA "may request" the Justice Department to file suit.

The complete latitude given EPA (and Justice) by the Act relieves the federal government of the obligation to sue every polluter simultaneously. Some degree of administrative discretion is obviously necessary, but EPA's discretion is so great that the agency cannot be legally compelled to take any significant abatement action.

The major federal act dealing with water pollution is inherently inadequate. Ironically,

the most effective piece of federal legislation is the recently resurrected River and Harbor Act of 1899 [46] This act is potentially the most powerful enforcement tool available to the federal government. "Potentially" is the operative word, as the Army Corps of Engineers and the Justice Department have used their granted authority very sparingly.

In passing the Act, Congress intended to give the Corps the requisite authority to maintain actual navigation in major harbors and rivers. The Corps has used this authority to regulate, by a permit system, dredging, spoil disposal, and construction of major structures such as bridges and wharves. Historically, the Corps has not given much weight to environmental factors when granting these permits. The Corps' traditional sphere of concern has been limited to the requirements of actual navigation. However, by interpreting the Act against the background of the commerce power, the courts mave held the Corps has the authority to regulate most discharges into navigable waters. Sec. 13 of the Act (popularly known as the Refuse Act) makes it unlawful "to throw, discharge, or deposit . . . any refuse matter of any land or description whatever other than that flowing from streets and sewers and passing therefrom and liquid state, into any navigable water" without permission from the Corps.

The Supreme Court has given "refuse" the broadest possible deninition, as "all foreign substances." [51] Although the section excepts liquid sewage and storm drain runoff, the Court has found this exception to mean solely municipal sewage. [52] Therefore, even industries which discharge directly into a public treatment facility are susceptible to regulation. Since the act makes no distinction between intentional, accidental or negligent discharges, the Corps has authority to set any nonarbitrary water quality standards and require industries to conform to them.

As the court said in the *Republic Steel* [52] case, "the philosophy of the statement of Mr. Justice Holmes—that river is more than amenity, it is a treasure, forbids a narrow, cramped reading either of Sec. 13 or Sec. 10."

By rejecting a "narrow, cramped reading" of the Act, the courts have created civil remedies as tools of enforcement. The Act is a criminal statute, providing up to $2500 in fines and one year in prison for violations. Although no mention is made of civil remedies, and although penal statutes are normally very strictly construed, the courts have held the Act to authorize both injunctions and actions for damages to reimburse the costs of removing obstructions. [53]

A Corps of Engineers Policy

Executive Order 11574 (December 23, 1970) directed the Corps to implement a functioning permit system under the Refuse Act. Although the Corps had issued only four permits under Sec. 13 during the last 70 years, all industries which discharge into navigable waters will now be required to have permits.

Most discharges were required to submit permit applications by July 1, 1971. (Some specific types of industries were allowed to apply by October 1, 1971). About half the estimated 40,000 dischargers had applied by July 22, 1971.

Dischargers are required to submit certain effluent data with their applications. The broad authority of the Refuse Act allows this requirement while the FWPCA does not. Penalties for intentionally false statements can range up to $10,000 in fines and 5 years in prison.

Sec. 21 (b) (1) of the FWPCA requires state certification before any federal discharge permit may be issued. However, the Corps has decided that any facility which was operating or under construction by April, 1970, will not need state certification until April, 1973. The Corps apparently does not think the permit system will be fully functioning before that date. [54]

The Corps must also consult with other federal agencies before granting a permit. EPA reviews the application and must approve it before the Corps issues the permit. The Corps must also seek comments from the Fish and Wildlife Service of Interior and the Marine Fisheries Service of NOAA about the probable effects on wildlife These agencies do not have an explicit veto power but strongly adverse comments by them could provide the basis for judicial review of the permit grant.

The Fish and Wildlife Coordination Act [55] allows the Corps to reject an application in order to prevent environmental damage even if other federal and state agencies make no objection. However, the Corps apparently intends to accept the EPA recommendation as binding without making its own determination of environmental effects.

The Corps may always reject an application if actual navigation would be adversely affected

The Corps must give public notice when an application is received and will accept positive and negative comments. The district engineer will convene an informal public hearing on the application in response to public clamor or when a state other than the certifying one objects to a permit. All information of the permit application relating to the nature and amount of discharges is available to the public.

B/ EPA Policy

The EPA must review and may veto applications It is not clear what criteria EPA will use in its review. EPA General Counsel John Quarles has indicated that state certification will be regarded as conclusive, at least on purely intrastate waters. If this policy is followed, the federal permit system would not only be redundant, but would bar prosecution under the Refuse Act as long as standards were met.

C/ Justice Department Policy

Sec. 17 of the act gives the Justice Department full control over legal enforcement of the act. Federal district attorneys have the "duty" to "vigorously prosecute" all violators when requested to do so by certain named federal officials There is decisional authority that [56] the district attorney must prosecute even though he received information from another source. Even though the Act makes the duty of prosecution clear and unequivocal, Justice considers itself to have complete discretion in prosecuting. [57] Justice Department guidelines **allow** local D.A.'s to prosecute without clearance from Washington whenever they are requested to do so by other federal agencies. However, when private parties request prosecution, the D.A. must refer the case to EPA and the Corps will not prosecute unless requested by those agencies. [58] Sec. 24 of the FWPCA states that Refuse Act enforcement will not be displaced by proceedings begun under the authority of the FWPCA. However, Shiro Kashiwa, head of the Land and Natural Resources Division of Justice, has said that no Refuse Act prosecution will begin if the violator has been subjected to any enforcement action under either the FWPCA or state law. Justice considers a polluter's compliance with applicable water quality standards to preclude prosecution.

The Refuse Act permit system could provide the basis for a comprehensive federal attack on industrial water pollution. However, current federal policies seem to ensure that primary responsibility for water pollution abatement be retained by the states where permit requirements will reflect the non-uniform state water quality standards and enforcement will fall only on the most flagrant violators. A look at some of the inherent deficiencies in the operation and administration of water management laws at the state level will give some understanding of why this will be the likely result.

In the past, states have tackled water resources problems on a piecemeal basis among several agencies. Such a strategy has grave faults in that it fails to provide an integrated or consistent management program. Moreover, it fails to insure that any of the agencies involved will devote sufficient attention to water quality, or to the interrelationships of air, water, and land pollution.

Recognizing the weaknesses of the scattered approach, states have consolidated authority over water pollution in a single agency. [59] Of course, consolidation also has its weaknesses—if the agency deals solely with water, it may be oblivious to adverse effects its program has on other environmental concerns. Conversely, if the agency has control over all aspects of pollution, it is likely that it will be unable to deal with each aspect adequately. Even where sub-agencies are set up, the question of whether the right hand knows what the left is doing remains. It should be stressed that no matter what organization path is followed, other interests and organizations are still involved. Federal and local agencies are only the beginning. In addition, state commerce, health, conservation, agriculture, and housing departments should not be overlooked. Superimposed on all bureaucratic structures, private interest groups and concerned individuals also play tremendously important roles in each state.

The basic unit of planning, management, and enforcement is the state-wide water pollution control agency, generally composed of a board and a permanent staff. California uses regional boards as its basic tool. The state board steps in only in cases of conflicting rulings, during appeals, and to formulate state-wide policies.

Typically, the board is made up of from five to ten part-time citizens who have no vested interests and who come from different parts of the state. Some states specify that representatives of vested interests such as industry, agriculture, recreation, and health shall be included. Others have a board composed of the heads of the state department of health, agriculture, commerce, and so forth, and may include a leading municipal official as well.

In the past, a number of states specified that the permanent staff was to be headed by a single full-time professional rather than by a board. It was felt that one person would be able to cut down on delays and conflicts. The trend today is swinging away from the concept of a single director [59: Sec. 227.4] Instead, the staff is normally headed by an executive director, who may or may not be a board member. The board itself is chaired by an individual who may be elected or appointed.

The staff does nearly all of the routine work. They come up with the terms contained in discharge permits, often after lengthy sessions of compromise. Responsibility for enforcement, monitoring, and research also rests with the staff Board members generally follow staff recommendations to the letter.

In order to define the limits of jurisdiction of a state water control agency, it is necessary to examine the enabling legislation in detail. The authority given varies considerably, as local problems differ.

For example, some legislatures gave jurisdiction over all waters within the state. Others excluded ground water, private ponds, storm runoff, and so forth. [59: Sec. 228.1]

Definitions included in the act are a key to understanding the jurisdiction that was granted in it. The definition of "pollution" is particularly important. One can easily imagine that such words as "any contamination," "any unreasonable contamination," and "all discharges from industries and municipalities" can greatly alter the sphere of activity an agency can oversee Similarly, the definitions of "waste," "nuisance," and "person" should be examined closely.

Nearly all states allow their control boards to adopt "necessary" rules and regulations, both procedural and substantive, for the control of water pollution, [59: Sec. 228.2] thus affording great power and flexibility. However, boards are aware that they must stay in their place most of the time so as not to offend their state legislatures.

If the agencies press for reform too strenuously, dischargers may well begin to lobby effectively against strong water pollution laws. The agencies may find that their power has been undermined rather completely.

An important function of state water agencies is research and technical advice. At first blush, this, along with the power to collect and disseminate information, may seem rather innocuous. However, a strong state board can utilize these tools to effectively bargain with dischargers. A staff which has done a significant amount of research into a particular water pollution problem can often argue effectively with industries and municipalities trying to get a permit. Moreover, states may be able to offer meaningful suggestions and alternatives to those dischargers who have been unable to conduct extensive research themselves. Water problems can be curtailed significantly when knowledge is centralized. Duplication of effort is minimized, thus making research activity more efficient.

Staff members spend a good deal of their time examining production techniques and conducting tests, not only as a research function, but also to make sure that standards are being complied with. Policies regarding prior notice vary considerably. The power to inspect seems useless as an enforcement tool if dischargers are sufficiently forewarned that they can clean up their effluent while the staff member is visiting. On the other hand, a guiding principle of agencies is that dischargers, especially powerful ones, should be encouraged rather than forced. Once strong opposition to water control erupts, effective regulation may cease to exist. All states have an extensive array of agencies which are concerned with water pollution. Often, various agencies have conflicting authority, either among themselves or with the federal government. Legislation or judicial precedent may outline which agency is to prevail. If it does not, power crises develop, and the water pollution agency's coordinating role becomes important.

The federal demand for water quality standards in 1965 called for states to consolidate water pollution problems to a great extent. The law called for stream criteria (expressed as average concentrations of deleterious substances) and implementation plans, to be determined by the state legislature or an appropriate state agency.

The Standards apply to all interstate

waters, polluted or not. As a result, they tend to be minimal [60] Non-degradation policies help to maintain high quality. But the lack of accurate base line surveys weakens the impact of the policy in many states.

Receiving water quality standards insures that water within the state will be of a certain minimal quality at all times. In addition, dischargers are allowed to make use of the natural assimilative capacity of state waters; unnecessary treatment may be avoided.

A political advantage is that actual planning and implementation of treatment programs is left in the hands of dischargers. Government interference as well as industrial and municipal interference should be slight once the standards are enacted. Moreover, direct costs to the public are kept low since implementation costs are borne by polluters rather than by government.

However, as may readily be seen, by limiting regulation to rather low quality standards, actual water quality is not likely to improve. [60] The approach has no built-in mechanism to spur polluters to install more efficient treatment devices or to modify production procedures in order to decrease discharges below standard levels. In addition, enforcement machinery is generally slow and rather ineffective. Penalties are often so low that it is less costly for a discharger to pay a fine than it is to continue polluting. [61] Water quality standards, which were nominal to begin with, have little chance of being raised. Even if standards for a given state were relatively high and dischargers were meeting them, the approach has a basic thread of unfairness. That is, it fails to allocate the natural assimilative capacity of a given stream among water users. Even among users at a given point on the river, there are no intrinsic rules governing who shall be allowed to discharge the permissable amounts of effluent

In answer to this problem, all but a handful of states have instituted a permit system for discharge of effluents [59 Sec 229] Under the permit system, water users are forbidden to discharge any waste material into state waters unless they have received permission to do so from the state's water pollution control agency

Agencies issuing permits attempt to limit certification to those dischargers which are able to meet existing criteria. Where certain types of criteria have not been enacted, the agency can include effluent standards in the permit. If a discharger is able to exceed legislated standards, his permit will theoretically impose higher effluent standards.

Unfortunately, the process also works in reverse. While state laws may declare that permits will not be given if minimal standards not not met, a loophole is frequently left open—if a discharger can show that he would suffer undue economic hardship in meeting the standards, the water control agency may issue a permit at its discretion. In practice, hundreds of industries and municipalities have been able to disregard the law in this way. A plant which consistently violates water quality criteria may be the major employer in a particular town. A state board would be hard-pressed to deny certification to such a concern, even if the plant could easily afford to curb its discharges. In the case of municipalities, the consequence of closing down sewage treatment plants is having raw sewage dumped into the water. Water control agencies have been unwilling to risk economic or health crises for the sake of holding state water standards.

Permits may specify that discharges contain no more than a certain percentage of particular substances, they may limit the poundage of substances in the discharge; or they may require a certain level of treatment of harmful substances.

Use of the percentage system has obvious shortcomings. In the case of a large user, if even a small percentage of the effluent material is harmful, it may mean that a substantial amount of a dangerous substance is actually entering the water. Industries need only to dilute their effluent to meet percentage standards. One can only wonder how long dilution can continue before pollution levels will become intolerable.

To combat the problem, several states are beginning to limit quantities of pollutants by actual poundage as well as by percentages. [59: Sec. 229.1] Efforts to implement poundage limitations have invariably been met with strong resistance. Users realize that poundage limitations may force them to make an effort to clean up their effluent, even where the poundage requirement is supposedly only a reflection of the percentage requirement already in force. (This is due to the fact that industries have used dilution extensively.)

Imposition of treatment standards seems to be a step in the right direction However, an industry need only start out with high percentages of pollutants in his effluent to buck the system. It may even be to his advantage to add harmful substances to his waste materials

so that his clean-up task will be easy when removal requirements are finally imposed.

Effluent standards and the permit system attack the problem of water pollution more directly by concentrating on those who contaminate waters rather than on the waters themselves.

Yet, effluent standards do not necessarily safeguard state waters. For one thing, they do not take changes in water flow into account Thus, during times of drought, pollution levels may be overwhelming unless higher standards are temporarily substituted or water quality standards are enforced stringently.

Moreover, in allocating permissible levels of pollution among existing users, serious problems arise when new industries come into the area. [60], [62]

Presumably, state agencies have included a margin of safety in their allocation calculations [63] thus wasting the natural capacity of water to purge itself of certain types of effluent.

The major weakness of water quality and effluent standards is that neither penalizes dischargers in any way. To be sure, violators may be forced to pay fines. But as long as existing low standards are met, dischargers have little motivation to do better. Effluent is looked upon as inevitable. Instead of prohibiting pollution, the law condones it in limited quantities.

Financial Incentive

Instead of cracking down on polluters, states in the past have hoped to encourage industries to cut down on discharges by giving them financial rewards [59: Sec 224.3]

Tax Deductions

By far the most commonly used financial incentive on the state level is the tax break for installing pollution control equipment [59: Sec. 229.3], [61] Deductions may apply to property or income taxes, on a state or local level.

Schedules are set out which give industries deductions on a percentage of the costs of pollution devices over a period of years. Scales may vary for different types of machinery and other methods of control.

Several states still allow deductions for treatment methods which are required by law anyway. [59· Sec 229 3], [61] Others limit deduction applicability to devices which exceed state and local standards.

A rather ingenious twist which several states have employed is centered around a time limitation clause [65]. Under such schemes, deductions are permitted only until a specified date. It is hoped that such clauses will spur industry to install equipment in time to get the deduction, and that pollution control efforts will, as a result, be speeded up.

Perhaps the primary drawback to a system of tax deductions is that there is no guarantee that devices which are purchased will be effectively utilized [61]. Pollution equipment requires maintenance Industries may not be willing to pay the costs of hiring competent personnel or even running the equipment at all.

In addition, tax deduction programs in reality, offer little financial incentive to polluters. Industries receive no return on most investments in pollution control devices. Most states limit allowable deductions to the cost of the equipment. [61] Thus, from a businessman's point of view, tax incentives are inane. The only benefits to be received are non-economic—a possible improvement in public relations and an easing of the corporate social conscience.

Direct Payments

Theoretically, the government may make direct payments to dischargers for cleaning up their effluent. At present, neither the federal government nor any state does this. [59: Sec. 224.3] Economically, a plan for direct payments is virtually prohibitive. In order to make improvement profitable, vast sums of money would have to be awarded (at least as much as industries are currently saving by not cleaning up effluent). And governments on all levels are in critical condition financially even now.

Subsidies

A more indirect method of payment to industries is a subsidy program, currently in force in a number of states. Under the guidance of the state water control agency, funds are awarded as loans or grants for purposes of construction of facilities or research and development.

In most states, very little action along these lines was initiated prior to the 1956 Amendments to the Federal Water Pollution Control Act Since that time states have moved on both fronts, although subsidies for research and development are only a fraction of the total effort because of the small financial stake most states are willing to invest.

The 1956 Amendments providing for the grant-in-aid program to states for the construction of municipal waste treatment plants, on the other hand, have been the most significant legislative subsidies in the field of water quality management in history. This program represents not only a direct subsidy to the municipalities involved, but also an indirect subsidy to industries in such areas which no longer are required to treat their own waste but may simply tie in to the newly constructed municipal facility. To be sure the industry often has to pay a higher user cost than the typical residence or citizen to compensate for its higher load, but seldom does it approach the comparable cost to the industry if it had to build and operate its own plant.

The Federal construction grant program did have the beneficial effect of ensuring the acceptance of a Federal role in fighting water pollution, as shown above. However, it has also resulted in a massive diversion of funds into an area which is essentially no more than a symptom of the problem. The heavy funding of a construction grants program implies that the solution to the water pollution problem is simply to build sewage treatment plants.

Figure 2.5 indicates the disproportionate emphasis on the construction grants program in the entire Federal water pollution effort. Since funding began in FY 1957, $3,077 million out of the total Federal effort—$3,737.4 million or about 87%—has been tied up in the construction grant program.

Such a heavy emphasis upon construction grants leaves the crucial political questions of who is to pay the required matching funds at the state and local levels undecided. For example, the original Federal grants were limited to 30% of project cost, or $250,000, whichever was smaller. Fifty percent of the total federal allocation had to be used for municipalities of 125,000 population or under, and the total allocation had to be alloted 50% in the ratio of the population of the state to all the states, and the other 50% based on the per capita income of the state in relation to all other states. Since that time there have been various revisions of the exact state formula, with the proportion of federal funds for specific projects rising to 55%. However, the state formula still favors disproportionately the medium-sized (as opposed to large) city and the less rather than most populated industrialized states [66].

FIGURE 2.5

BUDGET FOR OFFICE OF WATER PROGRAMS ENVIRONMENTAL PROTECTION AGENCY

Significant Legislation	Year	Construction Grant Appropriations	All Other OWP Appropriations	Total Appropriations
1956 Amendments to 1948 Act FWPC	1956	0 million	0 million	0 million
	1957	50 million	4.2 million	54.2 million
	1958	45 million	7.1 million	52.1 million
	1959	45 million	8.6 million	53.6 million
	1960	45 million	8.1 million	53.1 million
1961 Amendments to FWPC Act of 1948	1961	45 million	12.0 million	57.0 million
	1962	80 million	22.0 million	102.0 million
	1963	90 million	24.7 million	114.7 million
	1964	90 million	24.0 million	119.0 million
Water Quality Act of 1965	1965	95 million	33.1 million	128.1 million
Clean Water Restoration Act of 1966	1966	120 million	66.1 million	186.1 million
	1967	150 million	78.4 million	228.4 million
	1968	203 million	98.8 million	301.8 million
	1969	214 million	88.8 million	302.8 million
Water Quality Improvement Act of 1970	1970	800 million	86.4 million	886.4 million
	1971	1,000 million	98.0 million	1,098.0 million

In addition, the construction grants program—especially with its Congressional funding being handled by the respective Public Works Committees in the House and Senate—inevitably became considered simply another brick-and-mortar project (with little connection to pollution being manifest) with all the overtones of "pork-barrelling" endemic to such undertakings.

In any case, the question of who is to pay was effectively pushed down to the local level where municipalities and counties have been increasingly unable to pass bond issues to finance even their share of construction of waste treatment facilities. This has represented merely a passing on of the remedy to water pollution to the local citizenry and taxpayers, thereby providing an indirect subsidy to the industrial polluter who in many cases was the chief source of the most damaging waste materials.

More significantly, sensing that the thrust of the federal effort was chiefly to construct municipal treatment plants, most states began to defer from any serious section on the enforcement front which would put pressure on industries to clean up their waste before it was put into the rivers and streams. Instead, major efforts were devoted to drafting applications for subsidies from the federal trough. The result was to create a formidable backlog which the OWP (formerly FWQA) budget was unable to meet with any kind of scheduled regularity. Some other states deferred local action even in this effort and waited in the hopes that the federal proportionate share of construction funds would increase with time and some of the ground rules would change—a dilatory action which paid off.

In any case, the result was to shift the political onus for pollution from the industries which were doing the dumping and the states which were the "primary" level of government charged with moving against them, to the federal government which was put in the role of the country's Number One financer of waste treatment plants, but with little other significant jurisdiction.

Effluent Charges

Even though water pollution authorities have been recommending a system of effluent charges almost unanimously for years, there has been no implementation of the method anywhere in the United States. [67: p. 103-104]

Under such a system, dischargers would be required to pay the government a set amount for each discharged unit of particular waste materials. Rate schedules, based on poundage, percentages, or both would be set up. As pollution loads became greater, the rate would presumably, increase. Rate differentiation among waterways is also possible. This would tend to encourage industries to settle in particular areas. Such a system has several attractive features.

First, a negative economic incentive would stimulate users to cut down on discharges. If dischargers were suddenly forced to pay a charge for their emissions, it is likely that they would vigorously attack the problem of implementing technological mechanisms. If some would prefer to pay the charge, progress in pollution control could still be accomplished by applying the payments to treatment facilities and pollution research.

Obviously, in order to get users to reduce effluents, charges must exceed the cost of cleaning up. Since the costs of cleaning up increase as higher and higher percentages of removal are achieved, each discharger would balance the cost-benefit ratio for each level of removal.

While rates could be high enough to make all discharges prohibitively expensive, it would seem useful to differentiate between various kinds of pollutants. For example, rivers are able to recover from certain amounts of BOD. Chemical discharges, on the other hand, keep accumulating in the ocean no matter how much they are diluted. In order to protect the oceans, higher rates for chemical discharges would seem to be called for.

Rates could also change as water quality in different areas is taken into account. If it is desirable to try to resurrect a dead stream, for example, effluent charges could motivate industries and municipalities to cut down on effluent discharges drastically.

Water users have effectively resisted even vague attempts to implement any system of effluent charges. They argue that effluent charges discriminate against industries that have located on state waters while those which dump their waste into municipal systems are let off the hook. Such an argument may have an effect on decision makers; however, when the reasoning is examined, it fails in most respects.

First of all, it does not seem unfair to force those who pollute to pay for the des-

truction they cause. Industries which use municipal waste systems are subjecting their effluent to at least some degree of treatment, while industries located on rivers and lakes often make no attempt to treat their wastes. Dischargers who pipe effluent to treatment plants have been "discriminated against" in the past since they have had to pay sewerage charges all along.

Moreover, as effluent charges would be imposed on industries and municipalities alike, dischargers located away from natural waterways would also be forced to pay, but in an indirect way. Sewerage rates would rise so that municipalities could pay the required charges. To be sure, effluent charges may be rather arbitrary, especially at first. However, it is likely that the increased sewerage rates would closely reflect effluent charges. As time progressed, accurate economic formulas could, no doubt, be calculated.

Another feature of the effluent charge system is that it assigns the task of implementation of dischargers rather than to governmental agencies. Costs of administration would be minimal since many current functions of state agencies would be cut out. Agencies would no longer have to determine water quality and effluent standards. Their major roles would be monitoring and enforcement Delays and red tape, the cornerstone of bureaucratic institutions, would be supplanted by rapid action by water users.

Perhaps the greatest advantage of the effluent charge system is that it is equitable. Present effluent standards can easily discriminate against relatively harmless dischargers. For example, an industry which must remove a high percentage of a harmful waste material need only begin with a large percentage of the substance in the waste water to throw the system out of kilter. It can easily comply with the new standards. A "clean" industry, on the other hand, is subjected to significantly higher treatment costs.

Effluent charges reverse the process. Those users with a high degree of treatment have lower payments. While rates may be high even in the 90-100% removal range, amounts of effluent will be less.

Ultimately, of course, the cost of effluent charges fall on the consumer. Product prices will surely rise as industries are paying increased production costs It is probable, however, that the public will pay significantly less now than it will have to pay as water pollution worsens. The public pays, in the end; however, the problem of water pollution is attacked The only choice citizens may make is whether or not to attack the problem at all

Concerted Program of Education

In order to attack the problem of water pollution on all fronts, a massive education program must be superimposed on any administrative program which is established. Governmental action cannot be effective over a long period of time if it conflicts with social values. In the case of water pollution, it is obvious that prevailing social values are in direct conflict with social needs for cleaner waters.

The education campaign must pervade as many arenas of social thought as possible. The message, that we must clean up our enviornment, must be echoed in a forceful, consistent manner throughout formal and informal education-oriented media. Ultimately, ecological commitment should be passed on from parents to children, just as other social values are.

As intermediary steps to the ultimate educational process, we suggest several concerted programs:

—Courses in enviornment should be taught beginning in elementary school. As environmental questions become relevant in other courses, they should be stressed.

—A public campaign is necessary to acquaint the non-elite members of our society with information about pollution, polluters, and basic value conflicts. Public service advertisements on radio and television are only the beginning. Messages such as those currently being transmitted should be strengthened, enlarged, and dispersed more widely. The messages should go beyond merely offending the public by showing them pictures of dirty water. They should, in addition, state the consequences of our current industrial growth, population projections, supply of water, volume of garbage, etc. Current social attitudes and values concerning water resources should also be brought out so that people can identify and understand their now ill-defined feelings.

In addition to pollution information, the public should receive information about those who are degrading our environment. State or regional authorities should be required to report their activities, and the activities of those they regulate, to the general public. These reports (probably annual) should be printed locally in all daily newspapers. The

report should include.

a) major enforcement actions taken in summary

b) information on past and current dischargers, broken down by amounts of each substance discharged

c) a status report of the state of public waters

d) plans for the future

Groups wanting to collect and disseminate information about ecological problems should continue to receive a portion of their expenses from the federal government. (See P.L. 91-516). The money would be used for ecology movies (both the Tom Lear type and more sophisticated productions) and lectures.

Administrative action can only be an initial spur to getting a cleaner environment. In order to keep the ecology movement alive, the public must first become aware of the problem. Once the people are sufficiently incensed at polluters, more effective pressure will be brought to bear on those who degrade the environment. In addition to keeping the polluters in line, an informed and committed public can take action of its own to curb pollution of all types.

Conclusion

The purpose of our analysis has been to provide the fullest possible social and historical context regarding water quality problems. It is our sincere conviction that a frank recognition of the depth and complexity of the problem is prerequisite to intelligent planning and ameliorative action.

On this note, we must recognize that although our society shares common sources of difficulty with other industrial regions of the world, it also has its own special brand of impediments. This analysis is an attempt to identify objectively both the similarities and the differences in national conditions underlying the problem.

In this spirit, we must come to recognize that ours is a culture that denies long-term planning and stresses contemporary private competition as the best solution to questions of resource allocation. It is a culture in which the dominant institutions rest on political and economic individualism. It is a culture that contains no substantial tradition that would promote citizen cooperation—especially on domestic matters. However, there is an implicit faith in the idea that we can settle our differences through negotiation and compromise. But this is much different from a moral sense that "one ought to show deference" to the needs and points of view of fellow citizens. It is instead a commitment to taking from society "all the traffic will bear." It is tacit admiration of one who "puts something over the other fellow," and a glaring example of the American propensity to avoid facing responsibility for its domestic problems. For an excellent analysis of these tendencies in American culture see: Slater, Philip, 1970. The Pursuit of Loneliness: American Culture at the Breaking Point, Bacon Press, Boston.

With these understandings, the reader will discover that our recommendations for policy and supportive research take on a somewhat different cast than they usually do in reports of this nature. This is due to the fact that we can now see that change is not a simple matter of letting citizens know that powerful corporate interests have strange policy-making bedfellows, or that it is a problem of responsive and responsible government, but that it will also be a problem of responsible citizenry. It is also a problem of a well informed leadership. Without this understanding, the very formidable challenge that is faced—at the very least a reinterpretation of basic cultural values—must reach a less than satisfactory conclusion. Eventually America must come to recognize that whether through divine inspiration or otherwise, man has stated the values and rules by which he lives and uses his resources; and therefore, man, where the will is generated, can change them to suit his needs. A society that fails to recognize that culture is a set of tools—created by man to serve man in his struggle to adapt and improve the quality of life—is a society that lives at the mercy of its past. If rules and social forms become our masters rather than our servants, then our opportunity for a meaningful solution to our problem must remain elusive.

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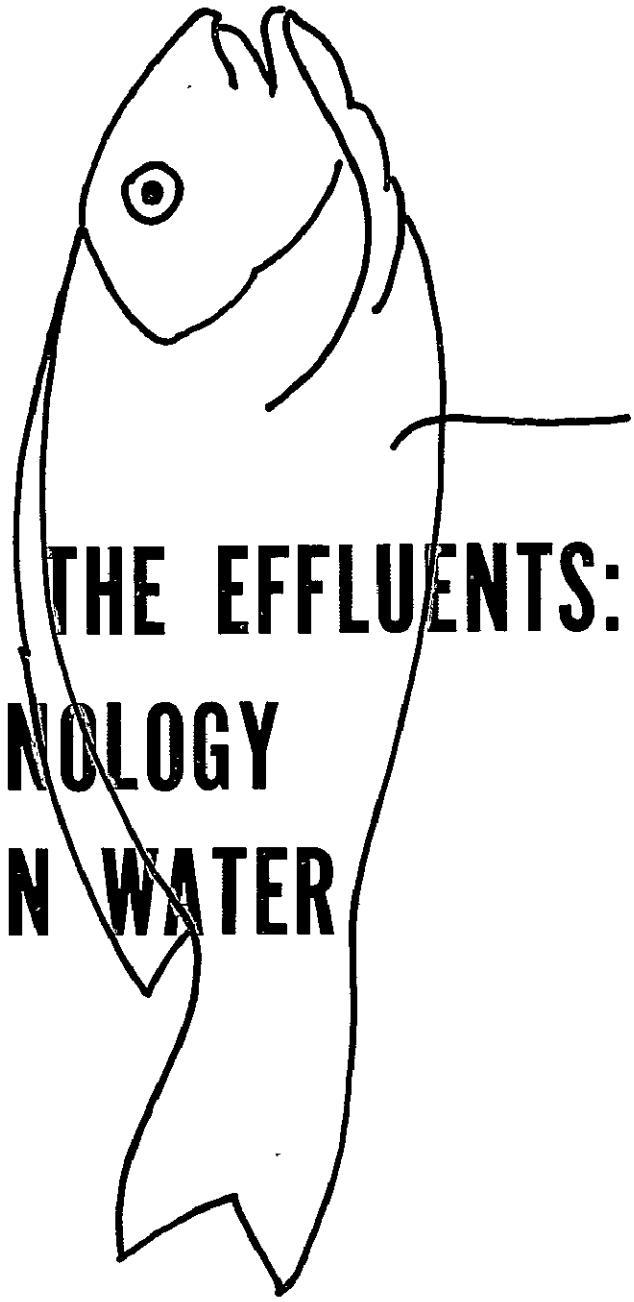

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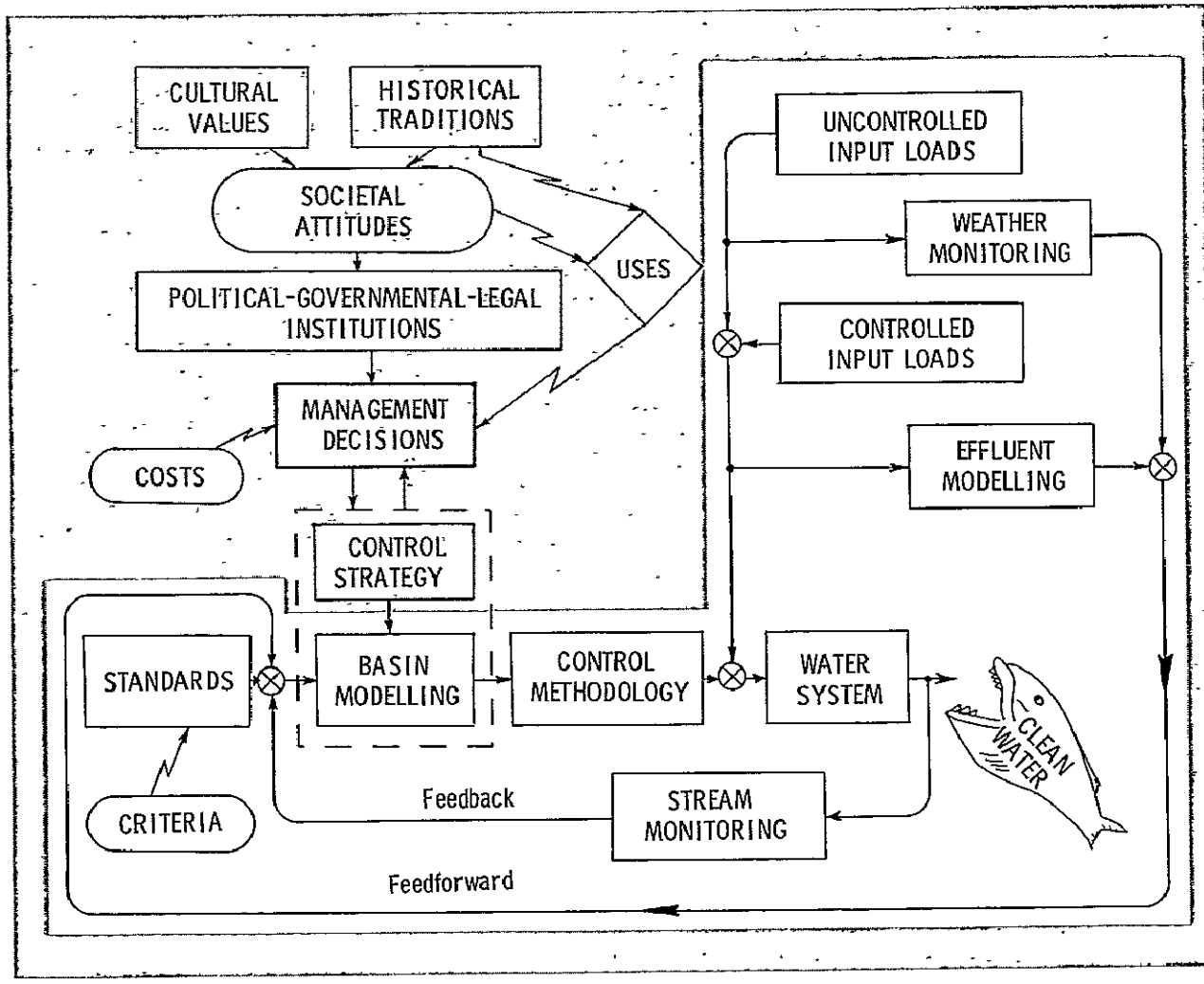
TREATING THE EFFLUENTS: THE TECHNOLOGY FOR CLEAN WATER



Introduction

In respect to the work immediately following, we defer to reader's choice and offer the option of skipping Chapter Three. It does not remotely resemble the classical prose of Henry James but consists of special sections, unified only by their relationship to clean water, as well as their relevance to the subject at hand. Some may find it unnecessary to study the majority of topics treated herein. This chapter has been prepared primarily as an aid to the non-specialist who may wish to review certain aspects of the many factors related to clean water.

The very portions of our country which enjoy high desirability and popularity as living places, namely water-land interfaces, happen also to contain the more delicate and necessary ecological systems. These systems are comprised of the intricate web of relationships between living organisms and their non-living surroundings such as forests, lakes, and estuaries. Larger ecosystems, or combinations of them which occur in similar climates and share similar character and arrangement of vegetation, are biomes. Examples of these complex systems and their interactions follow. That entire systems need to be studied as a whole, will be demonstrated.

The Aquatic Community And Existing Hazards

A river system normally contains an almost unbelievable number of different living organisms. These are interwoven into functional and dynamic life units. Stresses on individual species are echoed throughout the complex. Each type of organism has its own special (and generally essential) niche in the web of life.

Speaking in very broad terms, aerobic microorganisms (certain bacteria, actinomycetes, fungi, and algae) form a highly

specialized decomposition unit. The exact species composition of this flora is dynamic and varies with environmental conditions or available substrates By attacking dissolved and particulate organic matter, these organisms satisfy their energy requirements. Other than molecular oxygen, these decomposition organisms need few additional nutrients that are not usually common in water systems.

The breakdown of complex organic molecules consumes dissolved oxygen and liberates carbon dioxide. This latter substance is either converted into living material via oxygen-evolving photosynthesis, transformed into carbonates, or liberated to the atmosphere. Biological assimilatory power is a normal exchange pattern—and upon it, life on earth is dependent. If this process should be inadvertently destroyed, biological catastrophe results. That an almost unseen threat perils all water systems is aptly presented by the following statement.

> . Ecology and the ecological crises have become part of our popular language. Unfortunately, the intense political activity aroused by each instance of environmental destruction tends to obscure the fact that such destruction is often irreversible, and that the sum of small actions, or inactions, may well result in the end of human society as we know it.
>
> Y. H. Edmondson (1), editor
> Limnology and Oceanography

This nation cannot afford much longer to allow rivers like the James to continue to receive waste loads that always exceed their assimilatory capabilities. Who can know the magnitude of the detrimental effects that are happening to the system when oxygen-dependent life processes are being lost and excess waste material is accumulating like tailings from an overworked mine? Subsequent studies may well provide answers, but the inherent dangers cannot be minimized.

For example, consider the present tragic case of mercury contamination in the environment. After years of indiscriminate dumping, all at once this nation has been caught up in real panic Many rivers and lakes are closed to fishing because of mercury contamination. Some parts of the fishing industry have suffered an almost fatal blow by the scare. Even now the total magnitude of this environmental crime may not yet even be visualized.

Life forms are generally resistant to substances which have been common during their evolutionary development. On the other hand, rare and unusual elements are extremely toxic. Our many years of mining, refining, and using rare metals have resulted in the removal of many exotic substances from their inert ores and their eventual discharge into water systems. In this solvent system, the ionic (and active or toxic) state is rapidly assumed. For living organisms with eons of separation and no evolved inborn protective mechanisms, there is no defense.

As a minimum, sustaining programs for river systems must have at their heart a program of maintenance (or restoration) of the biological integrity of the system. To fall short of this is to accept defeat from the start—for this is, in effect, saying that man can no longer live within his environment. Ways must be found to perpetuate biological interactions within entire systems which promote vitality, not decay.

Existing Water Needs And Uses

Numerous and varied listings of current "uses" or "needs" pertaining to water systems are readily available and illustrate man's strong dependency on the limited resources of the hydrosphere. Some distinction between the two must be made however.

The ownership of natural water systems resides in the citizens collectively, and their control is relegated to the state. This concept is upheld by both tradition and common law. A set of inalienable collective rights then follows *a priori*. These, simply states, are:

1. A **right** to water for drinking, free from contamination by other uses.
2. A **right** to harvest the aquaculture of these waters for individual consumption without risk to health.
3. A **right** to enjoy the recreational and aesthetic benefits of the natural water system.

Utilizations of the water system, whether by individuals or groups, which have the potential to restrict or diminish these collective rights are classed as water "uses." Uses are only possible through public consent, either stated or implied. Conversely, certain water "needs," which maintain an **inherent** precedence over water uses, are directly dictated by collective public rights

Industrial Water Intake. Use upon misuse

An abundance of available water with which to satisfy basic needs allows a proliferation of uses as a trade-off to otherwise benefit the collective citizenry, either directly or indirectly. However, as this availability decreases, restriction and regulation of water uses that tend to usurp water required for basic needs become increasingly imperative. Throughout the United States, the latter situation is becoming increasingly prevalent.

Solids, Sediments, Spoil And Wetlands

Waters of the earth's hydrosphere are continually being transferred from one environment to another. The stream-system flowage of a drainage basin includes the surface run-off contained in well-defined channelized streams. These waters originate as basin precipitation and usually undergo continual exchange with underground waters during transit to the sea.

During transfer from headwaters to sea, the flowing surface waters carry varying loads of dissolved and solid materials which have been eroded from the land surface. Other than localized exceptions, the stream's solid detritus is generally a predominate concern in water quality management. Specific processes controlling erosion, transportation, and deposition of waterway sediment load are discussed separately in the appendix.

Erosion and litter at an industrial outfall

Natural Sedimentation Control

A river system is a constantly changing dynamic system, which, nonetheless, tends toward an overall balance between deposition, erosion, hydrologic, and biologic conditions in the short term. Under natural conditions, shifts in the overall balance tend to be gradual, systematic, and to proceed at an almost imperceptible pace with respect to human reference. Within drainage systems, certain processes act as natural buffers against abrupt, extreme changes in the network's overall balance.

The most effective natural control of sediment introduction into waterways in temperate and humid climates is the strong relationship between native biota and climate. Table 3.1 summarizes the ratio of erosion rate with different vegetative cover from a study

A misuse of the James

Table 3.1 Rate of Erosion for Different Soils

TYPE	TYPE OF LAND	Ratio of Rate of Erosion to That in Soils of Type 1
I	Fall plowing on structureless soils	1.0
II	Winter fields on structureless soils	0.5-0.75
III	Fall plowing on structural soils with furrow inversion slice	0.2
IV	Long-fallow lands and perennial grass	0.1
V	Forest	0.00

area in Transvolga. In addition to retaining the soil and decayed bedrock in place, plant growth assists percolation of run-off into the ground water and acts as a baffle to remove sediment from slope run-off. Contiguous with the waterways themselves, analogous sediment traps are formed by marshes and swamps. These wetlands likewise form protective shields against current erosion in the waterways by structurally reinforcing the sediment deposits with dense root growth.

A second but lesser control on sediment accumulation is the constant exchange of water between surface waterways and ground water in humid and temperate climate discussed above. This buffering system on the stream discharge is itself strongly influenced by ground cover (Fig. 3.1). Partial or complete obstruction of channels, typically resulting from a change in basement lithology, commonly forms slackwater stretches in which coarser sediment may be temporarily removed from transport. Finally, flood stage itself is a major control in preventing siltation of a river channel. Annual flood stage permits removal of sediment introduced by smaller tributaries into the main channel during periodic local rainfalls, too small to effect significant flow in the main waterway.

In arid regions, natural controls against excessive semidentation in streams are weak to nonexistent. With little vegetative cover, sediment is rapidly introduced into waterways during occasional rainfalls. Drainage patterns are marked by intermittent flow, indicative of unidirectional transfer of water toward a continually depressed water table. Even periodic floods are insufficient to flush much of these systems of the vast amount of sediment, in part because of the low relative precipitation and continual loss of water along the route to the ground water system.

Cultural Influences on Basin Sedimentation

The major problems with sedimentation in a river occur with the beginning of man-made

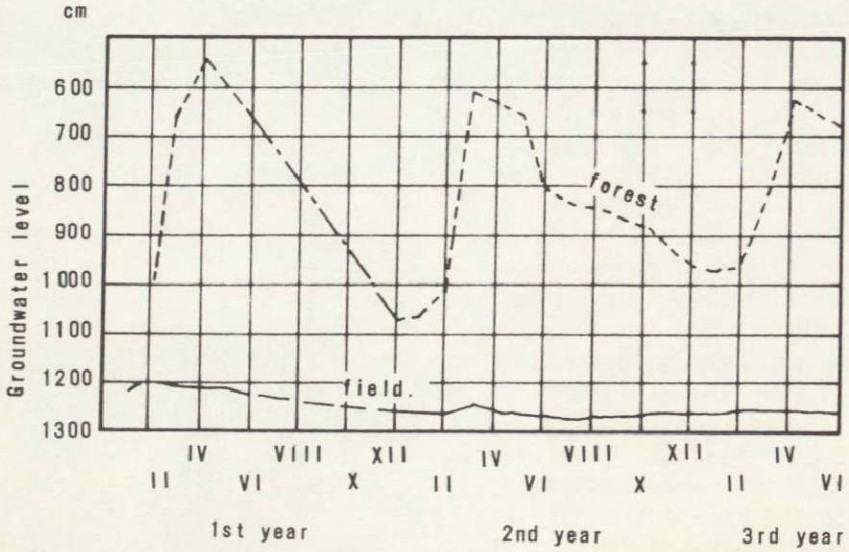


FIGURE 3.1 CHANGES IN GROUNDWATER LEVEL IN FORESTS AND FIELDS IN THE VORONEZH REGION (FM: OTOTSKII,)

activities. Especially affected by man are gound water and native vegetation—two of the main natural buffers of the system Forest depletion, land clearing, road and airport construction, and land cultivation all change the input characteristics of sediment into the stream. Channel development or flood control works drastically change the flow capacity of the stream and thus materially affect the problems of sedimentation Changes in the channel flow patterns are of great significance in that not only will the sediment movement be different; but, with modification in channel size, depth, or hydraulic efficiency, changes in the drainage pattern of the entire basin and in the ground water pattern may result.

Additionally, in lower extremities of the basin, changes in patterns and extent of salt water intrusion may substantially affect stability of wetlands and associated fauna and flora. These changes are difficult to predict and probably cannot be modeled precisely with any currently known form of model. For these reasons, great care must be exercised in any such construction. Changes in the river itself, such as the addition of wharves, bridge piers, debris traps, fishing traps, and so forth, will likewise affect the flow pattern in the river and may occasion, although to a lesser extent, all of the problems attendant to channel construction. Occasionally such construction will benefit an area ecologically if it is in a depressed state due to a lack of nutrient, adverse salinity conditions, or presence of predators, so that minimum maintenance is required.

Approaches to Controls of Sediment Pollution

Sediment forms a natural component of almost all stream systems. The amount of sediment flushed through will markedly vary within an individual stream from high to low water stage. Likewise, total annual sediment transported will differ from one basin to another. Consequently, no concentration level is broadly accepted as constituting pollution to a waterway. Measurement of stream transported material is likewise a problem. No automated method of measuring dissolved or suspended load exists, and no system, manual or otherwise, can determine adequately the rate of bed load transport by a river.

Effects of sedimentation on a waterway are two-fold, biological and physical. Introduction of increased sediment load into a waterway may cause the waters to become unsuitable for native aquatic life which previously used the water as an oxygen source and for filter-feeding Physically, such added sediment will cause excessively rapid rates of silting and shoaling in lower reaches of this waterway. This is particularly distrubing to man when the channel empties into an open estuary or other natural harbor. If the rate of sediment introduction exceeds capacity of the network to remove it even at flood discharge, well-developed channels throughout the waterway will begin to shoal and break into multiple, shallow, braided patterns. Both biologic and physical changes are characteristically gradual, often requiring years before new equilibrium conditions are established.

Methods of sediment control fall into three groups 1) activities in the watershed to minimize sediment movement into waterways, 2) control of river hydraulics either to remove materials from the stream water or to control the site of sediment deposition, and 3) physical removal of the sediment deposits accumulated by the water system. The latter approach, typified by channel and harbor dredging, depends on creating and maintaining an artificial imbalance in the network's erosion-transport-disposition equilibrium. Control of the river's hydraulics to alleviate siltation problems characteristically involves an imposed change in a channel cross-section area to increase or decrease velocity per given discharge Reduction of channel width near river mouths causes velocity and/or depth increase, often opening the channel to navigation with minimal dredging Expansion of the channel width, one effect of a dam, contributes to velocity reduction and resultant deposition of sediment load. Activities in the watershed to minimize sediment movement into the drainage system date back about 40 years in the U.S. and are primarily the result of activities by the U.S. Department of Agriculture's Soil Conservations Service. Similar controls in non-agriculture regions are woefully lacking, despite the inherent advantages of this approach to treating the cause rather than result

Channel Dredging Problems

Since maintenance dredging is a rather costly and nonproductive item in any port's maintenance budget, this is usually carried out at the cheapest cost. However, an

adequate minimum-impact disposal system is not usually provided. This is because there is often no information available to the dredge boat captain regarding this matter, and the spoils are often thrown in a portion of the stream most likely to carry it away from the dredging location. Planned procedures and spoiling regulations must be established for all areas with specific attention given to reduction of ecological damage.

Attempts have been made to reclaim dredge spoil, but these are usually not practical. Generally, the spoil from maintenance operations is "clay size" with poor consolidation and consequently of little use or economic value.

Construction dredging for large projects presents a slightly different situation in that it may be practical to remove the spoil a great distance from the project either by pipeline or by hopper-barges. Sand has successfully been transported as far as 20 miles for fill purposes. This suggests that large quantities of material from one location may be economically removed to other areas. Because of their effects upon the flow in the area, large dredging projects should be minimized. In saline areas this dredged spoil, if accumulated in one site, will generally not support normal growth for several years because of the salt content. It is recommended that additional pumping of fresh water be considered in order to leach some of the salt from the surface spoil to accelerate restoration of surface vegetation and to prevent loss of material from the area.

Dredged spoil is particularly detrimental to animal life because it not only impairs the gills of fish but also destroys for some time the natural growth in the area of deposition, thereby interfering with the natural food chain.

Because of the fact that no remedial measures have ever yet been able to restore a river which has been altered by man-made construction, great care must be taken in the design of all construction projects. Their net effect must be truly beneficial to the entire system and not just the man-segment.

The Wetlands Problem

Among the most complex and least understood environments in the drainage basin are its wetlands. Dependent on a fine balance between biologic, sedimentologic, and hydrologic controls, this environment typically represents a depositional transition stage between water-bottom and dry land.

The importance of retarding the rate of wetland decay has long been recognized by biologists Only recently, however, has the full importance and economic value of wetlands become recognized by other scientific disciplines and political administrations. Of prime economic concern is the dependency on wetlands of early stages in the food web of commercial and sport fishing (See Fig. 3.2). The state of Virginia, for example, has in excess of 330,000 acres of wetlands upon which over 95% of the annual fish harvest from tidal waters is dependent to some degree [4].

Wetland problems evolve because of their inobtrusive usefulness, lack of redeeming aesthetic qualities, and, locally, their danger to man as a breeding ground for the mosquito. With urban development, standard procedures have been to dredge, drain, and fill, "reclaiming" this environment for housing or industry on the adjacent waterway. This emphasis on development continues today, with **first** legislation designed to protect and preserve wetlands passed by Massachusetts as recently as 1963. Several states have subsequently introduced legislation oriented towards wetlands preservation while in others, no controls to total development exist to date.

Aside from direct cultural modification of wetlands which is potentially controllable by state ownership and planning, indirect modifications result from man's activities in adjacent areas. In particular:

1. Excessive extraction of groundwater for industrial or residential water supply may dry out and destroy the wetlands and its vegetation during a period of extended drought. Salt water destruction of the fresh water portion of the marsh may likewise result.
2. Small fresh water tributary dams for water supply or flood control also, if not properly planned, will result in drying and local changes in water chemistry. Additionally, the small amounts of silt and clay necessary to offset erosion and subsidence of the wetlands commonly will be trapped.
3. Construction of roads, locks, canals, and bridges to provide access to and across the wetlands, will also modify water and sediment transport through wetlands.
4. Residential, industrial, and highway construction, although not physically within

the environment, may introduce major quantities of sediment into the marshes by run-off during actual construction Although minimal amounts of sediment are necessary to maintain the wetlands, excessive rates of sediment introduction will destroy it.

5. Uncontrolled expansion of high-powered pleasure boats as well as commercial work boats contribute to accelerated erosion of marsh fringes, especially in narrow waterways.

Waste from Vessels with Particular Reference to the James River System

Summary of the Wastes and Their Traditional Handling

SEWAGE is traditionally flushed directly overboard from toilets essentially the same as those used ashore. The flushing water is usually the water in which the vessel floats. The composition has been estimated [6] for naval vessels as:

per capita flow,	gal/day
maximum	34.0
minimum	22.6
average	26.2
solids, mg/liter	
Suspended	23.6
Settleable	5.4
BOD, PPM	102.0
pH	7.1 - 3.2

WASHWATER comes from showers, laundries, and galleys, and also goes overboard. Estimates of quantities from [7] are:

Shower and Lavatory Drains	20 gal/day/man
Laundry	5 gal/day/man
Galley	5 gal/day/man

GARBAGE and TRASH traditionally go overboard, but in recent years there has been changeover to incineration or hauling ashore, at least while in port.

BILGE WATER originates in leakage from the sea, though this should be a trifling source for most vessels, and from internal leakages and deliberate drains from machinery. This water can be clean, but is usually oily and otherwise dirty from sloshing around in the bilges. It goes overboard like everything else, but except in case of emergency (ship sinking), there is rarely any real need to pump it overboard in port

BALLAST WATER is a problem mainly for oil tankers These ships must carry a partial load of water in the cargo tanks when running empty (i.e., otherwise empty) for propeller immersion and reasonable steering Depending on several factors, the amount taken on varies from 20 to 30% of total capacity [8]. This water is carried in "clingage" from the last cargo It is pumped overboard before loading the next cargo, which means oil contamination entering the harbor. Since that is now frowned on, the tanks are washed at sea and refilled with ballast that is consequently clean enough to be discharged in port. This process moves the problem out to sea, but solves it so far as harbors and inland waters are concerned. For further reading on the total oil pollution problem, try [8].

DECK DRAINS are usually not a problem, for this refers mostly to rain and sea water running off the decks, and the decks are seldom as dirty, usually, as city streets. It is mentioned, however, because decks may be hosed after loading dusty cargoes such as coal, grain, ore, and the like.

OIL LEAKS may occur from cargo and fuel tanks, but are rare except possibly from poorly maintained oil barges. It has been cited [8] as noticeable on the Western rivers, where barges are forever being roughly handled in the locking process.

OIL SPILLAGE can occur whenever oil is transferred from vessel to vessel, vessel to shore, etc. Avoidance requires care in draining hoses, care in tending mooring lines so that tidal change won't distort joints, care in monitoring the level in the tanks so that they won't overflow, and in general care to avoid spilling.

BOILER BLOWDOWN is water ejected from the boiler periodically to reduce the solids content of the water. Quantity should be on the order of 100 gal/day per boiler. Composition is that of the boiler water

LEACHINGS refers to emanations from the external surfaces of the vessel. Antifouling paint deliberately releases a toxic compound into the water to kill potentially attaching creatures. Zinc ions are released from sacrificial anodes that are intended to break

up the electrolytic couple between bronze propeller and steel hull.

CARGO SPACE WASHINGS are a problem from oil tankers, since the "clingage" must be removed before clean ballast can be loaded, or before a cargo of different composition can be taken out This is apparently the major source of oceanic oil pollution because the cleaning has always been done at sea. Recently, refinements have been introduced to promote separation of oil from the washings; and this reduces pollution of the sea, but separation is far from perfect.

SPECIAL NOTE FOR SMALL CRAFT. Small craft here means pleasure boats, harbor tugs, fishing-crabbing-oystering boats, etc. The main problem from these vessels is sewage, and maybe garbage and trash. They also use antifouling paint, but whether this is actually a problem is not known at this time. Also, a special problem that has been alleged, but not yet proven, is contamination from the engine exhaust, and from gasoline drippings.

Magnitude of the Problem in the System

HAMPTON ROADS. Personal inspection shows little visual evidence of contamination from trash, garbage, or oil, although pockets of such pollution doubtless exist. However, this sort of thing is the result of carelessness, and is not the inherent problem that sewage is. The biggest source, by far, of marine pollution is the floating navy population. This fluctuates widely in number, (e.g., the arrival or departure of a large aircraft carrier adds or subtracts about 5,000 men), but as a mean number, about 25,000 men are afloat. The population on commercial ships and pleasure boats is comparatively small and should fall well within the uncertainty in the 25,000 estimate Using 0.17 lb/man-day of BOD, the contribution of the floating population is 0 17 x 25 x 10^3 - 4.250 lb/day. In 1967, about 70,000 lb/day BODs issued into Hampton Roads from shore-side installations mainly from municipal treatment plants [10] . It thus appears that the ship contribution is small, but still significant.

The River—Hampton Roads To Richmond

COMMERCIAL TRAFFIC. In 1969 there were 28,482 upbound trips and 27,851 downbound [7] . Of these, only about 65 each way (an estimate) appear to be ocean-going ships. Assuming that each such ship spends 4 days on the river, and that its crew is 40 men, the equivalent sewage load is 65 x 4 x 40/365 - 30 equivalent people. Of the remaining trips about 10,000 were by barges, presumably unmanned. This leaves roughly 45,000 trips by boats, which are mainly seafood harvesters, plus the tugs that must accompany the forenamed barges. Estimate an average of 4 men per vessel, and a vessel-trip lasting one day, giving sewage load of 45,000 x 4 x 1/365 - 500 equivalent people.

PLEASURE BOATS. About 500 pleasure boats of size and type to be equipped with toilets are moved or used on the James and tidal tributaries. Assume that each is used one day per week by an average of 4 persons, giving sewage load of 500 x 4 x 52/365 - 300 equivalent people.

GOVERNMENTAL VESSELS consist mainly of the James River Reserve Fleet, and the Army Transportation Corps Fleet at Ft. Eustis in the same neighborhood The Reserve Fleet contains about 300 ships (313 reported on 7/13/71). It is unmanned, so that the sewage load is negligible. The leaching of antifouling paints and zinc, however, could be severe if indeed this is a source of pollution. Zinc, at least, has been monitored in shellfish [9] and apparently does not confirm a problem.

The Ft. Eustis fleet consists of a number (less than 50) of small vessels, tugs, small landing craft, small cargo boats; a rough estimate is that their sewage load is not more than 100 equivalent people.

The River above Richmond

The only noticeable watercraft activity above the falls consists of small pleasure craft in modest numbers, canoes scattered throughout, and powerboats on impoundments. Present impoundments are probably too small to support a houseboat population, and these are the only type likely to have toilets. All in all, the marine sewage problem is trivial.

Solutions

THE LEGAL SITUATION. Nonsewage wastes, such as oil, garbage, and trash, are covered by the Refuse Act of 1899. Sewage is covered by the Water Quality Improvement Act of 1970. It required EPA to set standards for all vessels, save those of the Department of Defense, for marine sanitation devices. Tentative standards were published in the

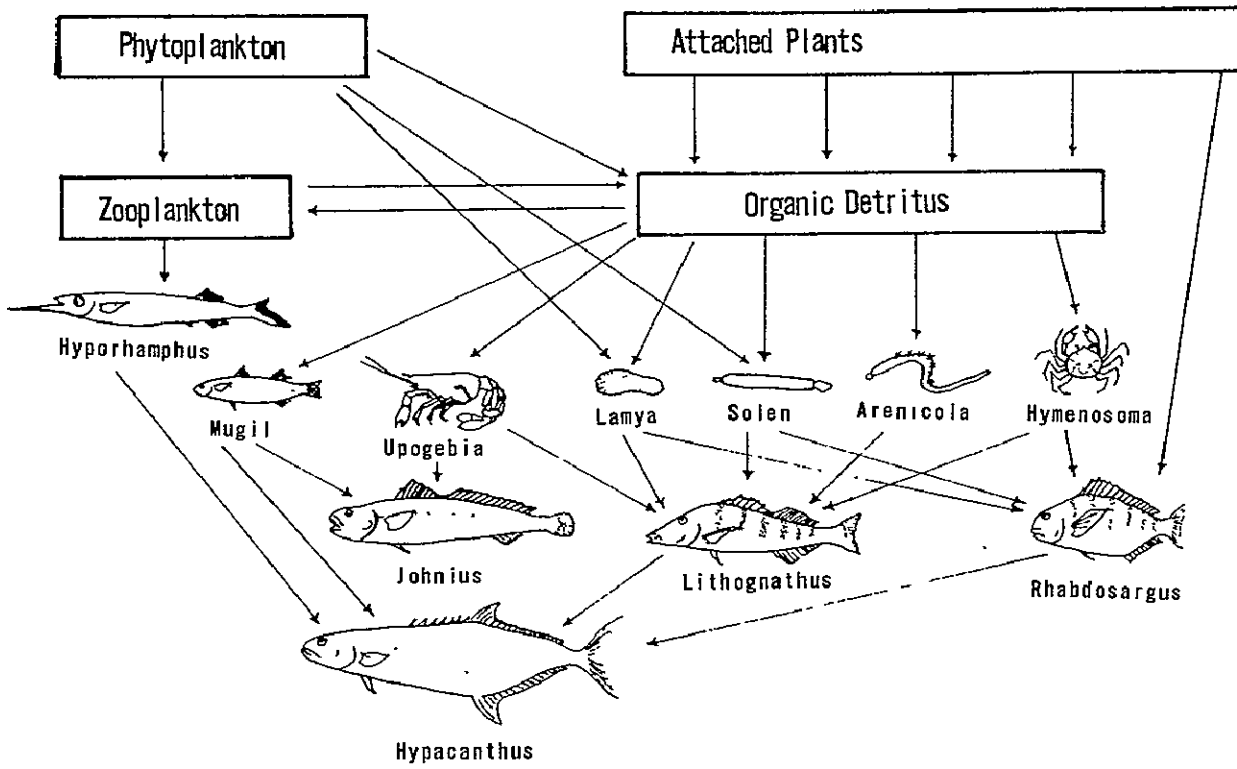


FIGURE 3.2 EXAMPLES OF TROPHIC RELATIONS IN THE KNYSNA ESTUARY (FM: DAY,)

Federal Register of May 12, 1971, and specify a nondiluted effluent that does not contain.

(1) Total coliform bacteria in excess of 240 pe. 100 ml.

(2) BOD_5 in excess of 100 mg/liter

(3) Suspended solids in excess of 150 mg/liter

These standards are subject to comment, with final standards reported to be due about September, 1971 Once these standards are published, there will be a two-year compliance delay for new vessels, and a five-year delay for existing vessels. Apparently, the Department of Defense is prepared to accept these standards.

The Technical Situation

OIL. Oil spills that result from handling cannot be prevented entirely since they are the result of carelessness, mechanical failure, etc. To control spills that do occur, various floating devices are available, such as booms to limit the oil spread or boats equipped with pickup devices. There is no removing the problem completely. What is required for a reduction of the accidents is technical standards on shipboard and shore handling equipment

The spillage that occurs from disastrous collisions is a more uncertain thing. The technical means to prevent collisions are already well-known, although improvements are doubtless possible. Much can be done, for example, to increase the stopping ability of ships. Technical improvements to ships could also reduce the likelihood of spillage following an accident. Double bottoms, which are almost unheard of in tankers though almost universal in most other ship types, could be highly beneficial in case of grounding [8]

Sewage Treatment

Several schemes have been suggested or used, beginning back in the 1950's Conceptually simplest is the **Holding Tank**, which is a tank into which everything flushes, and is held until it can be emptied whether ashore or at sea. Many people seem to abhor the idea of not "getting rid of it" right away, and many of these have favored the also-simple **mascerator-chlorinator** This device features a grinder and an injection of chlorine into the

resulting soup. Biological treatment has also been tried, the "biogest" (American Shipbuilding Corp.) being a prominent unit—a compact activated sludge (?) unit.

Several "second-generation" treatment devices are now just becoming commercially available; these depend on non-biological separation of solids as the fundamental process. These generally meet the present EPA standards for marine effluent. The General Electric device is used here as an example. This unit strains and grinds, and then mainly accomplishes its mission in an electrolytic cell. Direct current passing through fluid via iron plates forms ferrous hydroxide, which together with an added flocculant (alum), causes solids to settle. The solids are passed to an incinerator; the liquid is chlorinated and then discharged overboard. On the Great Lakes, where state laws forbid discharge, this water passes via the ship's make-up feed evaporator into the boilers (steamships). The claimed effluent quality is

total suspended solids	10 ppm
BOD_5	35 ppm
coliform bacteria	200/100 ml
turbidity	5 JTU

For small craft, for whom the cost, complexity, power supply, etc., make the ship systems impractical, several other devices are available, not all of which are satisfactory for present standards. When the first outcries against boat pollution (local laws beginning about 1955) were raised, the masceratorchlorinator was developed and once thought by clean-minded boatmen to be the solution to boating pollution. Some localities and states (Michigan, New York, Ontario, Wisconsin) have disagreed and enacted laws forbidding sewage discharge treated or not, thereby forcing use of the holding tank (or variations thereof) which deposits the entire business ashore. One significant variation is the recirculating toilet, identical to that used aboard passenger aircraft. In short, EPA standards cannot be met by available devices that discharge into the water. The federal law does not require that a boat have a toilet. Individual freedom of expression is still legal.

Existing Waste Treatment Practices

A good quality water must be both potable and palatable. A potable water must be free from pathogenic organisms, toxic materials, and excessive amounts of mineral and organic matter. A palatable water must be aesthetically pleasing, i.e., free from color, turbidity, and taste and odor. A water that is both palatable and potable can be produced by a good water treatment plant from most raw water sources. If we wish to keep water in such a condition that it will be fit for fish, recreation, or other beneficial uses we must provide treatment for the wastewater at the end of the sewer.

Waste treatment processes are grouped into primary treatment, secondary treatment, sludge treatment, advanced waste treatment, and industrial waste treatment. These processes may be physical, chemical, biological, or combinations of these. The system requirements for the treatment of domestic wastes are fairly well defined, and such systems can usually be designed without extensive laboratory analyses. The engineer can choose the series of unit operations and processes required to produce an effluent of the desired quality. Industrial wastes, because of their great variation in composition, normally require extensive laboratory characterization-studies to determine the processes required for treatment.

Primary Treatment

"Primary treatment" is a solids separation process. It normally includes screening or comminution, grit removal, and sedimentation of settleable organic solids. These processes are physical in nature.

Racks and screens are used to remove large objects from the sewage [11]. Coarse racks of steel bars have clear openings of from 1 1/2 to 2 1/2 inches between the bars. Fine racks will have openings as small as 1/2 inch. Screens will normally be expected to collect particles down to 1+16 inch in size. Screens and barracks can be cleaned mechanically or manually (For those with weak stomachs, the former is recommended.). Screenings are normally taken to a landfill and buried.

The racks are usually followed by a comminator. Comminution is a size reduction or shredding process wherein the large material passing the racks is reduced in size.

Heavy inorganic particles (sand, clay, etc) are removed in grit chambers These particles will normally be larger than 0.02 cm (0.008 inch) in diameter and have a specific gravity of about 2.65 The grit chamber is usually fairly shallow and elongated. The size of the particle removed is controlled by the displacement velocity. The grit chamber is

designed such that the displacement velocity is maintained at approximately 1fps over the entire design range. Centrifugal cyclones are also used for grit removal. The amount of grit collected varies from 1 to 12 cubic feet per million gallons, averaging about 4.

Settleable organic solids are then removed in tanks called "Primary Clarifiers." These tanks may be round or rectangular. Settling tanks will remove particles with a wet specific gravity of 1.001 and diameters as low as 0.01 cm (0.004 inch). The maximum hydraulic loading is 900 gallons per day per square foot and the minimum detention time is two hours in a ten-foot-deep tank. About 50% of the suspended solids are removed in the primary clarifier as well as about 35% of the BOD.

Secondary Treatment

Secondary treatment consists of an aerobic biological reactor followed by a sedimentation basin. A system having primary treatment followed by secondary treatment can remove up to 85 to 95 percent of the BOD (biochemical oxygen demand), COD (chemical oxygen demand), and suspended solids, although only activated sludge can be made this efficient. Secondary treatment can be subdivided into fixed contact systems and suspended contact systems. Trickling filters, the most common form of fixed contact systems are also called biological filters, percolating filters, and sprinkling filters. A trickling filter consists of a bed of rock media, plastic media, or other type of fixed bed 3 to 13 feet in depth and up to 200 feet in diameter over which the waste is evenly spread and allowed to trickle down over the packing. A film of microorganisms forms, attaches to the packing, and degrades organic waste effluents. These organic wastes are used by the organisms as their food supply. This form of secondary treatment will remove 65 to 85 percent of the BOD and 80 to 90 percent of the suspended solids. The contact time in the filter is from 3 to 5 minutes.

Trickling filters are referred to as standard or low-rate amd high-rate filters. Low-rate filters are loaded hydraulically at less than six million gallons per acre-day and with organic loadings of under 1100 pounds per acre-foot per day of BOD. High-rate filters have hydraulic loadings of 10 to 30 or more million gallons per acre-day and organic loadings of up to 3900 pounds per acre-foot per day of BOD. Low rate filters have no effluent recirculation while high rate filters have recirculation ratios of 0.3 to 4.0 times the influent rate.

Trickling filters require a minimum of supervision and are fairly insensitive to shock loadings. They cannot, however, meet most of the new standards set by regulatory agencies.

Activated Sludge

The activated sludge process can be used for both secondary treatment and for completely aerobic treatment without primary settling. Activated sludge is a suspended contact process in which the microorganisms are kept in suspension by mixing while air is supplied to the system to keep it aerobic. Under favorable conditions, the activated sludge process can remove 85 to 95%of the BOD, COD, and suspended solids. The contact time requirements range from about an hour to 72 hours depending on the system used.

In the conventional system, the activated sludge is mixed with the incoming waste water and is aerated in plug flow from 4 to 8 hours (average 6). The sludge is then settled out of suspension, and the clear effluent may be discharged or treated further. Some 70 to 90% of the sludge is then returned to the influent and the remainder discarded (sent to sludge treatment).

There are several modifications of the activated sludge process, each of which takes advantage of a different characteristic of the biological process. There are the tapered aeration process, complete mixing, step aeration, contact stabilization, and extended aerations. All forms of activated sludge process are sensitive to shock loading and require close supervision.

Lagoons and Stabilization Ponds

Lagoons and stabilization ponds are simple earthwork structures open to the sun and air. Ponds and lagoons may be aerobic, a combination of aerobic and anaerobic, or anaerobic. They may be aerated through forced aeration or by only natural aeration. They will remove up to 85% of the suspended solids and BOD. The holding time ranges from 3 or 4 days to several months.

Sludge Treatment

Sludge treatment processes are basically for water removal, volume reduction, and

Industrial Waste Lagoons near Hopewell, Virginia

stabilization of the sludge for disposal. Sludge, as it leaves the settling basins, is approximately 95 to over 99% water. A reduction in moisture content of 10% from 95 to 85% will reduce the volume by 67%.

Anaerobic sludge digestion is the most widely used method of sludge treatment. The total suspended solid in sewage, about 170 mg/l (milligrams per liter) [11fl, is concentrated in the settling basin and by biological treatment to about 10,000 to 50,000 mg/l. The digestion process further reduces the volatile solids through the anaerobic biological process, producing carbon dioxide and methane. The resultant sludge has a solids content of 50,000 to 150,000 mg/l.

The anaerobic digestion process is much slower than aerobic processes. The digestion process requires from 10 days for a completely mixed heated system to 30 days for a standard digestor.

Following digestion the sludge can be further dewatered before final disposal by vacuum filtration, or air drying in sludge drying beds. However, the quantity of sludge delivered from the digestors is quite large. If the aerobic treatment is activiated activated sludge, then the digested sludge will average about 7% solids and the volume will be about 27 cubic feet per thousand persons per day. Vacuum filtration will increase the solids concentration to between 20 and 32% while air drying will increase the solids content to about 40%. Air drying requires a minimum of from one to two weeks under optimum conditions.

Sludge Disposal

Sludge can be disposed of by landfilling, land spreading, incineration, wet combustion, or barging to sea. Landfill consists of hauling the sludge to a suitable site and burying or lagooning the sludge. The main disadvantages of this system are a lack of suitable sites, especially in large metropolitan areas, and the potential pollution of ground water.

Land spreading involves spreading the sludge on the soil and plowing it in. The land is planted, and crops or grass grown on it. The sludge in this case is used as a soil amendment or conditioner and is recycled into the ecosystem. Low lying crops or root crops should not be grown in soild treated in this manner because of potential pathogenic organism contamination.

Sludge burning furnaces operate at temperatures of about 2500°F. This temperature is approximately double that required to destroy sludge odors. The wet sludge is first dried by using the exhaust gases from the incinerator. Normally, sludges produced by the vacuum filtration of the sludge from primary sedimentation mixed with either trickling filter sludge or waste activated sludge will supply enough heat such that auxiliary heat sources will not be required while digested sludge will not. Incineration is a relatively expensive process.

Sludge in commercial fertilizer must be dried to a moisture content of less than 10%. This process is not very economical.

The wet oxidation of sludge requires that the pressure of the system be raised to between 1200 and 1800 (pounds per square inch) and that the temperature exceed 540°F. The COD of the waste can be reduced by about 80%, and the volatile solids by 90%. The wet oxidation process again is very expensive.

Barging to sea or sea disposal is practiced on both the east and west coasts. Barges are loaded with sludge, towed to sea, and emptied. In some areas the sludge is pumped to sea through an ocean outfall. In both cases care must be taken to prevent the sludge from washing ashore. Since dead areas have been found off New York, objections have been raised concerning this practice.

Chemical Treatment Used in Standard Practice

Chemical coagulation can be used to help remove suspended solids. It is not generally used in the United States. It is used in some overloaded treatment plants to help reduce the load on the biological unit.

When chlorination of plant effluents is practiced, the chlorine is applied in order to disinfect the discharge from the treatment plant. A treatment of 3 to 9 mg/l of chlorine is required in order to produce a residual of 0.5 mg/l after 15 minutes.

Advanced Waste Treatment

In many areas of the country, secondary treatment is not sufficient; therefore, some form of tertiary or advanced waste treatment may be required Advanced waste treatment is used for the final polishing of secondary effluents. It is used for removal of phosphorus, nitrogen, suspended solids, and BOD. The technical aspects of advanced waste treatment have been discussed previously [12] [13].

Phosphorus removal is accomplished mainly by chemical precipitation. The chemicals may be added either before or after biological treatment, but apparently the latter is more efficient. The phosphorus salts of aluminum and ferric iron are relatively insoluble. Aluminum is added as liquid alum or liquid sodium aluminate while iron can be added as ferric chloride or ferric sulfate.

Phosphorus can also be effectively precipitated by adding lime The lime is added at the end of the aeration tank or before secondary sedimentation. This reaction is strongly pH dependent; the higher the pH, the more effective the process. This reaction must be carefully controlled; otherwise the biological system can be destroyed.

Nitrogen removal by stripping and certain nitrification-dentrification processes have been studied. Organic nitrogen can be removed as ammonia by making the solution alkaline and passing the solution through a stripping tower. This process is temperature dependent and becomes inefficient at low temperatures.

The nitrification-dentrification process is completely biological Protein-and-urea-nitrogen are oxidized aerobically to nitrate. The effluent then goes to an anaerobic system containing a carbon source such as methanol. The nitrate ion is then biologically reduced to molecular nitrogen. This system is also temperature dependent.

Activated carbon is used for "polishing" the effluents from secondary units with regard to soluble organic material. Passing these secondary effluents through a carbon tower will reduce the BOD and COD by up to 75%.The carbon can then be regenerated with a loss in the area of 8%. Suspended solids are removed by filtration Such filtration can be accomplished by multimedia microstrainers or rapid-sand-filtration

Industrial Wastes

Industrial wastes may be treated by any or all of the above mentioned methods. In addition, other special techniques may often be required due to the special nature of the wastes. Nemerow (14) discussed industrial waste treatment in detail. This section will touch on some of the methods used that have not been previously discussed

Most wastes are acidic or alkaline. These wastes must be neutralized before discharge. The ideal way is to mix an acid waste with an alkaline waste, but this is not always possible. Acid waste can be neutralized by the addition of lime water, passing the waste over limestone, or using caustic soda. Alkaline wastes can be neutralized by using carbon dioxide from flue gases or by adding an acid such as sulfuric acid to the waste.

Chemical oxidation-reduction reactions are also used. Cyanides are removed from plating wastes by oxidation with chlorine Heavy metals are removed by ion exchange or precipitation The type of treatment used depends on the plant process and the wastes produced. Each industrial waste must be handled separately.

Current Treatment Costs

Cost estimates for treatment of major sources of potential water pollution have been gathered by FWPCA, FWQA, and the Water Quality Office of EPA and presented in their **Cost of Clean Water** Documents. The figures given in this report utilize these data, data from the Taft Center Advanced Waste Treatment Branch, advanced waste water treatment data from the Lake Tahoe Project, and several other texts.

Table 3.2 shows the latest projected EPA capital cost for wastewater treatment requirements through 1974 The total costs amount to 24 to 27 billion dollars. Of this, 18 to 21 billion dollars for municipal and industrial treatment costs plus ground water drainage control, fall under EPA. At present it appears Congress expects to use the federal tax sources to support 60 to 75% of this amount or about 12 to 15 billions of dollars. This will amount to about $75 per person in U.S over

Table 3.2

Projected waste water treatment costs in billions of dollars, 1971 through 1974

Municipal Treatment Costs.....

Sewer Construction.....

Industrial Wastes .....

Industrial Cooling .....

Ground Water Drainage-Contr

Total through 1974.....

Needs after 1974—Capita

Sources—Summary from "Cost of Clean Water," EPA all volumes 1968 through 1971. Costs through 1974 for current and projected needs.

the three years, 1971-1974. Incredibly, this amount is about one-half of what will be spent for toilet articles during the same period.

At present, the U.S. Department of Housing and Urban Development (HUD) had major responsibility for sewer construction grants [15]. The rationale for this responsibility is based on the relationship of sewers to urban development. A verbal communication from an EPA source indicated that HUD estimated sewer costs through 1974 to be between 3.5 and 8.0 billion dollars.

To show the capital and annualized costs for sewer treatment plants, Figure 3.3 indicates capital costs in dollars per 100 gallons for large "regional" (100 million gallons per day capacity) treatment plants (see also Figure 3.4 and Table 3.3).Since one person generates about 100 gallons of waste water per day, these costs represent each person's share in capital cost and his daily operating costs respectively. It is seen that primary treatment costs only $13 per person initially plus less than 1 cent per day, secondary treatment costs but $28 per person initially and about 1 cent per day, and complete wastewater renovation would only cost $64 per person initially plus about 2 cents per day. These figures indicate that sewage treatment plant costs are not prohibitive, but are well within reach of every municipality. However, they are high enough that the U.S. populations must readjust some priorities just a bit in order to insure environmental protection.

Cost of Urban Storm Water:

The annual discharge of untreated sewage by combined sewer systems is estimated generally at 3% of the amount that enters the system However, this amount is concentrated during a few times of heavy precipitation. It is estimated that it would cost from 15 to 50 billion dollars to separate existing sewers. This variation in cost arises from unknown considerable pollution itself. For example, the following data have been shown for Cincinnati [16].

If this study is representative, it would indicate that suspended solids are by far the worst problem in urban runoff. For cities with separate sewers it would appear that economic renovation of run off wastes for several uses, including potable water, should be considered.

Content in Thousands of Pounds per Square Mile per Year

Constituant	Rainfall	Runoff	Raw Sewerage
Suspended Solids	60	370	400
BOD	—	27	400
Total Nitrogen	6	6	80
Phosphorous	0.4	0.6	20

Table 3.3 Cumulative Dollar Values from Primary Treatment to Complete Renovation (potable water).

Plant Cap.	Capital Costs—$10⁶			O & M Costs—¢ per 100 gal.		
Process	1 mgd	10 mgd	100 mgd	1 mgd	10 mgd	100 mgd
Primary	.35	1.7	9	.45	.30	.16
Secondary (Activated Sludge and Coagulation and Sedimental to Remove Solids).....	.78	4.4	30	1.15	0.78	.54
Complete Organic Remov (Carbon Adsorption)	.50	2.1	9	1.0	.54	.28
Complete Inorganic Removal—Chemical Electrodialysis, Ammonia Stripping.....	.75	3.6	19	1.35	.92	.69
Potable Water Aeration Disinfection.....	.09	.21	.98	.14	.05	.02

Industrial Waste Treatment Problems

Before entering into the economic aspects of the waste treatment in industries, it will be convenient to discuss briefly the composition of the wastewater in industry and the technology utilized to clean such waters. The composition of industrial wastewaters changes from industry to industry, and in many cases is quite different from that of municipal wastes. The amount and composition of suspended solids, organics, and inorganics make some of these wastes impossible to treat in conventional sewage facilities without pretreatment.

The proper determination of treatment costs of wastewater is a complicated process because of the many different combinations in which the same degree of treatment can be accomplished. The treatment of liquid industrial waste can be subdivided into six major categories according to the type of material that is treated and/or removed. Each category represents a formal sequence in the treatment of industrial wastewaters. In many cases both the order and the number of steps required to treat the water can be interchanged or varied. The following scheme indicates the steps in the treatment of industrial wastewater. [18]

1 Pre-treatment
   A) Chemical Addition
   B) Equalization
   C) Oil Removal
2. Suspended Solid Removal
   A) Sedimentation
   B) Filtration
3. Dissolved Solid Removal
   A) Chemical Addition
   B) Reverse Osmosis
   C) Electrodialysis
   D) Ion Exchange
   E) Distillation
4. Liquid Disposal
   A) Deep Well
   B) Lagooning
   C) Receiving Waters
   D) Controlled Discharge
   E) Evaporation
   F) Ocean Disposal
5 Sludge Treatment
   A) Filtration
   B) Centrifugation
   C) Thickening
   D) Solid Disposal
   E) Land Fill
   F) Reuse
   G) Ocean Disposal
6. Heat Removal
   A) Cooling Tower
   B) Spray Ponds

For example, in the treatment of waters containing an excess of thermal energy as the major treatment pollutant, the sequence of steps required to treat such water consists of a cooling tower pond to remove the heat. The cooled water will be either recycled or

discharged. If certain dissolved solids (e.g., zinc and chromium) need to be removed, a chemical addition process followed by clarification is used. The suspended solids are separated by sedimentation and the water is finally discharged and ready for reuse. At least four operations are involved in the previous example, and to compute the cost of treating such water it is necessary to consider the cost of performing each operation.

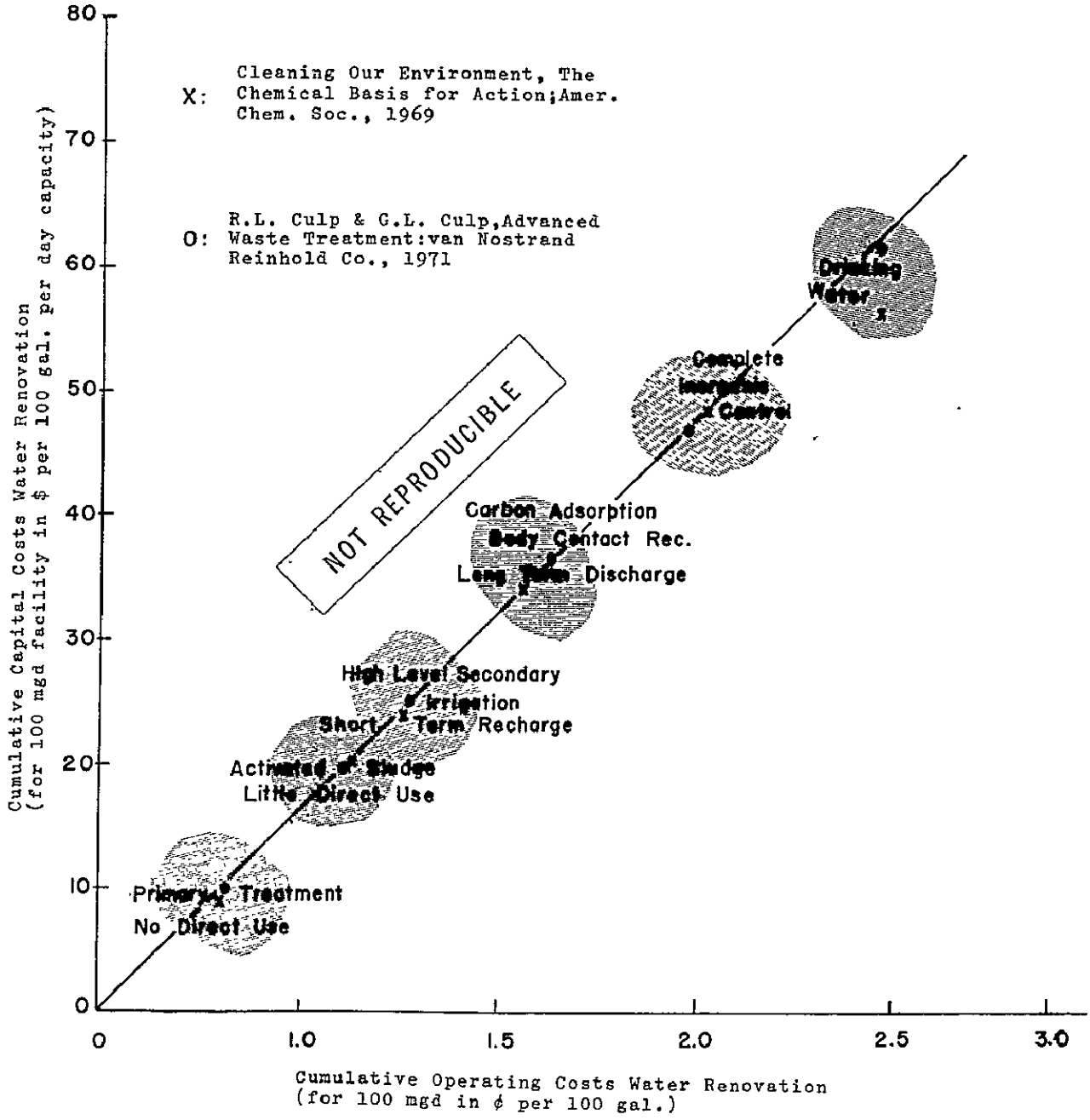


FIGURE 3.3 CONVENTIONAL AND ADVANCED TREATMENT PLANT COSTS

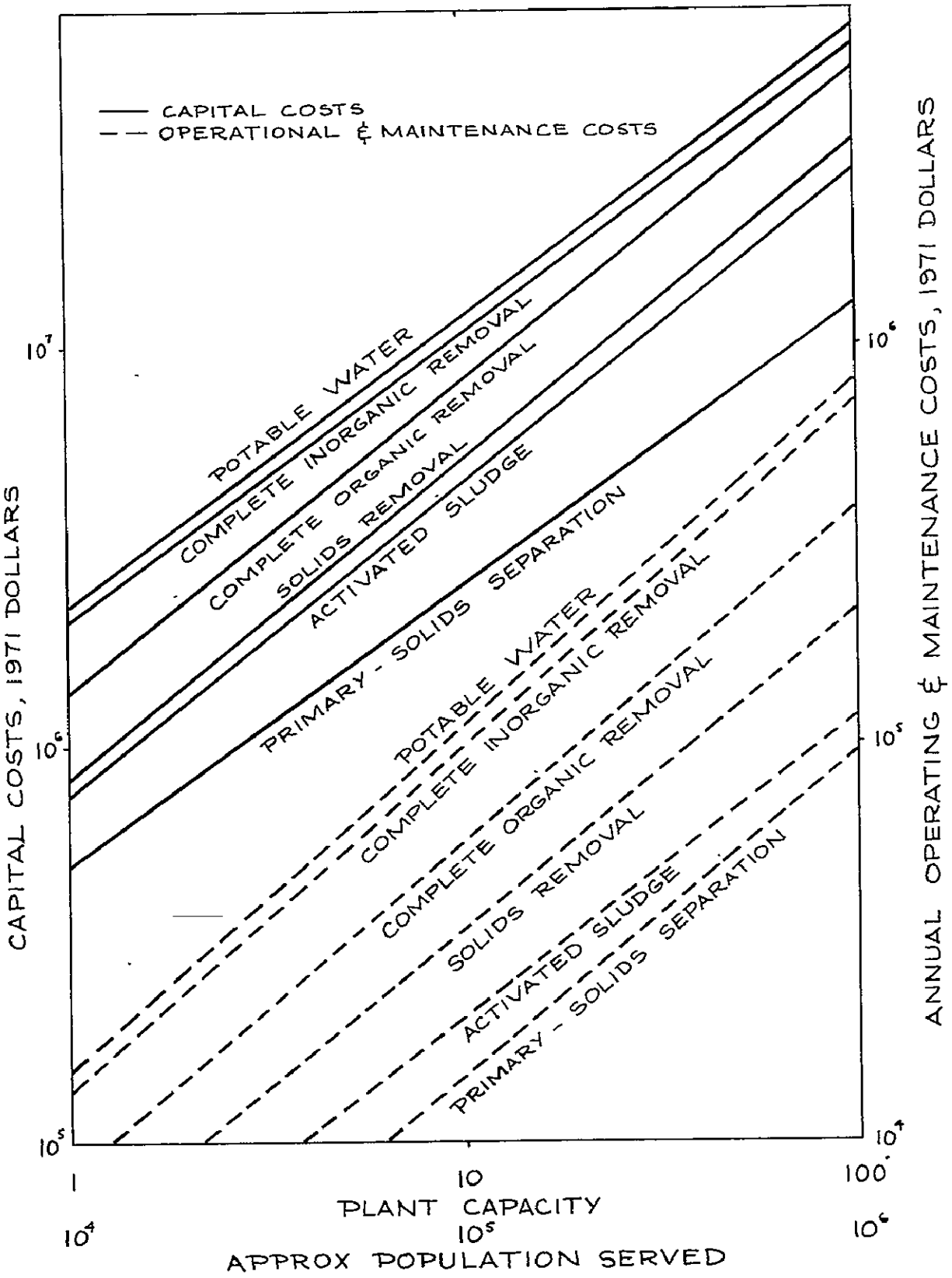


FIGURE 3.4 CONVENTIONAL AND ADVANCED TREATMENT PLANT COSTS

Industries quite often use municipal sewage facilities to treat their waste. According to the U.S. Department of Commerce's 1963 publication, **Water Use In Industry**, a total of 1.178 trillion gallons of water were discharged from industrial plants. Of this total, 48 billion gallons or 4.2 were discharged to municipal systems. Industries producing gases, paints, and allied products use municipal sewage facilities extensively. So does the pigment industry, although in not such great extent.

The 1964 Census of Manufacturers classified the water use and wastewater production into two classes according to the volume of water used.

Those classes are:

Smaller users (using less than 20 million gallons per year)

Larger users (using more than 20 million gallons per year)

It is normally assumed that the smaller users will discharge their waste directly to a public sewage treatment plant, and the cost of treating the water can be computed as a percentage of the cost of treatment in the municipal or public sewage facility. Some larger users will also discharge a small percentage (about 10) of their waste in the public sewage facilities but in general will treat their waste separately. This setup is not usually equitable since a very important element besides the volume of the wastewater is the composition of the waste.

For instance, some compounds are so dangerous that no amount of them should be allowed. Trace metals are a case in point as indicated below and in Table 3.4.

Table 3.4

Surface Water Criteria for Trace Elements in Public Water Supplies

Metal	Permissible Criteria, mg 1	Desirable Criteria, mg 1
Arsenic	0.05	absent
Barium	1.0	absent
Boron	1.0	absent
Cadmium	0.01	absent
Chromium (hexavalent)	0.05	absent
Copper	1.0	Virtually absent
Iron (filterable)	0.3	Virtually absent
Lead	0.05	absent
Maganese (filterable)	0.05	absent
Selenium	0.01	absent
Silver	0.05	absent
Zinc	5	Virtually absent

Absent—The most sensitive analytical procedure in Standard Methods (3) (or other approved procedures) does not show the presence of the subject constituent.

Virtually absent—This terminology implies that the substance is present in very low concentrations and is used where the substance is not objectionable in these barely detectable concentrations.

Source: Report of the Committee on Water Quality Criteria [20]

A better subclassification can be obtained by classifying industrial wastes by the actual pounds (volume X composition) of BOD and/or toxic materials that are present. The following statistical data taken from [17] will help to illustrate the volume of wastewater produced by industry in the past years and estimations for future years (in billions of gallons per year).

	Water Produced	Water Discharged to Public Sewers	
	(1968)	(1968)	(1973)
Smaller Users	310	310	350
Larger Users	14,473	1,029	1,157

A comparison of the pollution load contributed by process waters of several types of industries has been published [17], and it is reproduced in the appendix. It is also of interest to look at the following ratios which indicate the relative contribution to pollution among industries and municipalities. These ratios are as from 1964.

$$\frac{\text{Waste Water Volume Industries}}{\text{Waste Water Volume Municipalities}} = 2.47$$

$$\frac{\text{BOD Industries}}{\text{BOD Municipalities}} = 3.01$$

$$\frac{\text{Suspended Solids Industries}}{\text{Suspended Solids Municipalities}} = 2.05$$

Manufacturing industries in general seem to be greater in volume and pollution load than municipal sewages (measured in terms of BOD and suspended solids). A great deal of discussion without apparent concrete facts has been generated over the important subject of relative contribution to the pollution of the waters by different causes and the cost of solving such a vital problem. The Environmental Protection Agency in a report published in 1971, "The Economics of Clean Water," [19] estimated the contributions of different sectors to the problem and the expenditures required to correct the problem. These results are summarized in a Table 3.5.

Thermal Pollution

There are several sources of thermal energy input into watersheds. Amongs these are natural solar energy input, heated discharges from industrial plants, and cooling water discharged from electric generating stations. This last source has been estimated to have contributed 81% of the unnatural temperature load into a basin. [21]

The effect of the input of thermal energy into a stream may be summarized in the following ways:

1. An increase in temperature affects the physical properties of water such as density, vapor pressure, viscosity, and ability to contain dissolved gases, primarily oxygen.
2. An increase in temperature will accelerate chemical and biological rates. If sufficient heat is added, temperatures can be elevated enough to sterilize the environment by killing all organisms. Each organism has some upper limit of temperature tolerance above which it cannot exist.
3. The environmental temperature is extremely important to the living resources in a basin, and minor changes will greatly affect the reproduction, growth, and death of many organisms. A local section of elevated temperature in a stream may act as a thermal plug or block which will prevent the passage of anadromous fish, thereby reducing future populations
4. A temperature increase can result in synergistic actions in which the effect of several agents acting together is greater than the sum of individual effects.
5. The change in thermal environment may alter the aquatic organisms, possibly stimulating excessive populations of individual species to nuisance levels.

It has been estimated that the demand for electrical power has doubled every 10 years during this century and that power requirements in 1980 will be approximately three times what they were in 1963, representing an increase of a little over 6% per year during this period [21].

Fossil fuel plants may be expected to improve in thermal efficiency, giving a lower heat rejection, but this will be more than offset by the increased number of nuclear plants with their greater demands for cooling because of lower efficiency. For all practical purposes industrial thermal load will probably follow the electrical growth. The indications are that the thermal problem will thus grow roughly in proportion to the demand for electrical power.

Rejected heat from electrical generation or industrial operations must be received by some sink. This can be either the air, water,

Table 3.5.
Pollution Problems and Projected Costs

Pollution Source	Percentage to the Pollution of the Stream	Investment Required in millions of dollars year		
		Current	Additional	Operating Cost
Industrial Wastes	34	500	600	300
Municipal Wastes	33	1000	500	300
Agriculture	20	50	—	—
Mining	5	100	50	—
Power Generation	1	200	—	—
Other Urban Wastes (Storm runoff, etc.)	1	600	—	—
Others (Construction, Navigation, Recreation)	6	20	—	—

ground, or any combination thereof. Any sink has a limited capacity to accept such heat and cannot be stressed beyond this capacity without serious consequences. The use of land as a heat sink has an exceedingly limited application, usually in such forms as heat pump installations of a small size. Large scale use of the land for this purpose has not been attempted. Rejection directly to air is a relatively costly process and may be somewhat distrubing to the local atmosphere, although the effect of any plant is minuscule compared to the total atmospheric heat load.

Because of the fact that heat can be released to the atmosphere from a hot stream, it is possible to design holding basins or mini-reservoirs which do not affect the dynamics of the stream, but which allow significant heat release from the water before blending into the main channel.

One indicator that can be used to determine the capability of a river to absorb heat load from thermal sources is its surface area which can be used to dissipate heat to the atmosphere. It appears that the James River has adequate surface area for its present load in that the heat load from existing plants is dissipated in short reaches at reasonable temperatures. On this basis the James River might be able to accommodate several additional power generating stations. There may be local problems if too severe a thermal load is dissipated in one location, and each site must be carefully studied.

The Water Quality Standards of Virginia limit the temperature rise in lakes and impoundments to 3°F above that which existed before the addition of artificial heat. In flowing streams the allowable temperature rise is a function of location and season. In tidal streams a 4°F rise is allowed in winter and 1.5°F rise in summer. In mountainous regions, a 5°F rise is allowed at any time but with a maximum temperature of from 70 to 90 depending upon the classification of the stream. It is entirely possible that these temperature limitations are not sufficiently protective in certain areas and too protective in others. It might be far better if the code were a performance type which required that the biota at any outfall point not be adversely affected regardless of the temperature rise of the stream. This would allow the engineer and the biologist to produce a solution that would be economically sound without harmful effects, and quite possibly, with some beneficial effects at times of the year.

Modeling Systems

Prior to the early 1960's we did little in the way of anticipating the response of a given river system to change from its natural state. For the most part our actions were, in fact, reactions. For example, a region of regular flooding attracted our attention (or the Corps of Engineers') and we reacted by building a dam A river became loaded with silt, and we reacted by pursuing land conservation farming practices in its basin or we dredged. Even today we are forced by a lack of knowledge to pursue a reactionary mode of operation An oil spill occurs and we react, a fish kill occurs and we react, and so it goes,

on and on. But must it be this way? The answer is no, and one of the tools which can be developed and used for changing our actions from after-the-fact to before-the-fact, is modeling The change in fresh water flow through the Chesapeake Bay caused by the deepening of the Chesapeake-Delaware canal could have easily been predicted by model studies, and steps to prevent the problem could have been employed in the canal operation. That such information can be obtained from model studies has already been demonstrated for water systems such as the San Francisco Bay and the James River. [23], [24].

From the above it should be clear that sophisticated models must be developed and used as a regular part of any well-planned water quality program. Model development is already beyond the infant stage, and fairly sophisticated models are being used to a limited extent today, [25]. These started with the work of O'Connor in 1960 [24] and have progressed to the recent two-dimensional studies discussed by Fergner and Harris [23]. Continued development is necessary if we are to be fair to all the users of our water resources. Furthermore, if we are to exercise responsible control of our water quality and quantity we must know more about the interactions of the various elements involved. This information is also a prerequisite for successful remedial plans of action to restore our water resources to more acceptable levels. In order to set an appropriate course for model development and use, we should first review the state of the art.

Models can be classified into two broad categories; mathematical and physical. The physical models are generally scaled reproductions of the prototype and are usually constructed to represent a particular facet of interest As a result their flexibility is considerably limited. Mathematical models, on the other hand, are based on abstractions of the prototype and are very flexible.

Probably the earliest successful attempts to physically model tidal estuarine systems occurred in Europe in the late 1800's [26] In this country, K.C. Reynolds, in 1936, at M.I.T. [27] was one of the first to use such techniques to study the Cape Cod canal. Today, the best known physical models are those built by the Corps of Engineers at Vicksburg, Mississippi For the most part, these models have been built using Froude scaling, i.e., the scaling laws have provided similitude for gravity and inertial forces between the model and the prototype. Such a model is useful for studying hydraulic phenomena such as shoaling, erosion, salt water intrusion, and flooding. However, a considerable amount of verification and adjustment is typically required to force the model into agreement with the prototype. This requires extensive data sampling in the prototype, and adjustments on the model are made until it agrees with the prototype. After verification, the model can be used with a certain degree of confidence to examine the effects of changes in the configuration of the prototype without actually making them. At the moment, there is much experience in verification of models for hydraulic parameters but very little for water quality parameters. Even so, making a model "work" is still very much an art.

Because of necessary scale distortions in models, they have always been subject to criticism; hence, the above mentioned effort in verification has been put forth. During the past 10 years, models which were originally designed to represent hydraulic features have been pressed into service to model water quality parameters. Unfortunately, as mentioned above, there is very little experience in verification of such uses of the models, so the results of these studies must be considered cautiously. In fact, there are scientific reasons why one should be reluctant to accept such results. For example, the time scaling dictated by the Froude scaling law seems to eliminate the possibility of modeling those processes which are related to living matter. How does one time scale a living organism such as bacteria into another frame of reference? At present, this doesn't seem to be possible. In summary, it looks like physical models are, and will continue to be, useful in studying hydraulic oriented phenomen, but their usefulness for certain water quality analyses is doubtful.

There are several types of mathematical models which suffer the same level of development as physical water quality models Very little work has been done in modelling sociological and terrestrial biological systems as they interact with water systems. Probably the biggest problem with sociological models is the lack of quantitative information concerning almost all aspects of our interactions with our environment. A program directed at obtaining and then refining these pieces of information is necessary if we are to model successfully the ecology of our system.

Most of the biological models in existence do not include all the significant interactions between the biological system concerned with its environment. This inadequacy is due in part to our lack of knowledge of just what interactions are significant. Some, such as the dissolved oxygen—fish survival interaction are fairly well understood but this is a simple interaction. Others, such as the effects of heavy metals, are not so well understood.

As a result, most biological models deal with simple first-order interactions, and furthermore usually consider only a single species. The relatively successful predator-prey model studies are an exception, but verification of these is also lacking primarily because of inadequate data sampling.

In general, the future appears to hold promise of more and better biological models. The National Science Foundation is funding model studies in these general areas; however, relatively little support is being given to aquatic and estuarine biome studies compared with grassland and deciduous forest biome studies.

Economic models (see below) of water systems suffer from the same weaknesses as the sociological and biological but not to the same degree. They fail to include all the significant interactions and furthermore do not always have sound quantitative data for inputs. They are, by and large, static models in that the inputs are not allowed to vary in response to external factors once they are originally specified. Probably the most advanced models concern the economics of handling waste materials via river disposal. For example, Thomann et all [28] consider the relative merits of uniform vs. a least cost treatment for a case on the Delaware River. They find that the least cost is 1/3 the price of uniform treatment; however, they do not include the practical expenses for implementing and controlling such a program. It follows that in practice one cannot say which would be the better program to pursue. Deacon and Giglio [29] consider the merits of multiple vs. single outfalls for a model industry. They conclude that multiple outfalls allow the stream to assimilate more waste and that they save costs.

Generally, we have a good start in economic modeling and should expect to see some sophisticated but practical models emerge in the next few years. We must however, direct a significant amount of attention and energy at quantifying all the parameters which interact with our water systems.

Historically, hydrodynamic models preceded water quality models by quite a few years, (100 or more). Today they are often used hand in hand despite the fact that the quality models are far behind the hydrodynamic in development The lag is primarily due to the lack of quantitative understanding of these, let alone a quantitative one. Another of the prime reasons for the poor state of the art of water quality models is the lack of adequate data. Most, if not all, models of water quality depend on mysterious coefficients which must be determined empirically by taking data from the system to be studied. Such procedures are presently antiquated and therefore very time-consuming. For example, to obtain adequate data on the James River estuary for even the simplest model would take at least six months by present means. Model development will continue to be slow as long as such data obtaining techniques are continued.

A model type which appears to have been totally overlooked is one which examines the near effects of a polluting outfall. Most models which deal with DO (dissolved oxygen), BOD, and thermal pollution [28], [30], [31], [32] consider an overview of the stream or river system involved. Consider, for example, that the model developed for the evaluation of a thermal discharge averages about 650 acres as a uniform area [25]. The model can give no information about the details of what goes on in this region. Unfortunately, this type of region is the one for which we vitally need information because damage due to pollution sources often occurs while the pollutant is concentrated in a relatively small space. Additionally unfortunate, is the fact that these mixing zones are usually near the shoreline (which separates the user from the used) and consequently the potential values of the natural resources contained therein diminish.

Of all the models developed to date, the hydrodynamic ones are by far the most advanced. In fact, the sophistication compatibility of other models which are sometimes coupled with hydrodynamic models is quite doubtful. This is not to say that hydrodynamic model research and development should be stopped and all our efforts should go into bringing up the level of other model types. Rather, care should be exercised in matching the proper models.

While hydrodynamic models enjoy the

highest ranking in development, we still have only a few which have been developed and verified. And these are at best two-dimensional. One of the best known is the one used for the San Francisco Bay study [23]. It is basically a two-dimensional, vertically averaged model which can be used, with modifications in boundary conditions, etc., for studying broad, shallow estauries [23]. However, many phenomena require three-dimensional models. Take for example, the phenomena of channeling and shoaling. An accurate description of these requires not only a three-dimensional model but also a time dependent one with feedback. In particular, it must contain the possibility of time varying boundary conditions. It is easy enough to set down a set of equations, etc., which models such a situation, but solving the set for the desired unknown is an entirely different story. We do not at present have practical solution techniques to three-dimensional models.

It is difficult to see how one can model such things as sedimentation, shoaling, erosion, dissolved oxygen distribution, and so forth, without using 3-D models, so it is clear that much work remains for those interested in pushing back the frontiers of hydrodynamic models.

For a comprehensive (497 pages), up-to-date, review of the state of the art of estuarine modeling, one should consult [25].

Economic Models

Several economic models which could be utilized in the James River System analysis have been proposed in the evaluation of alternative solutions to the water quality problems. Liebman [33] has developed a model that finds the treatment levels necessary to meet stream standards at minimum cost for a group of plants discharging into the same river. Mair and Bieghtler [34] used Dynamic Programming to obtain similar results. Revelle [35] developed an economic model that maximized quality subject to cost constraints Deacon and Giglio [29] developed a model that examines the consequences on cost of water quality of discharging wastewater effluent through outfalls spaced along a river. A considerable amount of economic and physical data is required to implement this model. The numerical solution is obtained by an implicit enumeration techniques since the formulation leads to a 0-1 programming model. This model was applied to the Delaware River Basin.

Smith and Morris [36] developed an economic model that considers the evaluation of three different alternatives in the solution of the water pollution problem. They consider a uniform treatment model in which every source will be treated at the same level A cost minimization model was also considered, which tended to allocate degrees of treatment of each source in a minimum cost basis order to meet previously defined water quality standards. This type model is a linear-programming model, and the computational solution is easily obtainable. Finally, they proposed a zone optimization model which implies a uniform treatment level for groups of waste sources within zones of the river Mathematically this model is a non-linear programming problem which is computationally more difficult than the previous model. (All these three models were applied to the Delaware River and the zone optimization model was found the most suitable from an economic and practical standpoint) All those models require the evaluation of certain coefficients called transfer functions that indicate the DO effect in a given region from the BOD content of pollutants in another region Graves et al., [37] developed a non-linear programming model similar to that of Smith and Morris, but more powerful since it permitted the evaluation of different schemes like required secondary treatment, effluent charge, 3-zone percentage (in which zone 1 consists of all polluters currently treating over 80% and zone 3 consists of all polluters treating less than 40%). There are other schemes besides the three already considered [36]. This model was applied to the Delaware River, and again the treatment of regional plants was found the most successful. They developed an algorithm to solve the non-linear programming problem resulting from the formulation of the model.

Monitoring Systems

Traditionally, monitoring has consisted of measurements made by operators either in the field or through collected samples subsequently analyzed in the laboratory. With growing national concern about pollution of entire water basins, the need to monitor systematically major segments of, or even entire, drainage systems has developed. These proposed regional monitoring network

requirements drastically limit the potential effectiveness of traditional manual field and laboratory testing and have made the concept of fully automated monitoring an area of active research, experimentation, and development.

Specific designs and parameters of a successful monitoring system are always dependent upon the individual conditions. Such a system has only to supply a reliable "up-to-date" date-base in order to be functional. At the present time, most biological assays are still considered experimental or immature. Perhaps the greatest problems involve quantitation of biological and influent interactions. Too often, these interrelations are reflected by difficult-to-measure, subtle responses or as "all or none" (e g., fish kills) responses. Thus, it is readily seen that indicators, which are apparent only after what amounts to biological catastrophe, have little value; neither is there much value in those which demonstrate what is already completely obvious. It is axiomatic that those biological parameters which best reflect life conditions will usually vary with the system. However, continuity between different-system measurements will probably always be necessary for comparative purposes. Therefore, the implication of procedural standardization becomes reality and the design of "adequate," monitoring programs becomes increasingly difficult.

Automatic Water Quality Monitoring

The term instrumentation includes the following components or sub-systems of a surveillance network:

1) the sensor system
2) signal conditioning
3) multiplexing
4) telemetering
5) data registration

Many networks of automatic water quality monitors have already been installed throughout the United States. The purpose of these systems can be characterized by one of the following statements:

1) to assess existing water quality standards
2) to determine long-term trends in water quality
3) to evaluate compliance with state and federal water quality standards
4) to evaluate parameters of a system model

In addition to these purposes, water quality data gathered automatically from a monitoring system are usually assembled into a monthly report for statistical evaluation of all the data collected during the period.

In the sense used in the technical literature and in manufacturers' catalogs, an automatic water quality moniter is a device including a water sample delivery system (pump and piping), a variety of sensors installed so that the sampled water impinges on them, and an electronic signal-conditioning package for each sensor to provide the voltage and current level required by a data scanning and recording or transmission system. A complete monitoring station includes telemetering capabilities with registration of the data by automatic means. The final data record is usually in a digital form acceptable for storage, retrieval, and processing by electronic computer The purpose of this section is to describe the status of the current practice in the manufacture, location, and frequency of operation of automatic water quality monitoring networks. Specifications for the components of an integrated water quality data acquisition system have been set forth by Mentink [38].

Sampling frequency depends upon the variability of the parameters measured. Variability cannot be determined until actual measurements have been made The initial frequency selected when initiating a monitoring network must be based on experience and available manual measurements. The frequency is then set by considering water criteria at the location sampled, the potential for violation or stress, and the parameter most likely to be violated. Later analysis of recorded data can provide a better statistical value of sampling frequency. At least one research group has reported that sampling each parameter once per hour provides a statistically significant daily average value. [39]

Sample location can be determined for an entire basin by considering the hydrologic and population relationship In areas of sparse population with large stream flow relative to waste flow inputs, manual sampling might even be used. As the population becomes more dense and the biotic stresses and flow needs more complex, more frequent sampling is required and automatic systems must become more practical. Thus, a manual program versus an automatic sampling program is decided primarily by the frequency of sampling required and by the needed sophistication of the sampling system.

Automatic monitor installation should furnish a more accurate picture of the parameters measured. However, use of the automated system does not necessarily result in a reduction of the total work force. The gain by less manual operation, improved quality, and greater quantity of data collected is offset by the need for more sophisticated maintenance personnel and a more complex maintenance schedule. Although a total labor cost saving may result, this too may be negated by increased initial investment cost.

Sensors and Signal Conditioning

Those sensors currently employed in automatic water quality monitoring may be immersed in the stream or installed in a flow channel through which a stream sample is pumped. Sensors immersed in a stream are subject to damage from floating debris and to the fluctuations of the water level which may expose them to the air Furthermore, they are likely to acquire biological growths and accumulation of solids which affect their performance. On the other hand, sensors installed in channels remote from the stream may be exposed to a sample which is not representative of the actual stream conditions due to temperature and flow variations during the transport of the sample to the sensor housing. For example, dissolved oxygen could be released by cavitation if a submersible pump is not used and care is not taken to provide a pressure high enough to overcome head and flow pressure losses.

Sensors are presently employed to measure either physical properties such as water temperature and light scattering (reflection by the suspended particles) or to determine the concentration of dissolved ions through the use of electrodes or automated spectrographic methods. Table 3.6 lists the most common sensors employed in water quality monitors while Table 3.7 lists sensors available which can be used in special cases Sensors are noted for which automatic temperature compensation is available. In addition, required parameter ranges are listed.

It is worthwhile to note that colorimetric methods present several difficulties. Indigenous suspended matter and sample color strongly influence results. Thus, double-beam operation is generally required to compensate. Furthermore, the color complex formed during indicator-chemical reactions often builds up in the measuring cell and requires frequent cleaning.

In addition to the water parameters, many automated water quality stations include measurements of the following meteorological parameters:

1. Air temperature and humidity
2. Wind speed and direction (azimuth and elevation)
3 Solar radiation intensity by pyrometer

Modular signal conditioners employing solid state circuitry are currently in use. A signal from a single sensor may be modulated, or several sensors may share one modular unit The modular construction facilitates servicing and replacement of defective parts. Circuits employing operational amplifiers as the active elements are particularly well suited for amplification of the small direct current voltage produced by water quality sensors. Operational amplifier voltage output is stable, and temperature compensation and linearization are readily accomplished through operational techniques.

A wide range of new sensors known as specific ion electrodes has become available recently for laboratory bench work. These electrodes depend upon diffusion through selective membranes composed of single crystals or liquidation exchange medium Application of continuous monitoring has only been partially successful due to poor accuracy primarily caused by variations in electrode temperature, flow rate, and electronic drift. Green [40] has provided a list of sensors which would be useful if they could be developed which is reproduced in Table 3.8.

The most significant deficiency in the area of water quality sensors is the lack of a workable automatic biological monitoring device Part of the trouble stems from the lack of knowledge about the biochemical reactions taking place. Thus, many of our measurements imply the quantities we would like to detect rather than directly report the value of the variable of interest. New sensors needed included those listed in Table 3.8 and the direct and continuous measurement of the bacteria, viruses, and other bacteriological and biochemical characteristics.

Multiplexing, Data Registration, and Telemetry

Automatic water quality monitoring systems have the ability to produce great quantities of data. In order for this data to be most useful for the purposes previously listed,

Table 3.6

COMMON PARAMETRIC SENSORS

Parameter	Sensor	Range	Automatic Temperature compensation
1. Air Temperature	Thermistor, or	-30 to 40° C	
2. Water Temperature	Thermistor or Thermocouple	0 to 30° C	— —
3. Dissolved Oxygen	Polarographic or Galvanic	0 to 12 mg/1 0 to 24 mg/1	yes
4. pH	Glass Ag/AgC1 Cell	2 to 12	yes
5. Conductivity	Plantinized Electrode	0 to 6000 micromhos 0 to 60000 micromhos (6 intermediate automatic ranges)	yes
6. Chloride	Ag Billet/ Ag/Ag C1 Cell	0 to 240 mg/1 0 to 2400 mg/1	yes
7. Turbidity (Suspended Solids)	Optical by transmission or scattering of light	0 to 120 JTU 0 to 240 JTU 0 to 600 JTU 0 to 2400 JTU	yes

Table 3.7

Special Parametric Sensors Now Available

Parameter	Sensor	Range
1. Ammonia	Wet Chemical or NH4C1/Ag/AgC1	0.05 to 0.50 mg/1 as total Ammonia
2. Nitrate	Ion Exchange Electrode	1.0 to 50.0 mg/1 as NO3 ion
3. Cyanide	—	0.01 to 0.10 mg/1 as CN ion
4. Total Heavy Metals	—	0.01 to 1.0 mg/1

they must be put in a form that can be accepted by a digital computer. This means that the analog voltage produced by the sensor signal conditioning package must be transformed into digital form. It is not economically feasible to have an analog-to-digital converter for each sensor signal; thus the signals must be sequentially interrogated and then digitized one at a time. The sequencing unit is known as a multiplexer. At this point the digital data must either be directly fed into a computer or registered on punched cards, punched paper tape, or magnetic tape which is properly coded for the computer which is used.

In the case where more than one

Table 3.8

PARAMETERS OF CURRENT GREAT INTEREST FOR WHICH SENSORS DO NOT EXIST

PARAMETER	Ranges of Concentration Desired mg/ L	M	H	Precision Desirable mg/ L	M	H
(2) Organic nitrogen	0-1	-	0-10	0.01		0.5
(3) Ammonia nitrogen	0-1	-	0-10	0.01		0.5
(2) Nitrate nitrogen	0-1	-	0-10	0.01		0.5
(3) Nitrate nitrogen	0-0.1	-	0-2	0.01		0.1
(2) Inorganic phosphorus	0-2	-	0-20	0.01		0.5
(3) Organic phosphorus	0-2	-	0-20	0.01		0.5
(2) COD	0-50	-	0-500	1		10
(5) MBAS**	0-1	-	1-10	0.01		0.1
(4) Acidity or alkalinity	0-250	-	0-1000	5		50
(4) Hardness	0-250	-	0-1000	5		50
(3) Sulfate	0-100	-	0-1000	2		20
(1) Phenols	0-0.5	0-5	0-50	0.01		0.1
(4) Calcium	0-100	-	0-1000	2		20
(1) Cyanide	0-0.1	0-1.0	0-10	0.005	0.05	0.5
(4) Manganese	0-0.5	-	0-5	0.01		0.1
(1) Zinc	0-2	-	0-10	0.01		0.5
(3) Sodium	0-100	0-500	0-5000	2	10	100
(3) Potassium	0-10	0-100	0-1000	0.5	5	50
(1) Copper	0-0.5	-	0-5.0	0.01		0.1
(1) Methyl Mercury	0-0.01	-	0-2.0	0.005		0.1

**Methylene blue active substances
*Numbers reflect relative need for individual parameter sensors (#1 is greatest need)

automatic water quality monitoring station is in use, it becomes feasible to transmit the multiplexed signals to a central station. The signals can be digitized either before or after transmission. Analog telemetry systems are usually cheaper and simpler to operate but are more limited than digital systems in the rate at which data can be transmitted.

The least expensive transmission is carried out over telegraph grade lines which can be leased for $1.00 per mile per month. These lines are limited in transmission frequency from 0 to 15 Hertz (cycles per second). For more rapid transmission, the more expensive voice grade telephone grade lines are used. Based on a study of information rate, bandwidth and noise considerations of the transmission link for oceanographic data, Daniel, et al., [41] recommend use of time division multiplexing with pulse code modulation telemetry.

Data Management Systems

There are many sophisticated environmental quality monitoring networks being used for surveillance of our air and water systems (Table 3.9). Several cities such as Pittsburgh and Los Angeles have established air pollution alert warning systems. However,

Table 3.9

AUTOMATIC COMMUNITY ENVIRONMENTAL QUALITY MONITORING NETWORK

CITY	NUMBER OF STATIONS	TOTAL NUMBER OF SENSORS	VARIABLES MONITORED	ENVIRONMENT
Pittsburgh	17	103	SO_2, H_2S; Suspended Particulates; Wind Speed and Direction Air Temperature and Humidity; Solar Radiation	Air
New York (Maximum Capability	10 32	60 512	SO_2, CO Suspended Particulates Wind Speed & Direction Air Temperature (To be added later NO, NO^2, 0^3)	Air
Los Angeles	12	120	SO_2, CO, NO, NO_2 Suspended Particulates Wind Speed & Direction	
Detroit	13		Air Temperature and Humidity	Air
Rotterdam	31 1 2		Sulfur Dioxide Wind Speed Wind Direction	Air
Paradise, Kentucky TVA	14		Sulfur Dioxide	Air
Chicago, Illinois	8	16	Sulfur Dioxide Coefficient of Haze	Air
Ohio River (ORSANCO)	27		DO, pH, Water Temp., Conductance Chlorides, Solar Radiation, and ORP	Water
Delaware River (USGS)	12		DO and pH Temp. and Conductance Turbidity	Water

only in Rotterdam does there seem to be a sufficient degree of cooperation with industry to effect a production cutback during periods of high air pollution. The SO2 concentration is used along with meteorological information to determine the degree of stability of the atmosphere over Rotterdam The sampling system has been statistically designed to enable the operators to pinpoint individual manufacturers as sources of excessive emissions. The computer which controls the system receives a 5-second transmission of concentration data from each sensor at intervals of about one minute.Hourly mean concentrations are calculated. The mean wind direction is calculated every hour from readings taken every minute. Each station reading is then labeled with indices for site, wind direction, time, and concentrations. Measured concentrations are reduced to values independent of site, direction, and time of day. When a reduced-SO2 concentration level rises above a pre-set threshold value, an alarm is triggered. If the weather forecast indicates continuation of prevailing meteorological conditions for more than six hours, an

external alert is called, and the offending industries are requested to reduce their emissions.

At present, water quality management has not reached air quality management levels. For example, on the Delaware River, the Delaware River Basin Commission (DRBC) has been engaged in developing a water quality management system. Instead of an automatic monitoring system, data are collected weekly in the center of the navigation channel at 17 locations in the upper 79-mile reach of the estuary. Each of the samples is then analyzed for over thirty water quality parameters [42].

Also, an automatic monitoring system is being developed on the Delaware by the U.S. Geological Survey. At present the system consists of 12 automatic monitoring stations recording data on paper tape. The stations vary in complexity from stations monitoring only conductivity and temperature to stations which also monitor dissolved oxygen, pH, and turbidity.

Storet

The Environmental Protection Agency has developed the STORET (Storage and Retrieval) system to provide information for water quality management and research. STORET can provide water quality management systems with an inexpensive computer data bank containing much of the data collected on their river system and a file for information they collect Through the use of remote terminals, STORET can be used to satisfy many of their daily needs for information and processing. The STORET system is being used by more than 60 different groups and agencies. The average data retrieval time is 3.4 minutes. A user, with teleprocessing to the central computer, will have his data available within 24 hours if not one or two hours [43].

Data presently being stored in the STORET system include: water quality data from 42,000 stations; municipal waste facilities inventory with 16,000 community entries; municipal implementation plans with 8,000 entries; industrial implementation plans, 4,000 entries; contract awards for construction of sewage treatment plants, sewers, and waterworks, 100,000 entries; fish kills due to pollution, 4,000 entries; and the Corps of Engineers permits to discharge [44].

Data can be retrieved using any of the following retrieval coordinates: political (city, town, county, state); geographical (latitude-longitude); and hydrological (river mileage and index). The system is being expanded to add Congressional Districts and Standard Metropolitan Statistical areas to the retrieval coordinates [45].

All water quality data retrieved from STORET can be subjected to the following statistical functions average, maximum and minimum values, number of observations, sum of values, sum of values squared, variance, standard deviation, standard error and/or coefficient of variances At any one location, a maximum of 9 computer pages of data may be generated. Therefore, an inventory of all data by point location is available This inventory gives the exact locations of the data point, the statistics and date interval for each parameter [43].

Graphical displays are also available. A general routine has been developed for plotting up to 30 different stations on the X-axis and statistical results for one or two parameters (e.g., mean, maximum, minimum, confidence interval) on the Y axis. Data can also be plotted versus time at one data point.

To make use of the STORET system, one must contact the regional EPA office. If any agency desires a teleprocessing connection to the STORET system, it must have an ASR-33 compatible teletype, or an IBM-2741 compatible remote terminal The user must also pay the line charge to connect the terminal to the computer.

In summary, STORET will provide an economical solution for many river data management systems. In those cases where STORET is not adequate to handle the overall complexity of the problem, it should still be an important part of the total data management system

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BOTTLENECKS AND BOONDOGGLES: IMPEDIMENTS TO CLEAN WATER

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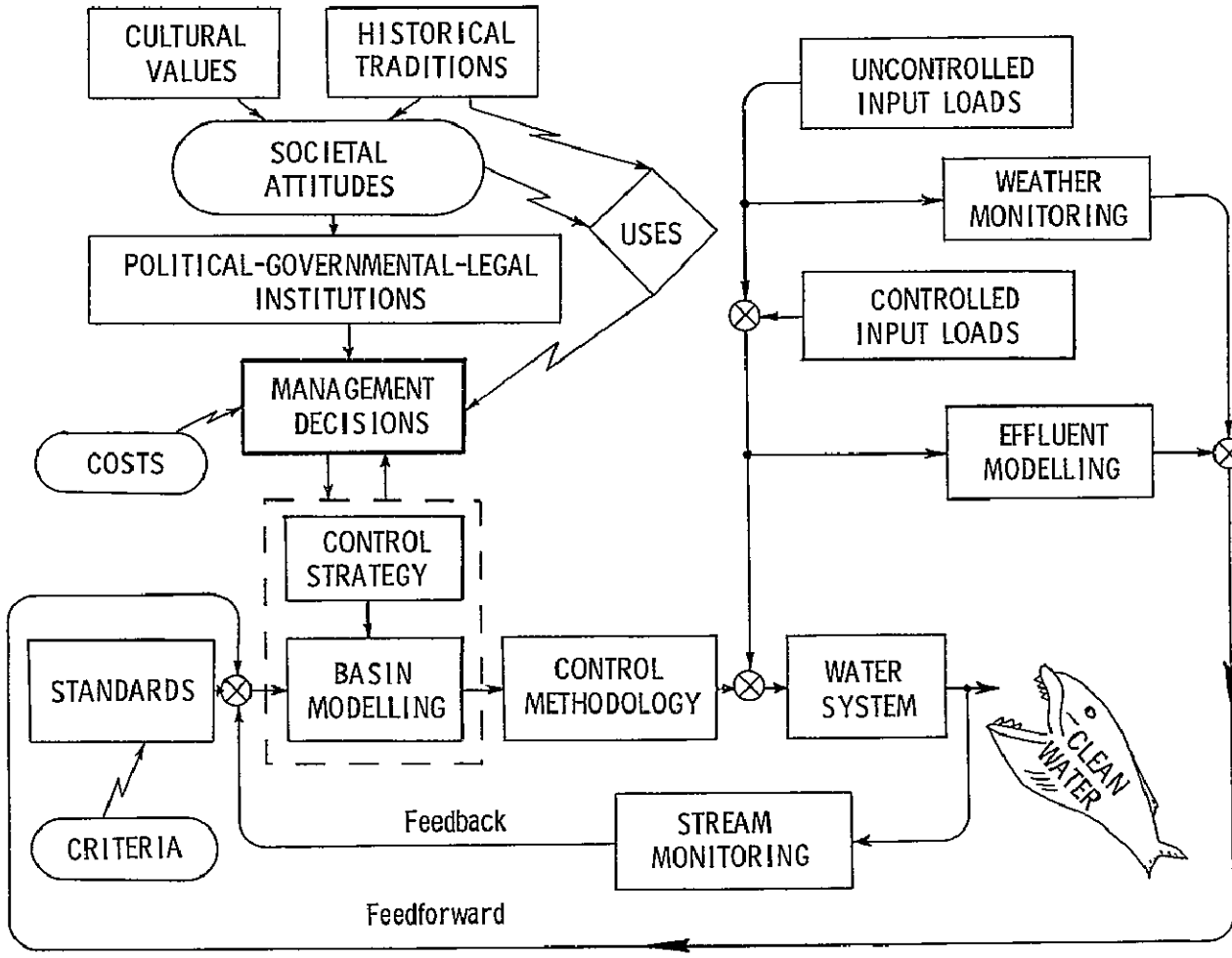

Introduction

The preceding chapters have dealt with wide-ranging aspects of our country's water resources. In this chapter the problems mentioned or implied will be brought into clear focus. They have been broken into two major types—social and technical, each of which presents some challenges. The more far-reaching difficulties appear to be of the social type because, although some technical problems do exist, few are beyond resolution if current technology is applied appropriately

While the solution to high birth rates lies outside the scope of this document, it does acknowledge that the overriding problem for our country and the world is to **control population growth.** But as we strive for the vital stabilization of the birth rate, we must also continue to improve the overall quality of life now. In the light of the foregoing remarks, this section will examine the major obstacles (other than population growth) to achieving improved water quality.

The Underlying Social Problem

Any philosophy of life, whether conscious or unconscious, contains assumptions regarding human nature and man's relation to man and to the natural order. The basic idea of the American culture has been that man's proper role is to dominate nature rather than live in harmony with it. This philosophy, coupled with a strong cultural commitment to progress, yields a powerful and pervasive ideology causing further societal exploitation of the natural resources. Progress is assumed by many to be self-evidently synonymous with population growth and the accumulation of individual and corporate wealth. In order to distribute this form of wealth, laws and customs have come into existence.

In particular, rules concerning water have always existed. They were not always consistent from region to region and have been in a state of flux. The laterations have been so gradual as to be changes in degree and not kind. In general, changes in degree proceed

relatively easily while modification of basic philosophy are intensely resisted. There can be little doubt that many solutions to current water quality problems call for modifications of the latter kind and therefore can expect to meet considerable resistence.

Political Impediments

Before a community can start to manage its water resources effectively it must precisely define the geographic region to be considered. These regions occur naturally as river basins or subbasins. The U.S G.S. has divided the conterminous states into 79 regions along natural boundaries [1] . Each of these might provide a basis for management rather than arbitrary political boundaries. That they are not considered as such reflects one of three political impediments. These are: conflicting jurisdiction, dilution of responsibilities, and poor administration.

Conflicting Jurisdiction

Two brief examples will give an indication of the magnitude of this problem The Delaware River Basin lies within the five states—New York, New Jersey, Delaware, Pennsylvania, and Maryland, but principally in the first four [3] . New York City has access to the headwaters and impounds this pure water for municipal use. Philadelphia, toward the lower end also uses the water for both drinking and industrial purposes. When extended dry weather occurs, these two mammoth metropolises are at sharp odds concerning water allocation.

A second example of some interest is provided by the Potomac River which runs through Washington, D C , Virginia, and Maryland. A continual disagreement persists concerning responsibility for the stream's despicable condition as it runs through our nation's capital, who should clean it up, and how.

Clearly, if Washington cleans up its sewage and Alexandria does not, or vice versa, the Potomac will not be clean. The solution must rest on the rational approaches based on the natural basin. In the case of the Delaware River, an attempt has been made to do just that, resulting in the Delaware River Basin Commission. This board has extensive regulatory powers as well as coordinated management. Over 100 organizations participated in the Delaware Comprehensive Study [3] which provided the basis for a water quality management policy. As an example of conflict, the EPA and the study group set up 5 objective sets ranging from holding the line at present pollution rates (Objective set 5), to restoring the river to pristine purity (O.S.1). A DRBC subcommittee discovered in confronting water users that they preferred level O S 3. to more rigorous clean-up. Vested interest questions might be raised here. However, the DRBC persisted in assigning O.S.2 as the goal Since Philadelphia (as a major user and polluter) was in favor of °.S.3, its officicals became highly incensed at the assignment of higher standards Litigation was the result. Some mechanism for settling such jurisdictional disputes must be established.

It has often been asserted that regional river basin authorities involving two or more states would provide effective control, where jurisdictional conflicts exist. Although the leading examples of these creations—ORSANCO, DRBC,etc.—do a laudable job in planning, their enforcement authority is generally left up to the states who were not doing the job in the first place. While regional approaches seem rational, they have been singularly ineffective due to the veto and lack of enforcement powers of the participating authorities.

The problem exists not only between the various levels of government involved, but within each level. The lack of solutions to water problems may not be caused by this proliferation of authorities, but is certainly exacerbated by it. As an example which illustrates the degree of the impediment, consider only federal agencies dealing with estuaries. Among the agencies having direct, significant effects are the following·

Department of Interior

Bureau of Commercial Fisheries
Bureau of Sport Fisheries and Wildlife
Bureau of Outdoor Recreation
The Goelogic Survey
Office of Water Resources Research

Department of Commerce

Maritime Administration
Environmental Science Service Administration
Economic Development Administration
National Industrial Pollution Control Council

Department of Defense
Department of the Army's Corps of Engineers

The incomplete list above extends to those which have related effects but not direct control such as NASA, the NSF, National Academy of Engineering, and others which fund research in water pollution problems. Suffice it to say, bureaucratic red tape contributes heavily to the pollution load of our nation's streams, lakes, and estuaries by fragmentation.

A river basin almost always includes a number of political jurisdictions and actions appropriate for river use in one locale. However, these certainly may be very inappropriate for river quality elsewhere downstream.

Assigning overall jurisdiction to the federal government might initate actions of reform. But despite federal interest in water quality since 1948, every piece of national legislation since then has been written to retain **primary** authority, not just flexibility of implementation, at the **state** level.

Dilution of Responsibility

The James River drains a furly large basin lying, for all practical purposes, entirely in Virginia [2] However, before significant actions pertaining to its waters can be effected, as many as 185 different political entities may be involved, ranging from a city council to the federal Environmental Protection Agency. Clearly here is dilution of responsibility. Most other basins suffer similarly.

Of the four major sources of water pollution (individuals, nonpoint sources, industries, and municipalities), the third and fourth classes represent sources of consistent, repeated discharges which can be indentified and isolated. It should be possible to control these discharges. Various levers can be applied to industry and they can react by changing production methods to reduce pollution, install adequate treatment facilities, or shut down completely. However, the levers which are needed to apply sufficient pressure in some other areas are difficult to come by. This is particularly true with regard to municipalities. Experience has shown that one of the main reasons for the inability to stop identifiable polluters has been the disparity of power between the polluter and the enforcing authority. Superficially, it would seem that the level of government closest to area waters would be the agency most familiar with the local problem of water supply, usage, and quality. However, it is at precisely this local level that societal and political dependency upon the good will of major polluters (e.g., the employer in one industry town) is most extreme. So the power of the enforcing government authority is often inadequate. Unequal power and jurisdictional conflicts combined present formidable impediments to improving water quality.

Poor Administration

If the federal government issues a policy of removing 85% BOD from all wastes today and changes that to 65% tomorrow and 90% the day after tomorrow, no polluter will be anxious to comply with standards until some stability in policy is attained. If the key governmental agency is reorganized during each Presidential administration, no one will know whom to contact for expertise or assistance. Significant progress will not be made until organizational stability is achieved After all, jobs are done by people, not by positions on an organizational chart. Eastablishing a consistent direction and getting on with the work is a pressing need.

Lack of initiative and commitment is manifested in the money appropriated and in the **loopholes** consciously built into existing legislation both at the state and federal levels. The loopeholes can be grouped within five categories: 1 time delays, 2. feasibility considerations, 3. acceptance of relative improvement, 4. wide discretionary authority and, 5. the preference for a "cooperative" solution. Each of these areas causes abatement in efforts to clean up water rather than abatement in pollution and should be reduced or eliminated.

Summary of Socio-Political Impediments

1. There is a demonstrated lack of political will to effect enforcement procedures of existing anti-pollution laws—seen in conscious underfunding of enforcement functions of anti-pollution agencies' budgets (federal/state).
2. Clean water is a low priority political issue (compared with poverty, defense, etc.).
3. There is an overemphasis on "construction" (of waste treatment plants) compared to enforcement as a solution to the problem of water pollution.

4. Justice Department (and states' attorneys general's offices) not as enthusiastic about enforcing anit-pollution laws as anti-pollution agencies are likely to be.
5. Typical enforcement procedures are time-consuming and costly for government.
6. The attitude that cleaning up pollution must be a cooperative venture between the polluter and the government.
7 Reliance upon the polluter to provide evidence against himself because anti-pollution agencies seldom have powers to extract information about manufacturing processes upon demand.
8. Most governmental anti-pollution agencies have little or no control over how/why other agencies within their branch of government spend their pollution abatement funds.
9 Government is reluctant to enforce standards if it can't simultaneously provide the violator with the funds to do the job.
10. Not enough "ties" in the construction grants program; "assurance of efficient operation maintenance" clause is often ignored
11. RD funds often used to put off solving problem; are seldom used to investigate area of enforcement.
12. Many federal water resource programs are still not under the control of EPA.
13. Section 102 statements of NEPA, while laudable, can't be adequately managed by small staff of CEQ.
14. Divided governmental, commitment must start in National Industrial Pollution Control Council vs. Environmental Protection Agency missions.
15 Lack of commitment to enforce Refuse Act of 1899; the Justice Department foot-dragging only a symptom, is not really an issue of usurped or divided authority.
16. Office of Water Programs still has a very passive role vis-a-vis Office of Management Budget in coordinating the funding of anti-pollution efforts.
17. Congressional committee division over water programs.
18. Congressional lack of scientific expertise in water and related matters.
19. Existing Federal-State structure of government leaves predominant authority over water quality management in river basins in the hands of state and local authority; all Federal legislation to the present (FWPCA) with its amendments) continues to retain primary authority at this level.
20. There are great pressures upon the governor of a state NOT to invoke the Federal anti-pollution enforcement machinery currently available to him.
21. There is great disparity of power between the enforcing authority for federal laws and the potential "targets" for enforcement action.
22. Regional authorities, while they may correspond to the river basin, cannot command significant political loyalities over people in the area to be taxed/enforced
23. State levels of "supra-govt." have traditionally been unable or unwilling to command funds necessary for successful river quality management of intrastate waters.
24 Attitude of most state water quality agencies is protective of industrial polluters even to point of reserving seats for them within state apparatus.
25. Regional solution with an "equal" Federal presence and unit-veto for state members can easily co-opt the Federal authority, lead to "mutual security pact" between the states vs. the Federal enforcement machinery.

Socio-Economic Impediments

The orientation of our society toward consumption rather than conservation is a large problem There is disagreement as to the impact of advertising on the level of resource use and the amount of waste generated It is clear though that, to the extent that advertising does affect these things, its effect is to stress consumption and its rewards rather than conservation and its rewards.

There is at present no way to assign valid dollar values to subjective costs and benefits such as aesthetic improvement. Yet benefit-cost ratios are computed, usually including an arbitrary value for recreation benefits where they are expected to exist but taking little or no account of subjective benefits or cost. The long range ecological and health impacts of a particular project are usually unknown and so are left out of account. It may be that, for many projects, these are the most important effects.

One large economic impediment to attaining cleaner water is lack of local money to build adequate sewage treatment facilities.

The federal government will provide matching funds, if a comprehensive basin-wide plan is presented [5]. However, the red tape at the state and local level creates difficulties in obtaining the matching funds.

One additional hindrance in the economic area is lack of data for use in predictive mathematical models which generate accurate cost and benefit functions Some industries are very reluctant to help establish such data, even to the point of being uncooperative. Such belligerent attitudes preclude attaining good economic data and control various important parameters is largely unexplored

Other Impediments

Technical Impediments. One would think that with the technology available which can take us to the moon and back, keeping water clean would present no problems. But even though lack of technology is not the major excuse for poor water quality, problems do exist. Gaps in basic scientific knowledge on the physical and especially practical biological responses to changes in water quality exist. Likewise, specific instrumentation to measure

Standards and Measurements

Standards are poorly defined in the water quality area. The EPA, Department of Health, and other agencies have issued guidelines from time to time; but these have largely been emergency responses to situations which occured. Criteria may exist for some standards, but much is needed in the way of carcinogens, drugs, hormones, viruses, and other similar entities.

The quantities of dissolved impurities to be measured or removed are not always of the magnitude encountered in industrial production. For example, sea water is about 96.5% H^2O, domestic sewage about 99.9% H^2O and the James River about 99.95% H^2O. However, describing purity in terms of gross percentages is an inadequate approach to water quality That percentages are coarse measure of our scale of interest can readily be seen from Figure 4.1. Note the typical measure of 1 mg/1 (1 ppm) compared to the scale of concern for viruses, 10^{-12} g/1. The possible

10^3	1 g/l	0.1%	Total Contaminants in sewage
10^2			Ca in hard water
10^1			Ca in soft water
10^0	1 mg/l		1 ppm F. Steroid Hormones
10^{-1}			
10^{-2}			
10^{-3}	1 μg/l		LSD Detection
10^{-4}			Carcinogenic Hydrocarbons
10^{-5}			
10^{-6}	1 ng/l		1 Bacterium/100 ml
10^{-7}			
10^{-8}			
10^{-9}	1 pg/l		
10^{-10}			Sr-90 MPC I-131 MPC
10^{-11}			
10^{-12}	1 fg/l		1 virus/100 ml

Figure 4.1

Scale of Concentrations of Substances in Water

dangers inherent to water users from alien pollutants can be detected only by critical analytic techniques. Most of the present day methods of water quality monitoring are manual/wet-lab procedures which require from 1 hour to 5 days. Instruments and procedures for speeding the monitoring functions are needed.

Processes

Current waste processes are referred to in terms of primary and secondary treatment. These terms mean something specific in terms of physical operations performed, but do not guarantee limit to the mass or concentration of residuals present in an effluent. In addition to the problem just mentioned, thermal pollution, radioactive wastes, and new organic complexes, many of which are unidentifiable, result from processes which discharge into waterways.

While identifying some materials in the water is a problem, determining the effects of various compounds on the biota and ecosystems is an even greater one. Direct means of measuring effects on living organisms is almost non-existent with the resulting time delays due to the use of indirect measurements. The lack of knowledge of these life processes is a definite deterent to intelligent planning for marshes, streams and estuaries.

Inadequate Planning

Long range planning requires dedicated commitment to solving or preventing problems. A major bottleneck in improving water quality has been an almost total lack of long range planning. Stopgap solutions have been reactions to crises. The development of flood control projects, for instance, has been shown to be correlated to the occurrence of severe floods [7]. Lobby groups sent by conservationists also tend to operate on a crisis basis. Instead of presenting their case to the legislature while bills are being drafted, they usually wait until it is already being voted on, then complain bitterly that the respective bill does not reflect conservation practices.

Summary

Most of the impediments which have heretofore been stated **could** become minor providing more enlightened officials and private citizens would react favorably and more speedily to the current problems. These bottlenecks and the consequent deplorable state of many of our nation's waterways become all the more appalling when it is realized that they can be overcome. We have the technology and we have the means. All we lack is a commitment by the people to **get the job done.**

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SYSTEM DESIGN FOR CLEAN WATER

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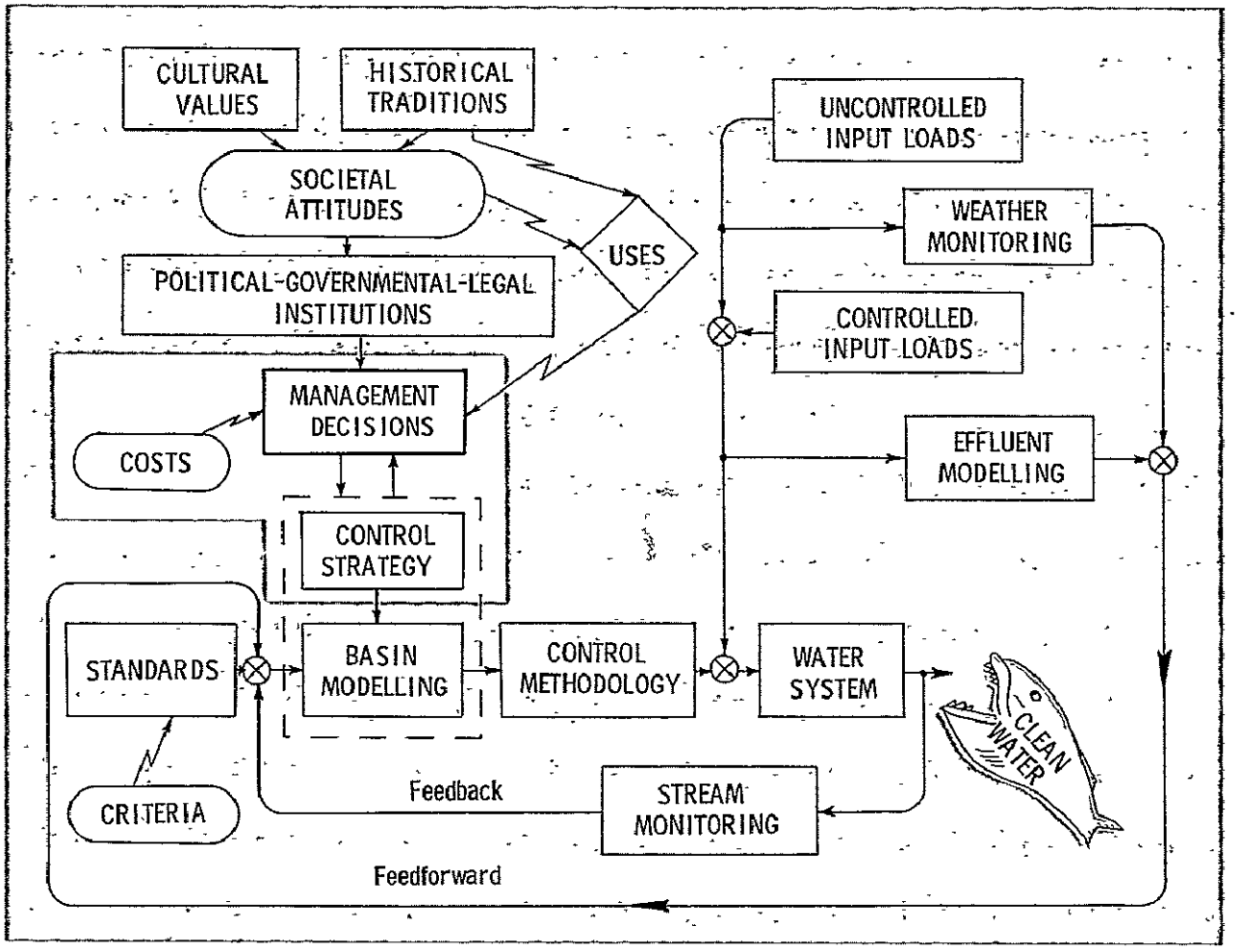

Introduction

We can have clean water. To accomplish this, however, we must define the goals of clean water and then develop a systematic approach to achieving these goals. To date, we have not done these things. This chapter represents a confluence of ideas expressed in this document. The result is a development of five basic appraoches which will produce clean water and a description of attendant problems and costs associated with each. These control plans are discussed in the section titled "Control Plans for Water Quality Management." But first, some general comments appear to be in order.

The scope of concern in environmental problems could be centered on very broad aspects such as **Regional Planning** or **Environmental Resources Management**. It is realized that water quality problems are but a subset of these categories. However, America is not ready for massive regional planning and related numerical or demographic population controls. But America's populous is concerned about water pollution and social values can be reoriented to the extent that America is ready to pay for the larger and more obvious clean-up problems. We can go a long way towards this end if we concentrate on water quality management.

A major bottleneck to meeting the objective of clean water is the "comfortable" way in which responsible agencies operate their programs of water quality within the scope of present legislation. The present concept is to use the political system of U.S. as the basis of Federal participation in the program. The boundaries of state and local governments have, of course, little or nothing to do with natural water basins or to water quality needs. To obtain clean water, a maximum program effort in waste treatment facilities must be carried out over the next five to eight years at a probably total cost of some 15 billion dollars from the federal treasury. To illustrate the lack

of controls over these monies with which to assure our "dollar's worth," consider the following·

First, it is noted that the several states are allocated a "share" of Federal monies based on the common formula for such monies which has no relationship to environmental needs save that higher populations create more waste.

Next, states set their own standards for water quality subject to federal "approval."* The federal grants for specific projects can supposedly be held up if standards are not acceptable. However, has any grant application been refused at the Washington final approval level? Certainly not.

Consequently, states set their own priorities of problems; again the Federal government having no direct control such that the final object of equally clean water can be realized over all the U.S

Then, assuming the Federal government is ready to fund its share of the costs, the state must fund its share and the local areas their remaining share before design and construction may begin. Thus, defeat of a local bond issue for any reason results in a legacy of one more continued dirty river left to America. In their March, 1971 Cost of Clean Water Reports, EPA shows over 50% of the states now plan expenditures below the minimum Federal estimate required to give us clean water. New legislation compounds this problem because monies allocated as Federal share funding to states which do not request them can now be reallocated to other states This could easily result in standards in some states being more stringent than necessary at the expense of an American legacy of dirty waters in other states—all to the tune of Federal tax dollars.

It is difficult for us to see that the attempt to channel water quality problems into political boundaries will result in an America of clean water Water quality is a national problem. Participation in water quality enhancement by local and state political entities is necessary, but leadership at that level is not efficient. Some may feel that equality or justice is served by this set-up. However, we submit that this kind of participation does not assure a more rational decision, but leads to political power moves and influence.

*After 6 years some 40% of the states had not received complete approval

Water Bill of Rights

We submit that the major physical contributions to pollution are few and definite (municipal sewage, industrial sewage, industrial cooling, agricultural run-off, sediment control, and ground water flow). Feeding these facets of pollution back into our political system for solution is to lose sight of our object—to be able to go anywhere in the U.S. and experience water as clean as possible within the capacity of a rich America. Our objective does not lend itself to excessive concern with certain states' or individual rights of free rule when the result may be burial in our neighbors' excrements

It is time for legislation at the national level which declares that the quality of waters everywhere is an equal right of all people. Water planning regions have been determined by engineers and scientists already, but any little planning within them that has been done has been transferred to action along political boundaries, thereby relegating standards, funding, and probably results to extreme uncertainty and variability.

Step number one for the federal government is to declare a Water Bill of Rights. This bill of rights, which could be expanded to air and land environments as well, might read as follows

> "No person shall threaten public health by altering the quality of natural waters or unreasonably affect the waters for beneficial uses or facilities which serve such uses."

If necessary, the courts would then be free to interpret this statement in terms of the U.S. Constitution and the history of water rights One such interpretation might be:

> "While the legal individual ownership of waters (or water bearing land) cannot be questioned, the right of Clean Waters is a national (and international) right shared by all peoples whether they are normally physically located near a particular water body or not; and that the natural interchange and transport system is so efficient and complex that uncontrolled use of natrual water bodies anywhere is certain to affect water quality elsewhere—water quality being a publicly shared right."

With this interpretation of the Water Bill of Rights, we have established the basic definition (and goal) of Clean Water—a

legacy of clean water in **all** America, **for** all America

Control Plans for Water Quality Management

Figures 5.1 through 5.5 present block diagrams which outline the steps necessary to implement the control system aspects of a complete water quality control program. Each plan illustrates a different strategy for the controlled input loads. Five plans, and the strategy for each, are shown in the figures. Allocation, Effluent Standards, Non-Degradation, Regionization Concept, and Closed-Cycle Concept. In addition each river basin would need to develop a set of contingency plans for the uncontrolled input loads. See Appendix E for an example of a contingency plan to control oil spills.

These control plans each represent a systems approach to water quality management. There are similarities to these approaches, and portions of some could be incorporated into others. Similarly, other approaches could be described However, the object here is to exemplify approaches which are significantly different in their legal, political, cultural, and technical aspects, and to show that any or all will lead to clean water if carried out completely. Laws, public support, research and construction must be part of a planned effort.

The alternate approaches or philosophies for implementing the water bill of rights are:

PLAN1—**Allocation:** Specifications for each zone are determined by **net assimilative capacity** of the stream. Outfalls are determined and controlled by allocation (as in Delaware River Basin) or by effluent charges (discussed in Chapter Two).

PLAN 2—**Effluent Standards:** All discharges into interstate and intrastate watercourses and their tributaries will be required to meet standards for all then currently established parameters in terms of quality and quantity Standards are not based on total river assimilative capacity, but on continually upgraded technical feasibility and ecological impact of discharges.

PLAN 3—**Non-Degradation:** The basic premise of this system is that the effluents must not lower the water quality. Thus, in the final state of the river, the value of the water quality parameters in the effluents would be the same as or better than their values in the stream.

PLAN 4—**Regionalization:** No discharges are permitted into interstate and intrastate water courses and their tributaries except by regional treatment plants. Authorized exceptions to individual industries and subregional plants are based on their incorporation into the regional system and submission to outside control.

PLAN 5—**Closed Cycle:** No discharges permitted into interstate and intrastate watercourses and their tributaries. Water removal from watercourses is also controlled to established levels. Except for losses, the system is self-contained, by-passing natural watercourses. Water supply and wastewater transmission are integrally controlled and service charges are made on individual users as water is metered and monitored in and out of each property. Charges would be based on both quantity and quality. This system is most advantageous to highly-developed, overworked watercourses.

PLAN 1 (Figure 5.1)

One approach to water quality management is to consider the river as a resource to be utilized for a defined set of beneficial uses. Presently, waste disposal is one of the major uses of a river. This use, which has become the primary use of many streams, seems to compete with most other uses. In a waste allocation scheme, all of the uses and use-regions of the stream must be defined. The value of the water quality parameters for each region is then determined. Using a water quality model for the stream, maximum discharge allocations are specified so as not to degrade the zone quality below what is needed for other uses. Discharges allocations only pertain to materials which the stream can assimilate. Other materials are limited by standards. Potentially harmful foreign substances may not be discharged into the stream.

To establish individual outfall allocations, several different techniques are available. These can be based on effluent discharge levels as was done by DRBC (Delaware River Basin Commission) or allocated indirectly via effluent charges. The latter concept is based on charging users a fee based upon the quantity and quality of their effluent. The effluent charge is set by economic analyses. As the charge is increased, polluters find it cheaper to treat their effluents.

A number of potential problems are associated with the allocation approach to

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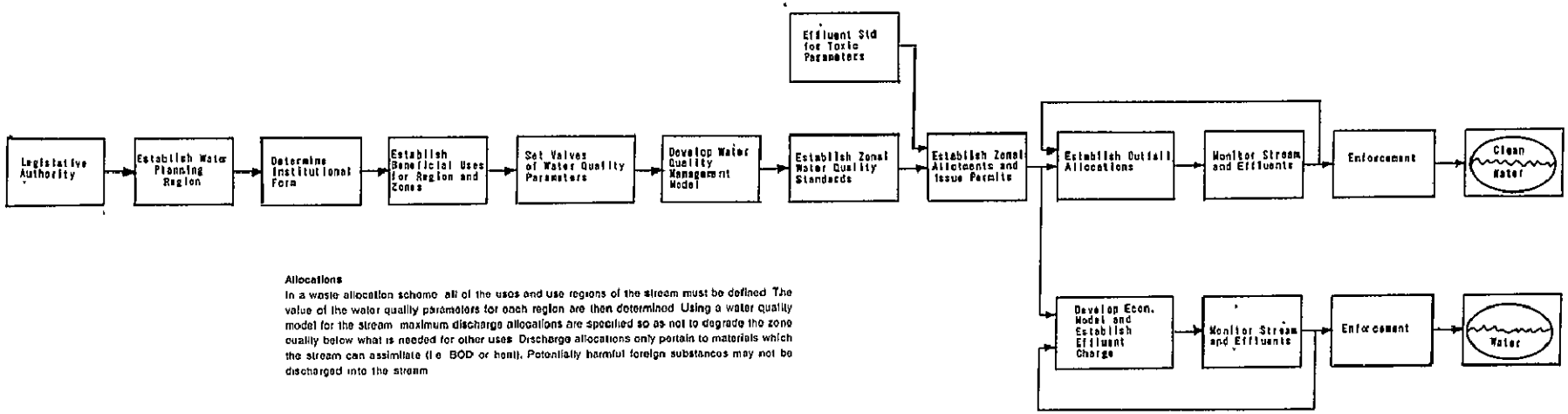

Allocations

In a waste allocation scheme all of the uses and use regions of the stream must be defined. The value of the water quality parameters for each region are then determined. Using a water quality model for the stream maximum discharge allocations are specified so as not to degrade the zone quality below what is needed for other uses. Discharge allocations only pertain to materials which the stream can assimilate (i.e. BOD or heat). Potentially harmful foreign substances may not be discharged into the stream.

FIGURE 5.1 FLOWCHART FOR WATER QUALITY MANAGEMENT — PLAN 1

water quality management: 1) It must be applied to a complete water basin or the net pollution upstream will not be consistent with downstream uses. 2) Since assimilative capacity varies, a mechanism for control of abnormal events (i.e., droughts) more severe than predicted is needed. 3) The system must be able to accommodate new users within zonal allocations. 4) Once initial allocations are established, it is difficult to upgrade standards by reducing individual allocations. It is our opinion that the latter two approaches render this system extremely difficult under the U.S. economic system.

Effluent charges will reduce overall pollution, but will not prevent short term misuse of the river.

PLAN 2 (Figure 5.2)

Plan 2 is based on effluent standards. All discharges into interstate and intrastate watercourses and their tributaries would be required to meet the standards for all then currently established parameters in terms of quality and quantity of effluent. The standards would not be based upon total assimilative capacity. Technical feasibility of removal would be a key factor, and the federal government would issue standards based upon proven capabilities regardless of economic impact upon individual dischargers.

Once legislative authority is established, it is important to establish a national organization with authority to set water quality standards, and to conduct research on ecological impacts of water additives and technical feasibility of removal as a continuing process. The result is a continuously changing set of water quality parameters and standards for these parameters. All dischargers would be issued effluent permits only upon submittal to any effluent monitoring which outside authorities deem necessary, plus certain standard devices to be installed and monitored at the expense of the discharger. The initial legislation should include the first set of parameters and values (standards) for these plus irrevocable sliding dates for meeting the standards. This method would probably result in amazing technical innovation to meet these standards once the "handwriting is on the wall" for all segments of our society to see. It is noted that stream monitoring is held to a minimum in this scheme and is mostly research-oriented in order to determine the effects of effluent standards and to upgrade continually the water quality parameter set and effluent standards for these parameters. Data collection for enforcement would be from dischargers themselves.

This scheme for clean water implies that we have only limited knowledge of the effects of any discharge on the biota of natural watercourses, and that the natural interchange and transport system is so efficient and complex that uncontrolled discharge into natural water bodies anywhere is certain to affect water quality elsewhere. It is clear that there is a certain artificiality to effluent standards when it is the stream or other watercourse we are trying to protect. However, it is a system which will work and which is, in principle, simple to implement. The initial legislation with set standards and dates of compliance would eliminate stalling and pleads of "economic infeasibility."

PLAN 3 (Figure 5.3)

This system is based upon **non-degradation**. This approach to water quality management denies the use of the stream for assimilating undesirable materials. All water users must discharge the same quality of water (in terms of an established set of paprmeters) as that in the watercourse at the point of discharge (no mixing zones). These parameters may change periodically as research shows the importance of other variables. As opposed to effluent standards, no set values of the parameters are given, but rather natural stream values are automatically set.

In order to implement this system, predictions of water quality will be necessary so that water users can be informed as to their expected input and output water quality.

Permits are issued for predicted effluents with specified time-tables to meet these values. Monitoring of both stream and effluents is required in this system.

PLAN 4 (Figure 5.4)

This concept embodies the philosophy that the only discharges permitted into interstate or intrastate waterways and their tributaries may be from regional authority treatment plants. All domestic, commercial, institutional, and industrial effluents are routed to regional treatment plants. Exceptions may be granted to individual discharges if they can show:

1. Their discharges will be of a quality equal to or better than that of the regional plant.

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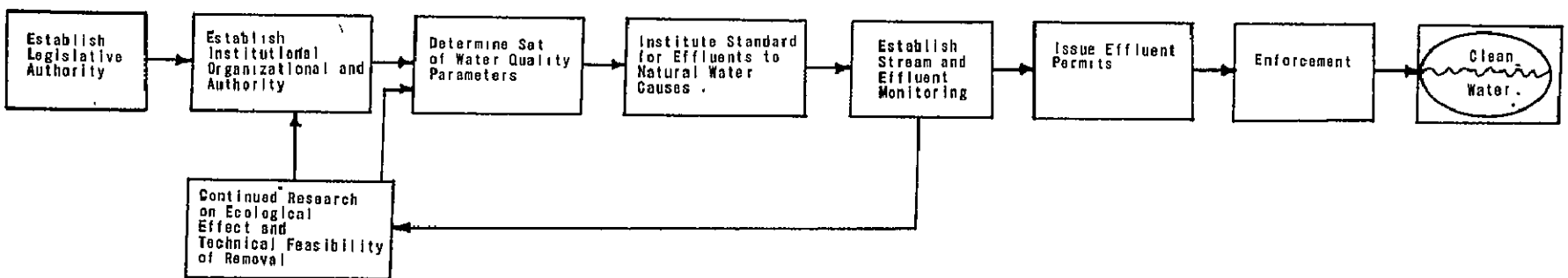

Effluent Standards:
All discharges into interstate and intrastate watercourses and their tributaries will be reouired to meet standards for all then currently established parameters in terms of quality and quantity Standards are not based on total river assimilative capacity but on continually upgraded technical feasibility

FIGURE 5.2 FLOWCHART FOR WATER QUALITY MANAGEMENT — PLAN 2

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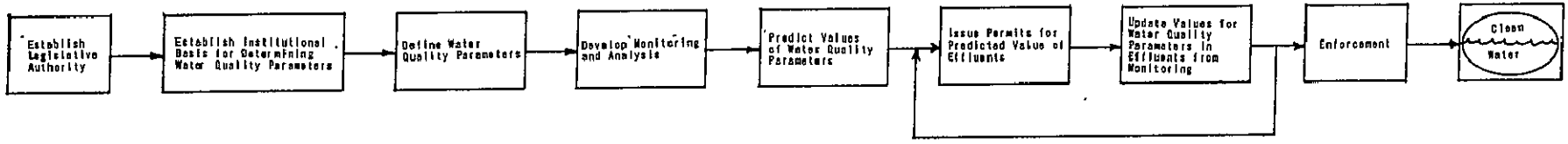

Non Degradation
The basic promise of this system is that the effluents must not lower the water quality. Thus in the final state of the river, the value of the water quality parameters in the effluents would be the same as or better than their values in the stream.

FIGURE 5.3 FLOWCHART FOR WATER QUALITY MANAGEMENT — PLAN 3

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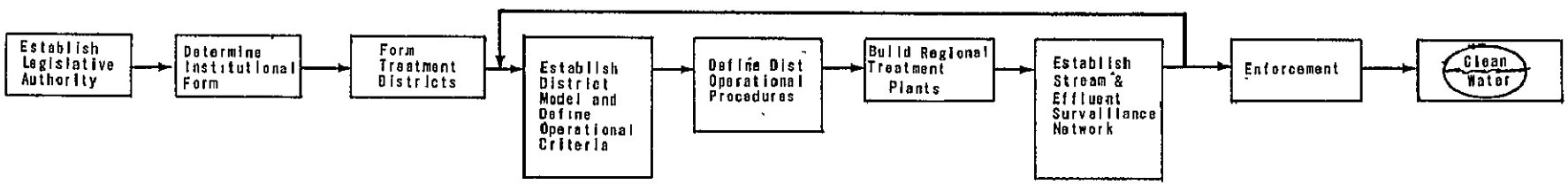

Regionalization Concept.
This concept, the ultimate form of regionalization, embodies the philosophy that only discharges permitted into interstate or intrastate waterways and their tributaries come from regional authority treatment plants. All domestic, commercial, institutional, and industrial effluents are routed to regional treatment plants or to local plants subject to regional authority.

FIGURE 5.4 FLOWCHART FOR WATER QUALITY MANAGEMENT — PLAN 4

2. Their effluent is monitored by the Regional Authority.

3. It is less economical to route the waste to the regional authority.

All discharges to the regional plant must guarantee that their waste is compatible with the treatment system, i.e., no toxic material that would affect any biological process. Industrial contributors must also bear their equitable share of construction, operating, and maintenance costs.

Regional treatment systems have the advantage of scale. Large systems are usually cheaper to build per unit of treatment. They have the advantaage of being able to train or hire skilled operatos and supervisors. Furthermore, they can support a professional staff of engineers, chemists, and biologists. A disadvantage is that discharges are concentrated. This can be avoided by distributing the treated waste over a reach of the receiving stream.

Once legislative authority is established it will be necessary to determine the institutional form of national and regional administrations. Treatment districts based upon watersheds, demography and socio-political systems then can be established. A model of district operations and criteria would be formed leading to final decisions on all treatment plants and their locations. Monitoring is reduced to a minimum in this system since discharges are few in number and will be necessary only to determine results of the system and to guide discharge quality and quantity.

PLAN 5 (Figure 5.5)

No discharges are permitted to interstate and intrastate watercourses and their tributaries. All wastewater from the system is processed for reuse and returned to the system. Consumptive losses are made up by withdrawal from nearby watercourses. The processing of wastewater may be done by the user and returned to his system or by a central processing plant and returned to the system as a whole.

Water may be processed to different levels of purity as needed by the user, and a multiple distribtution system can be used The user can then purchase the quality desired.

The closed cycle system will require the least amount of monitoring (monitoring is not required except in very special instances), and stream monitoring is confined to overall control and research.

Common Elements of Control Plans

A matrix presentation of treatment methods as a function of the potential discharge sites is shown in Figure 5.6. Listed above each treatment method is the capital, operating and maintenance cost. Additional cost data can be found in Figures 3 3 and 5.7. They show high level water renovation to be economically feasible. In many localities this may become mandatory as total water use tends to exceed total water supply. In the treatment methods shown, increasing water quality is towards the right.

Some of the major chemical constituents in water are described in detail in Table 5.1, taken from U.S. Geological Survey data. These chemical constituents are normally monitored as indications of water quality. Table 5.2 describes monitoring effort required for the plans presented above.

Beginning with Raw Sewage Influent, the figure traces the possible steps on processing water. The effluent consists of two segments—the desired product, called the supernatant and the byproduct, called the sludge. All effluents should undergo a Disinfection/Neutralization process.

Looking at the results of Receiving Waters, one finds that both the supernatant and the sludge from a primary treatment plant should be denied, or not allowed into streams, rivers, or estuaries. The effluent should be sent on for biological treatment Sludge from biological treatment should not be allowed in receiving waters, although controlled discharge of the supernatant may be allowed. Proceeding in a similar manner the supernatant discharge from Final Treatment is listed as "not practical". The implication is that the Final Treatment produces pure drinking water, and therefore, it is not economical to dump this polished product into natural drainages.

The effects of discharging the effluent into aquifers (underground water supply) via wells are listed under Ground Waters. Primary supernatant may not be discharged into ground waters except in an emergency.

Land Discharges refers to possible ways in which the water may be utilized. Many industrial processes can use supernatant effluent. As the water quality improves,

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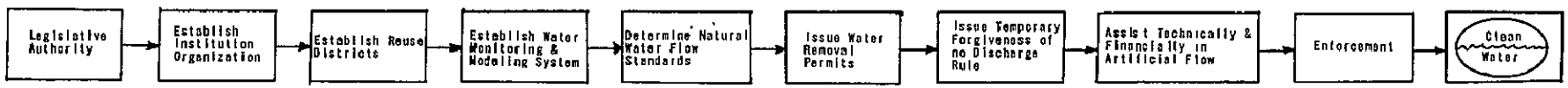

Closed Cycle Concept

This system is based upon no discharges permitted into interstate and intrastate watercourse and their tributaries Water removal from watercourses is also controlled to established levels Except for losses the system is self-contained, by-passing natural watercourses Water supply and wastewater transmission are integrally controlled and service charges are made on individual users as water is metered and monitored in and out of each property

FIGURE 5.5 FLOWCHART FOR WATER QUALITY MANAGEMENT — PLAN 5

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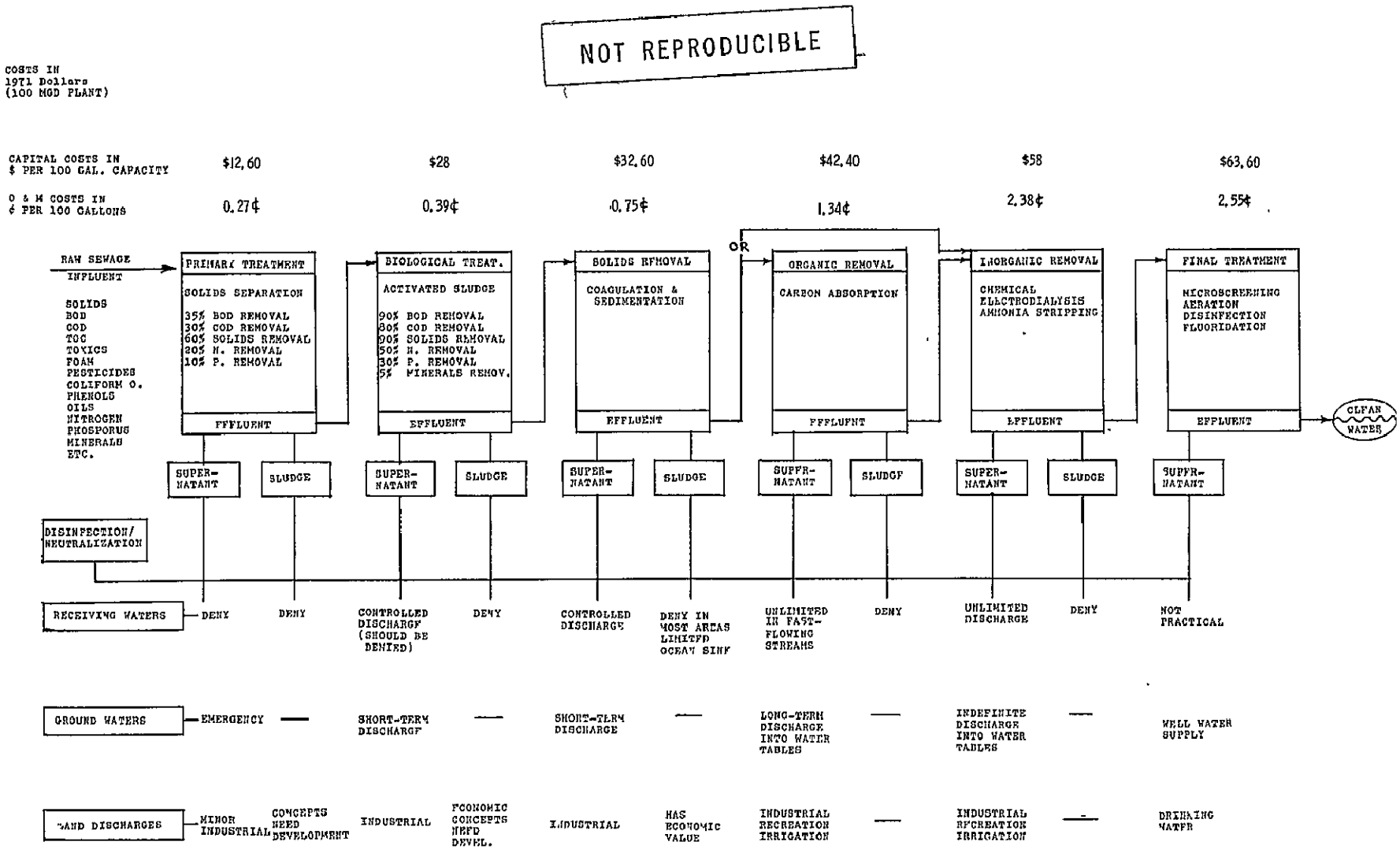

FIGURE 5.6 RENOVATED WASTEWATER AND COSTS

TABLE 5.1 — MAJOR CHEMICAL CONSTITUENTS IN WATER, THEIR SOURCES, CONCENTRATIONS, AND EFFECTS UPON USABILITY

(Source U S Geological Survey, 1962)

Constituent	Major sources	Concentration in natural water	Effect upon usability of water
Silica (SiO_2)	Feldspars, ferromagnesium and clay minerals, amorphous silicachert, opal.	Ranges generally from 1 0 to 30 ppm, although as much as 100 ppm is fairly common; as much as 4,000 ppm is found in brines	In the presence of calcium and magnesium, silica forms a scale in boilers and on steam turbines that retards heat, the scale is difficult to remove Silica may be added to soft water to inhibit corrosion of iron pipes
Iron (Fe)	1 *Natural sources:* Igneous rocks Amphiboles, ferromagnesian micas, ferrous sulfide (FeS), ferric sulfide or iron pyrite (FeS_2), magnetite (Fe_3O_4) Sandstone rocks Oxides, carbonates, and sulfides or iorn clay minerals 2. *Manmade sources:* Well casing, piping, pump parts storage tanks, and other objects of cast iron and steel which may be in contact with the water Industrial wastes	Generally less than 0.50 ppm in fully aerated water Ground water having a pH less than 8.0 may contain 10 ppm; rarely as much as 50 ppm may occur. Acid water from thermal springs, mine wastes, and industrial wastes may contain more than 6,000 ppm	More than 0.1 ppm precipitates after exposure to air, causes turbidity, stains plumbing fixtures laundry and cooking utensils, and imparts objectionable tastes and colors to foods and drinks More than 0 2 ppm is objectionable for most industrial uses.
Manganese (Mn)	Manganese in natural water probably comes most often from soils and sediments. Metamorphic and sedimentary rocks and mica biotite and amphibole honrblende minerals contain large amounts of manganese	Generally 0 20 ppm or less. Ground water and acid mine water may contain more than 10 ppm Reservoir water that has "turned over" may contain more than 150 ppm	More than 0 2 ppm precipitates upon oxidation, causes undesirable tastes, deposits on foods during cooking, stains plumbing fixtures and laundry, and fosters growths in reservoirs, filters, and distribution systems Most industrial users object to water containing more than 0 2 ppm.
Calcium (Ca)	Amphiboles, feldspars, gypsum, pyroxenes, aragonite, calcite, dolomite, magnesite, clay minerals	As much as 600 ppm in some western streams; brines may contain as much as 75,000 ppm	Calcium and magnesium combine with bicarbonate, carbonate, sulfate and silica to form heat-retarding, pipe-clogging scale in boilers and in other heat exchange equipment Calcium and magnesium combine with ions of fatty acid in soaps to form soap suds; the more calcium and magnesium the more soap required to form suds A high concentration of magnesium has a laxative effect, especially on new users of the supply.
Magnesium (Mg)	Amphiboles, olivine, pyroxenes, dolomite, magnesite, clay minerals.	As much as several hundred parts per million in some western streams, ocean water contains more than 1,000 ppm, and brines may contain as much as 57,000 ppm	
Sodium (Na)	Feldspars (albite); clay minerals, evaporites, such as halite ($Na_2SO_4 \cdot 10H_2O$), industrial wastes.	As much as 1,000 ppm in some western streams, about 10,000 ppm in sea water' about 25,000 ppm in brines.	More than 50 ppm sodium and potassium in the presence of suspended matter causes foaming, which accelerate scale formation and corrosion in boilers. Sodium and potassium

TABLE 5.1 — MAJOR CHEMICAL CONSTITUENTS IN WATER, THEIR SOURCES, CONCENTRATIONS, AND EFFECTS UPON USABILITY (CONTINUED)

(Source. U S Geological Survey, 1962)

Constituent	Major sources	Concentration in natural water	Effect upon usability of water
Potassium (K)	Feldspars (orthoclase and microcline), feldspathoids, some micas, clay minerals	Generally less than about 10 ppm' as much as 100 ppm in hot springs, as much as 25,000 ppm in brines	carbonate in recirculating cooling water can cause deterioration of wood in cooling towers. More than 65 ppm of sodium can cause problems in ice manufacture
Carbonate (Co_3)	Limestone, dolomite	Commonly 0 ppm in surafce water; commonly less than 10 ppm in ground water Water high in sodium may contain as much as 50 ppm of carbonate	Upon heating, bicarbonate is changed into steam, carbon dioxide and carbonate The carbonate combines with alkaline earths—principally calcium and magnesium—to form a crustlike scale of calcium carbonate that retards flow of heat through pipe walls and restricts flow of fluids in pipes Water containing large amounts of bicarbonate and alkalinity are undesriable in many industries
Bicarbonate (HCO_3)		Commonly less than 500 ppm; may exceed 1,000 ppm in water highly charged with carbon dioxide	
Sulfate (SO_4)	Oxidation of sulfide ores; gypsum; anhydrite, industrial wastes	Commonly less than 1,000 ppm except in streams and wells influenced by acid mine drainage As much as 200,000 ppm in some brines	Sulfate combines with calcium to form an adherent, heat-retarding scale More than 250 ppm is objectionable in water in some industries. Water containing about 500 ppm of sulfate tastes bitter, water containing about 1,000 ppm may be cathartic.
Chloride (Cl)	Chief source is sedimentary rock (evaporites). minor sources are igneous rocks. Ocean tides force salty water upstream in tidal estuaries	Commonly less than 10 ppm in humid regions, tidal streams contain increasing amounts of chloride (as much as 19,000 ppm) as the bay or ocean is approached About 19,300 ppm in sea water, and as much as 200,000 ppm in brines.	Chloride in excess of 100 ppm imparts a salty taste Concentrations greatly in excess of 100 ppm may cause physiological damage Food processing industries usually require less than 250 ppm. Some industries—textile processing, paper manufacturing, and synthetic rubber manufacturing—desire less than 100 ppm.
Fluoride (F)	Amphiboles (hornblende), apatite, flourite, mica.	Concentrations generally do not exceed 10 ppm in ground water or 1.0 ppm in surface water. Concentrations may be as much as 1,600 ppm in brines	Flouride concentration between 0.6 and 1 7 ppm in drinking water has a beneficial effect on the structure and resistance to decay of children's teeth Flouride in excess of 1.5 ppm in some areas causes "mottled enamle" in children's teeth Flouride in excess of 6 0 ppm causes pronounced mottling and disfiguration of teeth

TABLE 5.1 — MAJOR CHEMICAL CONSTITUENTS IN WATER, THEIR SOURCES, CONCENTRATIONS, AND EFFECTS UPON USABILITY (CONTINUED)

(Source U S Geological Survey, 1962)

Constituent	Major sources	Concentration in natural water	Effect upon usability of water
Nitrate (NO_3)	Atmosphere; legumes, plant debris, animal excrement, nitrogenous fertilizer in soild and sewage.	In surface water not subjected to pollution, concentration of nitrate may be as much as 5 0 ppm but is commonly less than 1.0 ppm. In ground water the concentration of nitrate may be as much as 1,000 ppm.	Water containing large amounts of nitrate (more than 100 ppm) is bitter tasting and may cause physiological distress Water from shallow wells containing more than 45 ppm has been reported to cause methemoglobinemia in infants Small amounts of nitrate help reduce cracking of high-pressure boiler steel.
Dissolved solids	The mineral constituents dissolved in waste constitute the dissolved solids	Surface water commonly contains less than 3,000 ppm; streams draining salt beds in arid regions may contain in excess of 15,000 ppm Ground water commonly contains less than 5 000 ppm; some brines contain as much as 300,000 ppm	More than 500 ppm is undesiralbe for drinking and many industrial uses Less than 300 ppm is desirable for dyeing of textiles and the manufacture of plastics, pulp, paper, rayon. Dissolved solids cause foaming in steam boilers; the maximum permissible content decreases with increases in operating pressure

TABLE 5.2

MONITORING REQUIREMENTS FOR WATER QUALITY MANAGEMENT PHILOSOPHIES

Philosophy	Manual Sampling Laboratory Analysis	Automated Instrumentation* Station Registered	Automated Instrumentation* Telemetered to Central Registered
Effluent Standards	Regular Program on all Effluents		Stream
Allocation		All Effluents	{Major Effluents {Stream
Non-Degradation	Regular Program on Minor Effluents	All Major Effluents	Stream
Regionalization	Regular Program on Stream		Within Regional Plant
Closed Cycle	Regular Program on Stream		

*In many cases, manual monitoring must be used to supplement automatic monitoring, since automatic instrumentation is not currently available for some of the important parameters

Irrigation appear in the figure. Drinking Water is the ultimate form of Land Discharge.

Clean Water and the Economic System

EPA estimates that a total of 16 billion dollars capital outlay is required to put some 30% additional population on sewers and to bring all treatment to secondary level (approximately 85% removal of BOD). This figure could be reduced to about 12 billion dollars with regionalization. Industrial waste and cooling-water treatment costs are estimated at 6 billion dollars. Ground water drainage is a difficult item to quantify, but, clean-up estimates range from 2 to 5 billion dollars. Control of urban and agriculture runoff is in the experimental stage. The total of these figures, plus treatment operation, plus continuing research if amortized over reasonable periods (as 25 years for municipal sewage bonds) amounts to about 3 billion dollars per year. Comparison of this figure to other expenditures is not completely meaningful, but it does serve to illustrate that logic is not always a prime factor in society's cost-benefit ratio calculations Just to use one such figure, we spend about 10 billion dollars per year on toiletries in this country. Perhaps a more meaningful set of figures shows electrical, gas, and water utilities amounting to approximately 10 billion dollars, 5 billion dollars, and 3 billion dollars, respectively. An additional 3 billion dollars for sanitation is comparable to these figures, and amounts to a fraction of one percent of our gross national product.

It has been said that it is the affluence of our society which has caused our pollution problems. There is probably little basis for this statement, affluence being only one multiplier of pollution problems. However, it is true that the affluence of our society can be the key to cleaning our environment. We can afford it—we should.

Cost distribution among citizens, municipalities, and industries is as important as total costs. The use of federal and state income taxes would distribute costs in almost an inverse order to contributions of BOD, one usual measure of pollution On the other hand, the use of income taxes is one of the most seemingly innocuous methods to the largest segment of the population as long as the total tax is not increased.*

It seems clear that the most proper and least objectionable way to distribute industrial costs is directly to consumers. Therefore, grants for industrial shares of treatment plants should be eliminated.

Figure 5 7 shows municipal treatment plant capital and operational costs distributed as utility costs to a family of five. The curves show that for largest metropolitan areas requiring 100mgd plant capacity (population equivalent of about 1 million persons) family sewer bills would be of the order of $1.50 per month for high-level secondary to $6.00 per month for renovation to drinking water level. These low costs reflects the following: (1) the costs of cleaning up municipal sewerage is not as great as many would imply, (2) the economy of regionalization (corresponding figures for 10,000 population are $5.25/mo. for secondary, and $14.50/mo. for tertiary treatment for a family of five), and (3) the relatively low differential costs to treat to very high levels in large metropolitan areas where most of the sewer lines are already in place. It should be noted that if the local community is required to pay only a fraction of their share of the capital costs of treatment via service charge, the remainder coming primarily from state and federal income taxes, these monthly service charges are considerably reduced. Figure 5.7 shows that these charges, if local capital costs are included, are 20% of the total

From a total economical point of view, there is need for a national water quality program so that we might encourage economic and social development in conjunction with the cleaning of our environment Any efficient water quality improvement scheme which is not nationwide in scope has undesirable effects on the geographic distribution of industry. Artificial cost differentials are introduced which place firms in an area where water quality is being raised at a disadvantage relative to their competitors in other areas. To the extent that abatement costs are a significant fraction of total costs, profits of the affected firms will fall. If some of these firms are producing at a high cost, perhaps in obsolete plants, profits may fall enough to induce the firm to close out the operation earlier than it otherwise would have done. In other cases a firm may be able to shift emphasis from the affected operation to

*As an aside A 5% "Environmental Protection" Federal Income surcharge would net enough money to take care of the Federal share of air, water, and solid waste pollution. This could be coupled with a neat, political move of a 5% "decrease" in military spending due to reductions in the Asian Campaign

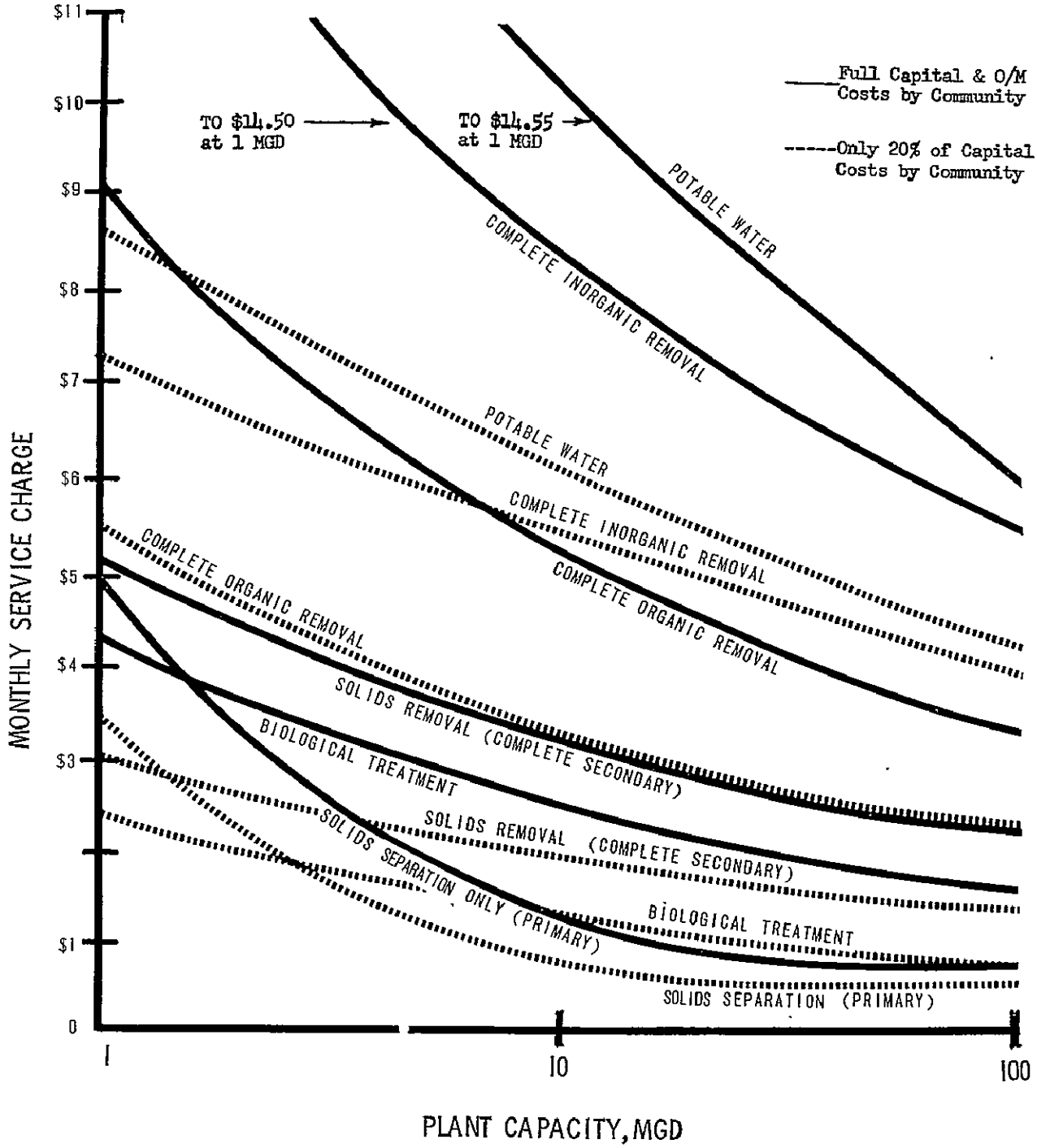

FIGURE 5.7 CUMULATIVE SERVICE CHARGES FOR A HOUSEHOLD OF FIVE TO OFFSET TREATMENT PLANT CAPITAL & O & M COSTS. (DATA SOURCE: CINCINNATI WATER RESEARCH LABORATORY)

a similar operation in another location. Such attempts by a firm to escape the cost of impact of water quality will affect income and employment in the area, the size of the impact depending on the relative importance of the firm as an employer.

A nationwide water quality improvement program largely avoids the above problems. Such a program can bring the costs of pollution abatement to bear on all competitors, introducing no artificial cost differentials. In fact such a program will permit real differentials in abatement cost, which were previously hidden, to become apparent They can then have their proper impact on industry location decisions. For these reasons it does not seem likely that water quality will be improved substantially except by an effort which is nationwide in scope.

The criterion governing the extent to which the quality of a society's waterways should be raised is that of maximum net benefit to the society from the use of its resources. Cleaner water confers benefits of various kinds. It also involves costs since the resources required for waste treatment, program administration, and so on must be drawn from other uses. If the added benefits from cleaner water are greater than the added costs, then there is a positive net benefit to be obtained by raising water quality.*

Neither the costs nor the benefits of clean water are readily quantifiable. Considerable effort has been devoted to developing waste treatment technology and the resulting treatment costs. Consequently,when a waste treatment problem arises, usable treatment cost estimates can be developed and adjusted for location differentials and price level changes. In many cases, though, the most economical abatement technique for industrial wastes is not treatment but avoidance, i.e., changes in production processes which permit efficient by product recovery, recycling, or which avoid generating a particular waste. Sometimes these adjustments are simple and quite effective For instance, a Georgia poultry processing plant was able to reduce its discharge of BOD by about two-thirds simply by tightening up its production practices and doing a dry clean-up of viscera, feathers etc., before the final wet clean-up. [1] In other cases these adjustments are more complex and expensive. In most cases, however, the possibilities for this type clean-up are not known. Industries have been under little or no pressure to reduce waste discharges and so have had little incentive to explore these possibilities. Consequently, advance estimates of abatement costs ordinarily must be based on the costs of waste treatment. The result is that the costs are often overestimated.

Quantification of all of the benefits of clean water is not possible at this time and perhaps will never be. Reductions in water treatment costs and other costs to water users can be estimated as well as the value of the increased yield of fish. Some of the benefits of increased opportunities for water-based recreation can be estimated, but a large part of them cannot be. The **extent** of increased recreational use of a cleaner body of water can, in principle, be estimated. However, many of these recreational uses are never priced in a market. Up to now, no alternative method of **valuing** them has been discovered. Such attempts which have been made involve the use of concepts such as the "merit weighted userday" which involves an arbitrary weighting process and is, in turn, valued at an arbitrary price.

Still other benefits are even more elusive. For example, cleaner water may result in the preservation of species which now have no apparent use to mankind. Many people, perhaps most, would be reluctant to see such a species extinguished, indicating that they do not have value despite their lack of present usefulness. Cleaner water also has an aesthetic value which cannot presently be determined in exact terms.

A clean stream also has an "option value" to many who may never go near it or benefit financially from it The option to use it has value nonetheless, but this option and its value depends on the existence of a clean stream.

Lacking the data necessary for even a rough benefit-cost analysis, it is necessary to fall back on less precise methods of determining the best level of water quality for society. Judgement must be substituted for data. In a democratic society the ultimate responsibility for exercising the necessary judgment must rest with the elected representatives of the people. It is assumed here that these judgments have been made and translated into a set of target values of the relevant water quality parameters for each stream basin or other body of water. More detailed discussion of how these steps might

*Ordinarily, both benefits and cost will be spread over time and, for decision purposes, must be discounted to present values.

be accomplished will be found in other sections of this report (for example, see Appendix P).

The incentive system favored by industry is an indirect subsidy in the form of tax credits for investment in wastewater treatment facilities and/or accelerated depreciation of such facilities for tax purposes. [2] This type of incentive is deficient in a number of respects.

First, it does not make purchase and use of this equipment profitable, only less unprofitable. Direct regulation will still be required if firms are to make these expenditures which generate little or no revenue. Such indirect subsidies can serve only as "sweeteners," which make the use of coercion less unpalatable than it would otherwise be

Second, by reducing the cost of treatment relative to other abatement techniques such subsidies would lead to undue emphasis on treatment at the expense of needed investments in developing other abatement technology. To the extent that such technology remains undiscovered, the cost of abatement will be higher than it need be.

Third, such subsudies tend to place part of the burden of abatement expenditures on taxpayers rather than on the consumers of the products involved. This makes the retail prices of these products understate their true costs, leads consumers to consume more of them than they otherwise would, and so tends to increase pollution

Summary and Comparisons

Vital to the process of obtaining clean water for America is developing a carefully organized plan and following it to completion. Random legislation and research projects aimed at the water pollution problem are not likely to produce clean water for America What is needed are commitments to a national plan of action.

The five plans presented here are not an exhaustive set of plans, but rather, represent basic schemes of five different philosophies with respect to water quality management. It is possible to create other systems for water quality management by combining features of several of these plans. The purpose of this discussion was not to select an optimum optimal plan, but to present several alternative potential solutions to the problem of pollution.

Plan 1 recognized the current use of our streams for waste disposal and tries to maximize waste disposal subject to the constraints imposed by the other beneficial uses. In Effluent Standards, Plan 2, waste disposal is recognized as a misuse of our streams and is minimized subject to the constraints imposed by technology and reason. Plans 3 and 5 are also based on the concept that waste disposal is a misuse of our water resources. In Plan 3, the non-degradation scheme, the water quality of all effluent discharges is required to be at least equal to the water quality of the natural unpolluted stream. This plan assumes man is capable of defining "non-degradation of water quality." At present, man cannot do this with absolute certainty. The closed cycle scheme, Plan 5, is an even more cautious approach than Plan 3, since it achieves clean water by preventing all discharges into the stream. This plan should be a very attractive solution to pollution in areas with a shortage of water. Regionalization, Plan 4, differs from the other four plans in that it obtains clean water by eliminating only all uncontrolled discharges into our streams. All discharges are processed by regional treatment plants, thereby achieving clean water when sufficient treatment is provided by the regional plants. Costs of tertiary treatment for large plants are less than secondary treatment for small plants.

There are a number of common steps in the various plans. All of the plans require enabling legislation, establishing management regions, and institutional form, monitoring and enforcement. The implementation of a given function in the flow charts will vary greatly, depending on the plan being implemented.

The total costs to our economy for the purpose of attaining clean water in the United States are estimated to be a fraction of one percent of our gross national product. Therefore, we conclude that the costs of the type of clean-up discussed here are affordable.

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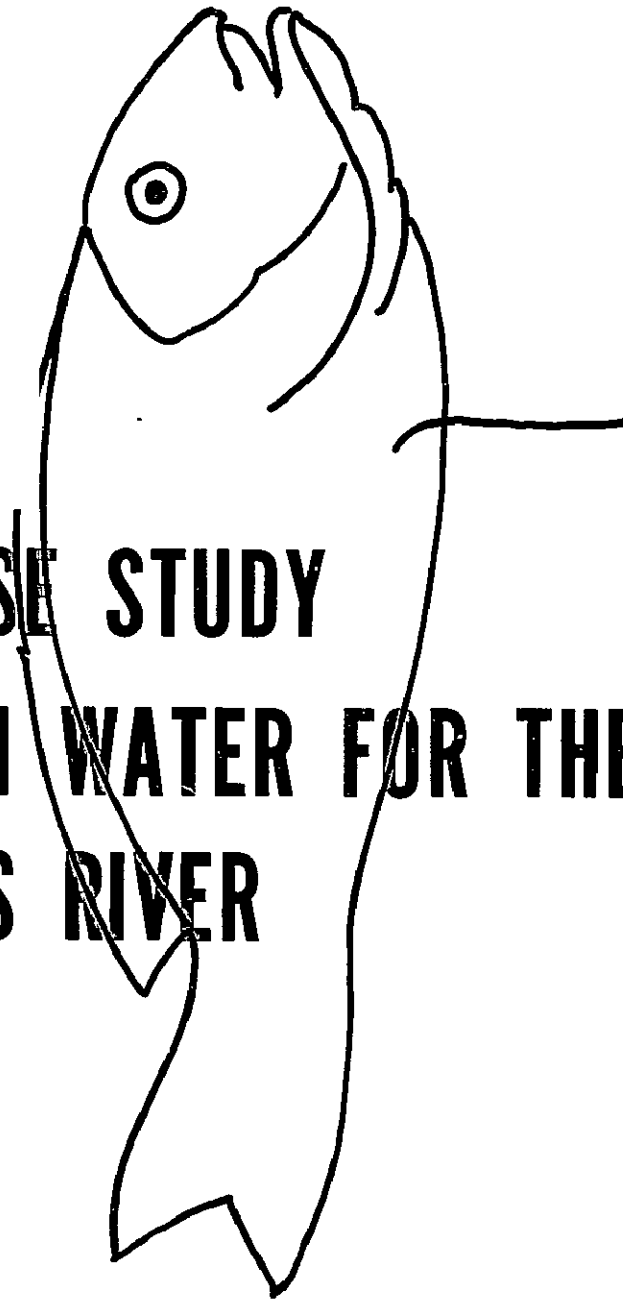


A CASE STUDY CLEAN WATER FOR THE JAMES RIVER

6

General Introduction

The James River is the southernmost major tributary of Chesapeake Bay and is the 141st largest river in the world. [1] Its basin extends approximately 230 miles across the state in a triangular, southeastern course, varying in width from ten to ninety miles. The James River Basin is unique in that its watershed boundaries, except for eighty square miles, lie entirely within the State of Virginia. It contains all or parts of 38 of Virginia's counties, covers 10,102 square miles or about 1/4 of the total area of the state, and forms the largest drainage basin in Virginia. (Figure 6A)

The Jackson River is formed at the confluence of Back Creek and Potts Creek in Highland County. Four miles below Clifton Forge, in Botetourt County in the Appalachian Mountain, the Jackson River joins the Cowpasture to form the James River. From this point the river wanders southeast for nearly 340 river miles to meet Hampton Roads at the mouth of Chesapeake Bay.

As it crosses the state, the river traverses four physiographic provinces. (Fig. 6.1) The initial tributaries of the James arise in the Valley Ridges province in lush woods and fertile valley farm land. The river cuts through many parallel ridges in this province, producing a large number of potential dam and reservoir sites.

As the river passes through the Great Valley Province, it begins its 988 foot drop in elevation [1] to the sea and passes through some of the richest farm lands in Virginia. The James drops rapidly in elevation as it passes through the Blue Ridge Province, falling over numerous rocky ledges. Upon entering the Piedmont, with its gentle, rolling topography, the river drops slowly through rich farm lands and forested areas and begins to pick up its first major pollution from large cities and industries. At the geologic fall line in Richmond, the river drops rapidly for seven miles and enters the coastal Plain Province. [2] The River probably receives its greatest pollution load at Richmond and continues to receive effluents from the industrialized Coastal Plain until it reaches Chesapeake Bay. The James in this region often reaches a width of five nautical [1] miles

Historical Introduction

The James River was the earliest avenue of commerce to English-speaking America, serving first to bring the colonists to the New World and later to provide a means of returning their products to the Old World. Because the river was the center of commerce and trade for colonial America, population rapidly moved up the river valley, and by the late 1600's settlements were appearing in the upper reaches of the basin. As the population centers expanded, the need for food increased with the result that before 1700 certain game became scarce and game laws had to be enacted. [2]

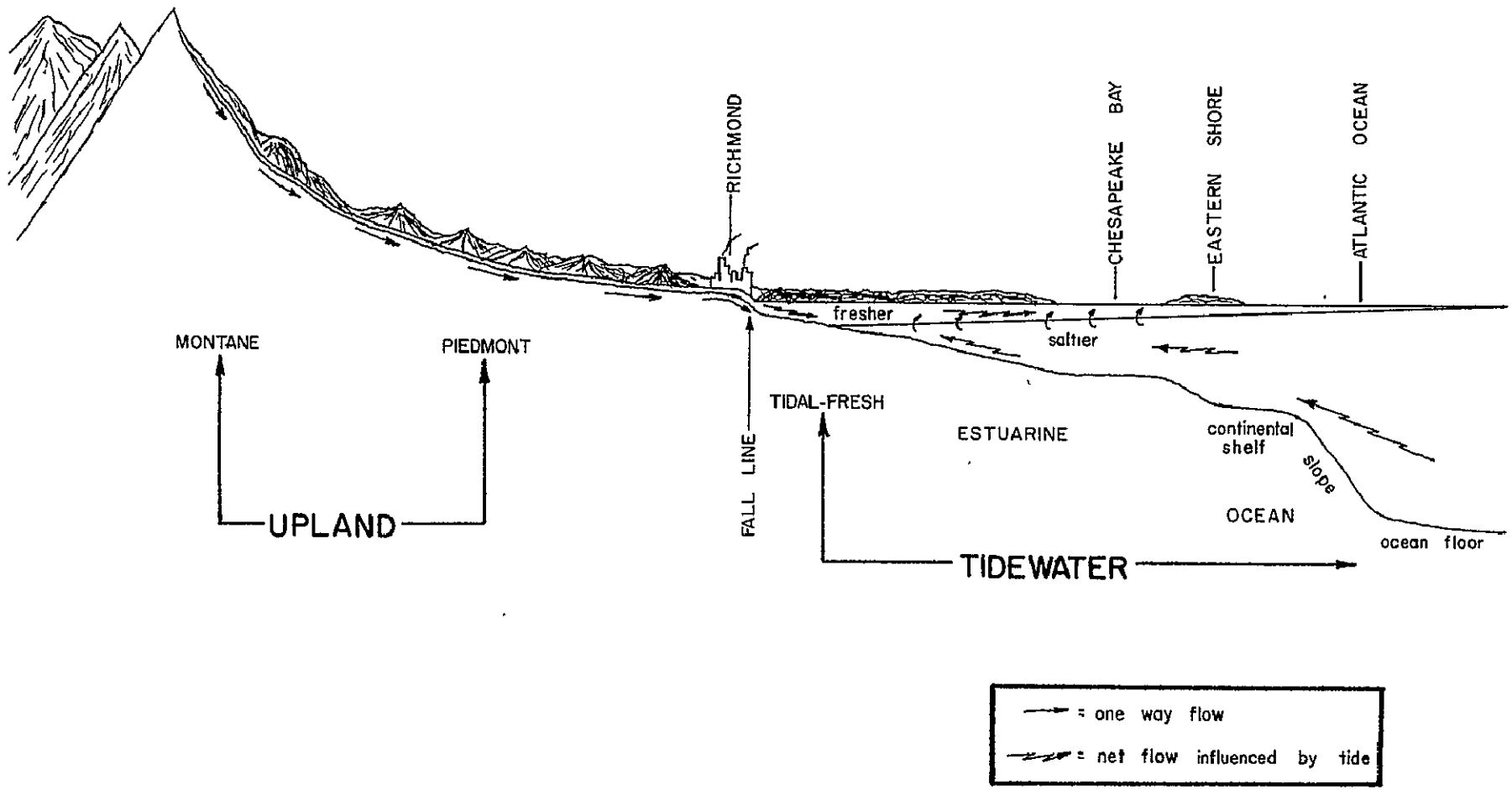
Farming became the chief industry, and cleared land rapidly emerged from the primeval forest along the banks of the river. Because of the abundance of land, when it became depleted in many cases it was vacated, leaving acres of prime topsoil to be washed into the James. As a consequence, sedimentation developed in the slow moving reaches and has persisted as a problem today. This was perhaps the earliest man-contributed pollution in the basin. The scars from this farming practice may still be seen in the basin, represented by land in the final stages of ecological succession. Soil conservation practices did not come to the James River valley until the late 1930's. [2]

Earliest accounts of the James River valley noted an abundance of fish and wildlife, mineral springs, and clean waters Streams of vacationers moved up the valley in summer, even in colonial times, to partake of the abundant recreational opportunities and health-giving waters. It is reputed that Thomas Jefferson built a summer home in the Piedmont in order to escape summer vacationers of his acquaintance, who made it a practice to stop and visit him enroute to and from the mountains. [2]

With continued urbanization and industrialization, coupled with little or naive planning, the James began to show major signs of pollution by 1832. This is when Richmonders began noting "muddy water" being pumped from the James for drinking purposes. [3] Specific accounts of pollution in the basin in the 1800's are lacking except for the City of Richmond, where unsafe drinking water caused numerous deaths from typhoid. [3] Richmond at that time contaminated its own drinking water by dumping raw sewage directly into the river, [3] a practice that is still continued today. [4]

The pollution problem reached major proportions by the early 1930's, especially in population and industrial centers such as Richmond and Hopewell. [2] By the mid-forties, the word "pollution" was common in

FIGURE 6A. JAMES RIVER BASIN (8)



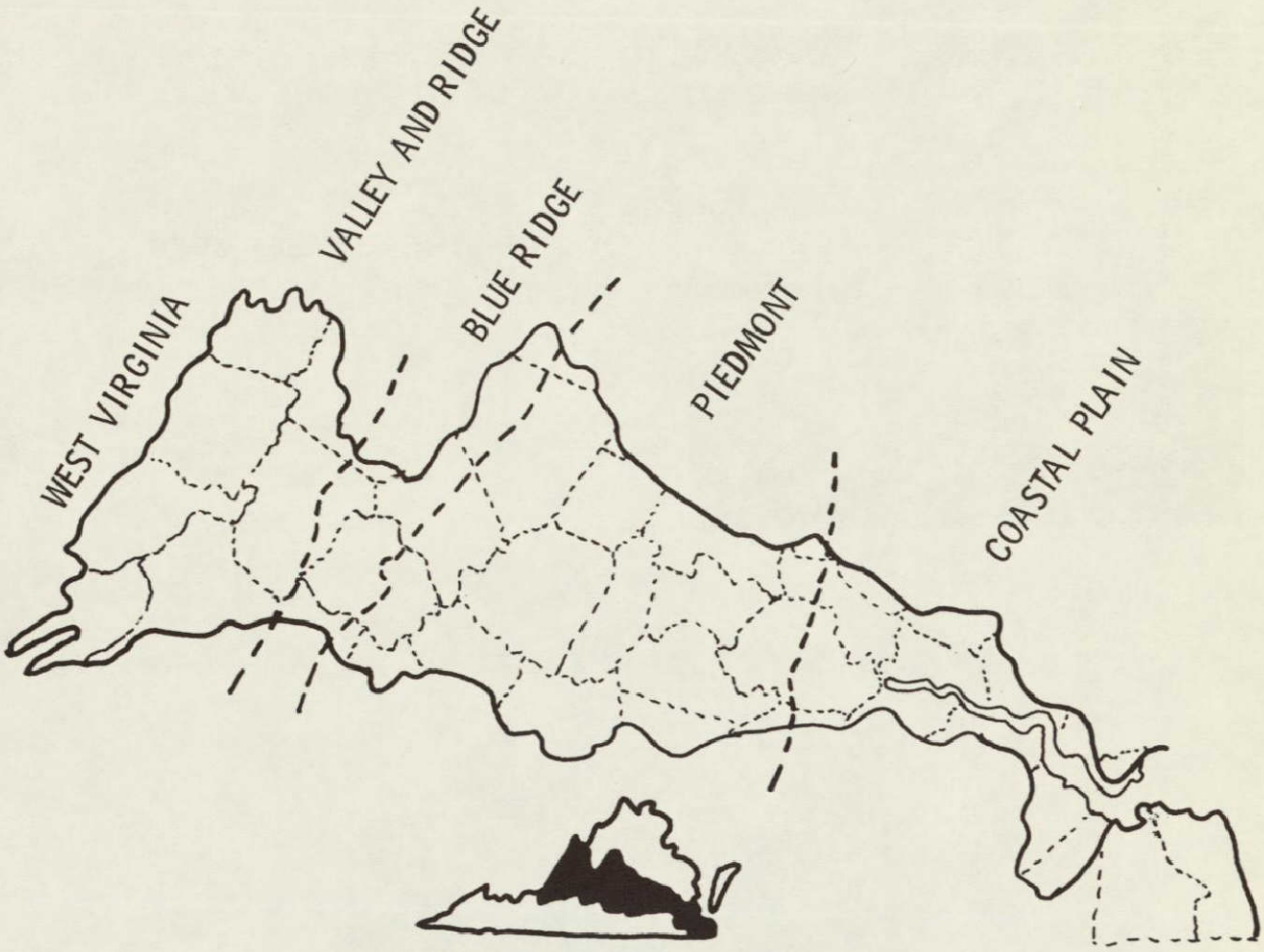


FIGURE 6.1 JAMES RIVER BASIN STUDY AREA PHYSIOGRAPHIC PROVINCES (5)

literature pertaining to the Basin, and major problems became common by the mid-sixties.

And now pollution levels have risen to the point that the seafood industry is in jeopardy. In the lower James, one of the richest seed oyster grounds in the world is threatened by domestic and industrial pollution. In fact, shell fishing is not permitted in much of the lower James and Hampton Roads area. [5]

The government of Virginia, as well as the citizens of the James River Basin, has only now started to acknowledge the presence of the problem and is taking steps to rectify it. New and stronger laws are being proposed, often with the assistance of citizens groups such as the Conservation Council of Virginia, Inc., The Council for Environmental Quality, Inc., and Citizens Against Pollution, Inc.

Portions of the James now lie dead or dying; those near Lynchburg, Richmond, Hopewell, and Newport News may soon be beyond rectification unless a solution to the pollution problem is rapidly found. The James River today represents a growing open sore on the countryside—a vast change from the once rich fertile river valley known to the Jamestown settlers.

Geological History

At its terminus, the James River enters Chesapeake Bay, a drowned ancient river system formed in recent times, primarily by the Susquehanna River. During the last period of glaciation, some 70,000 years ago, the Susquehanna River flowed out across the exposed continental shelf to the sea, cutting a valley which is now Chesapeake Bay. The present Potomac, Patuxent, Rappahannock, and York rivers flowed into the Susquehanna as tributaries; however, it appears the James was not a tributary to this system, but

VARYING VIEWS OF THE JAMES RIVER

remained separate—perhaps merging with the Susquehanna on the continental shelf. With the melting of the continental glaciers, the concomitant rise in sea level caused a change in the river regimes, initiating an interval of channel filling due to a rising base level. Increased rise ultimately drowned the valleys and created the estuarine complex which exists today. Although sea level rise has slowed to several inches per century, it continues as the Greenland ice cap melts and will continue to promote deposition to take place within the estuaries, gradually filling them. It is estimated that within several thousand years the estuarine character of the Chesapeake Bay will be completely destroyed. [6]

As stated earlier, the James River drains over 10,000 square miles of Virginia. Because of this vast watershed, it contains large quantities of suspended sediment, making it one of the more turbid rivers of the eastern seaboard. The mean freshwater discharge is approximately 7,500 cfs (cubic feet per second) but extremes of 329 to 325,000 cfs have been recorded. [7]

Energy Flow in the James River System

Of major importance in contemplating methods of pollution abatement in the James River system is the nature of the energy flow through the system, that is, the estuarine circulation pattern which is responsible for the distribution of the nutrients and pollutants. This material is presented in detail at this time since it is not clearly specified in the Comprehensive Water Resources Plan, yet is primarily the reason why the James River is becoming a degraded system.

The James River system is complex and includes both fresh-water and salt water segments. Above Richmond, the Montane and Piedmont portions of the river are characterized by a uni-directional flow of fresh water. Below Richmond, the situation is less definite In general, this reach can be subdivided into: 1) the **fresh-tidal**, 2) the **estuarine**, and 3) the **coastal zones**. Each is separate and distinct from the other; yet, each interacts with the other during each tidal cycle. The boundaries shift with the tides and with variations in rainfall, often extending through distances of thirty or more miles.

The **fresh-tidal** portion of the James, located below Richmond, is characterized by a net downstream movement of totally fresh water. However, the net velocity of downstream movement is much retarded, due to the influence of the tide and geography; and wastes dumped into this reach reside longer than in the non-tidal reaches above Richmond. [8] The velocity of downstream movement is greatly dependent upon rainfall variation and the resulting fresh water run-off. During periods of low rainfall and low run-off, a month or more may be required to transport wastes a distance of thirty to forty miles downstream. [8]

Nichols [9] has presented data on water characteristics and circulation for the **estuarine portion** of the James River. A profile from Newport News to Jamestown would show the maximum velocities at flood and ebb tides near the bottom to vary from nearly zero at slack water to a maximum of 2 6 feet per second three hours later. Greatest variation occurs between Hog Point downriver to Rochlanding Shoals, and again from Newport News seaward some 45 miles. Velocity changes reflect the bathymetry of the channel, showing a change of 0.7 feet per second where cross-sectional areas change between wide and narrow reaches of the estuary channel.

The estuarine portion exhibits a two-layer density flow phenomenon, whereby the lower, more saline sea water flows landward and the upper, lighter, fresh-water flows seaward. The net sediment transport direction, however, averaged over many tidal cycles is upstream. **It is this pecularity which precludes using the estuary as a refuse disposal system.**

The two-layer flow gives rise to a distinctly stratified salinity system which changes from well-stratified to well-mixed during the year. Stratification is poor or non-existent in the estuary during periods of low fresh-water inflow (usually summer and winter). Salty water reaches 54 miles upstream during this time. During periods of high fresh-water runoff, stratification is greatest and salty water (0.5 parts per thousand) is limited to Hog Point, 23 miles above the mouth. Hence, the edge of the salt water wedge fluctuates through a distance of 30 miles while the estuary changes from well-stratified to essentially homogeneous with vertical mixing. Pritchard (1955) determined that the James River could be classified as a Type B (Horizontally stratified) estuary. (Fig. 6.2) In a type B estuary the level of no-net-motion, that is the boundary between upper and lower water layers, is nearly horizontal with a slight upward inclination to the right (northward).

FIGURE 6.2 FLOW PATTERNS IN ESTUARIES.

Generally an estuary will move from a Type B to a Type C with a decrease in fresh water inflow (such as draught periods)

(Diagrams from Williams, J *Oceanography* Little, Brown, and Co Boston)

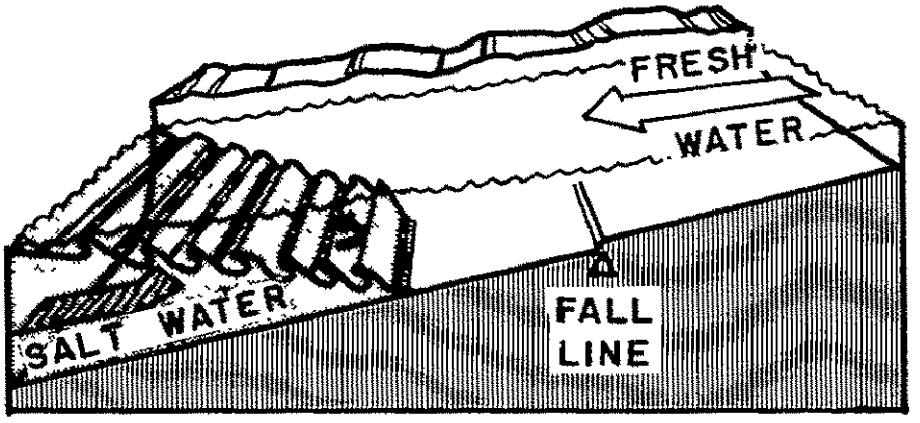


FIGURE 6.2-1 THE SALT WEDGE ESTUARY (Type A)

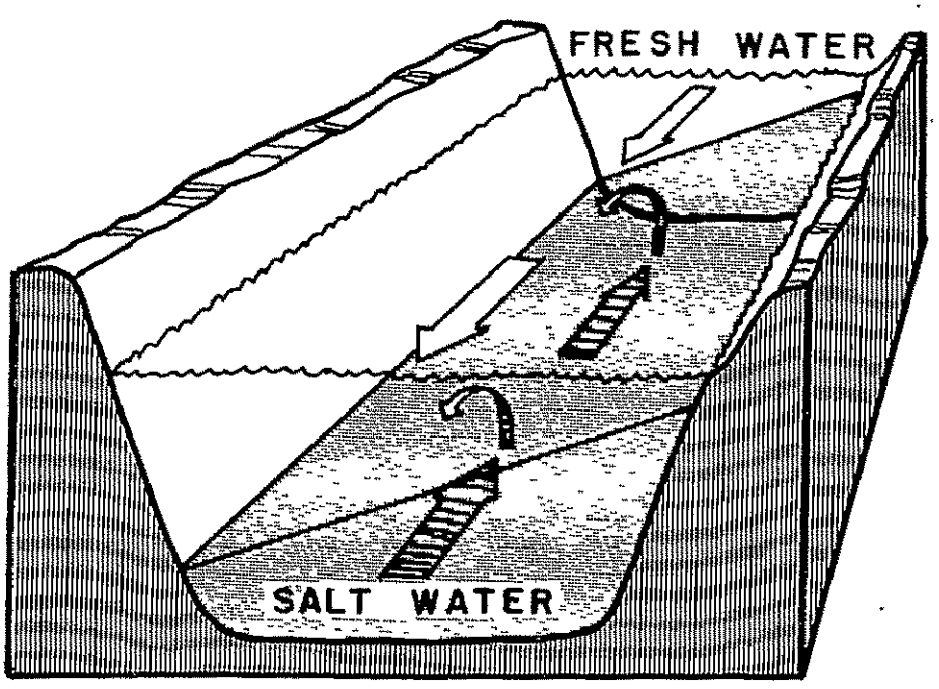


FIGURE 6.2-2 THE HORIZONTAL BOUNDARY ESTUARY (Type B)
THE SLOPING BOUNDARY SURFACE REPRESENTS
THE LEVEL OF NO NET MOTION

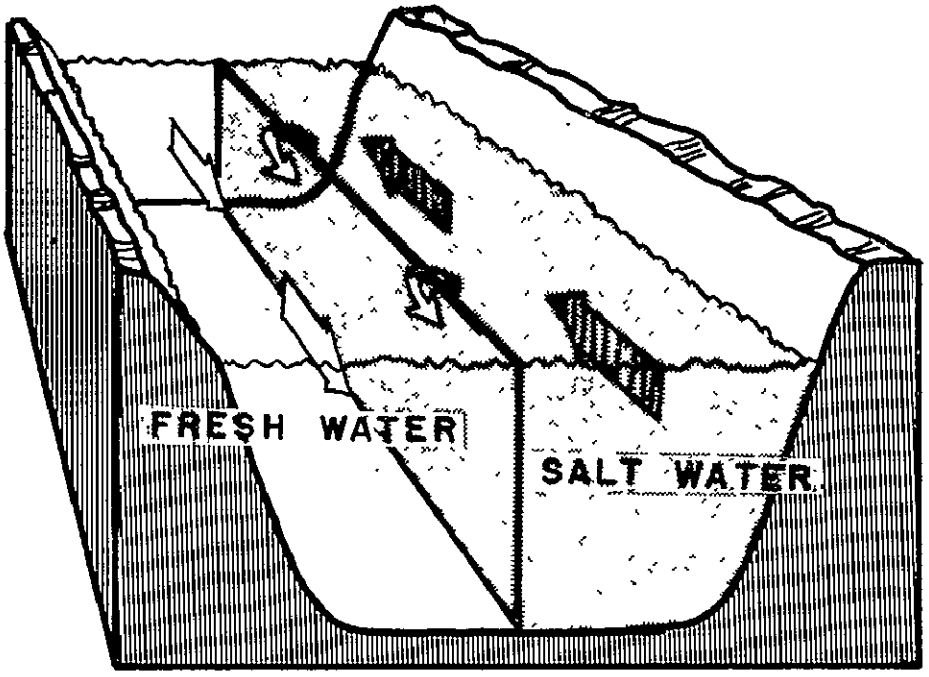


FIGURE 6.2-3 THE VERTICAL BOUNDARY ESTUARY (Type C)
THE VERTICAL BOUNDARY REPRESENTS
THE LEVEL OF NO NET MOTION

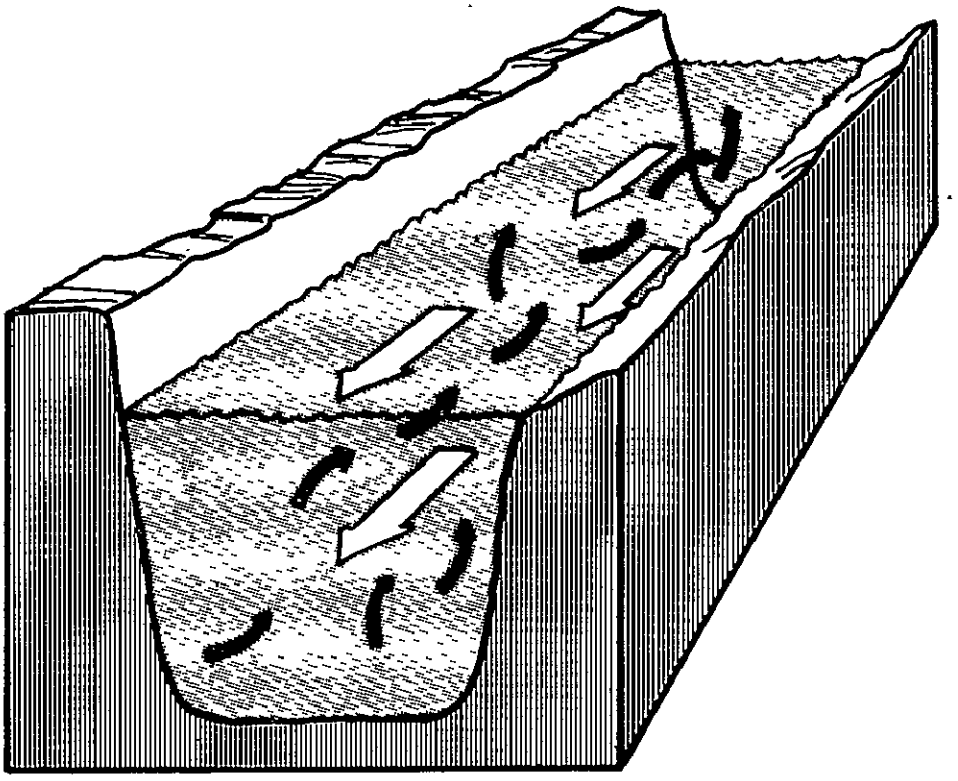


FIGURE 6.2-4 THE VERTICALLY AND HORIZONTALLY
HOMOGENEOUS ESTUARY (Type D)

Toward the mouth of the James, the estuary becomes a Type C as classified by Pritchard. [10] In this type, the level of no-net-motion is nearly vertical; looking upriver net flow is landward on the right and seaward on the left, with mixing taking place from the right to the left In this reach, the system is capable of flushing wastes introduced from the left bank out to sea. However, pollutants introduced on the right side will travel up the estuary and be retained within the salt wedge as the level of no-net-motion changes from vertical to more nearly horizontal.

If exact flow rates of any particular tributary, the specific geology of a portion of the watershed, or the quality of the ground water feeding into a specific stream are needed, the four volumes dealing with a comprehensive water resources plan of the James River Basin and published by the Division of Water Resources of the Virginia Department of Conservation and Economic Development should be consulted. [5]

Sedimentation

Chiefly, three sediment types are found in the James River. [11] They are 1) silty clay, 2) sand, and 3) a mixture of sand-silt-clay. The prefix "shelly" or "gravelly" is added where the sediment contains more than 5% shell or gravel coarser than .08 inch in diameter.

Silty clay is the most dominant sediment type throughout the estaury. It is found near the mouth of all tributaries entering the James (Chickahominy, Nansemond, and Elizabeth rivers), and particularly on the south side of the river and upper estuary. It floors the channel of Burwell Bay (middle estuary) and extends seaward into the lower estuary south of the main channel. This fine-grained material forms the suspended load of the river, and much is resuspended due to bottom currents during each tidal cycle.

Sand is generally found in the shoals throughout the estuary. In the upper estuary it forms a narrow zone along the shore, some 0.16 miles wide; in the middle and lower reaches the zone becomes more than a half-mile in width Sand predominates on the north side of the estuary near Newport News and headward along the north side of the channel. Some areas within the channel are predominantly sand, i e , off Mullberry Point, Jamestown, and about the mouth.

Mixed sediments occur between areas of sand and silty clay. Storms, excessive tides, and burrowing activities are effective mixing agents. Some gravel and gravelly sediment is found, chiefly where extensive dredging may have cut into older deposits. Areas containing gravel are around Hog Point, Jamestown, the shoals of Burwell Bay, and the floor of Rocklanding Shoal.

Economic Activity—General

The banks of the James River and its tributaries are largely undeveloped, but there are several concentrations of urbanization. Hampton Roads, Richmond, and Lynchburg are centers of metropolitan areas with over 100,000 people, but each is separated from its nearest neighbor by roughly 100 miles of river. Petersburg and Hopewell in the tidal drainage area are centers of smaller concentrations (50,000-100,000), and Smithfield, Suffolk, and Williamsburg are smaller but notable urban areas in Tidewater. Charlottesville, Covington, Clifton Forge, Buena Vista, Glascow, Lexington, and Farmville are smaller centers within the river basin. [5]

By comparison with others, the river is not a heavily industrialized body of water, but there are concentrations of industry that are significant in water quality and water use considerations. The paper industry, in particular, is represented on the upper river by: West Virginia Pulp and Paper (now WESVACO) in Covington, Mead Corporation, and Owens Illinois (Lynchburg area). Lynchburg is a center of industry, though not of the "heavy" variety; electrical machinery and nuclear reactor components are examples of high-value industries; foundries, shoes, clothing, and food processing are also prominent. Richmond is noted for cigarette manufacturing; there are also paper producers, manufacturers of tobacco and food processing machinery, and producers of snythetic fibers Hopewell, which is nearly contiguous to the Richmond industrial zone along the west bank of the James, is a locale of chemical and paperboard industry. Hampton Roads, although the most populous area of the river system is industrially noted only for shipbuilding, though port activity might be put in this category. Charlottesville, although best known as an educational pinnacle, is also a center of electronics manufacturing. Smithfield is a meat-packing center. Other minor industrial locations can be identified, such as Clifton Forge, Petersburg, Buena Vista, Glascow, James City County, and Suffolk.

A summary of industry size by number of employees gives a picture of the major in-

dustrial activity. Table 6.1 contains only those industries in the basin that reported [12] 500 or more employees in 1970.

For the purposes of this study, the most noteworthy industries are those that contribute significantly to stream pollution. These may be conveniently mapped into three pollutional zones (Fig. 6.3)

Table 6.2 is compiled from the James River Basin Study [5] and contains a list of the major dischargers with more than 100 lbs. of BOD per day in the James River or its tributaries It also contains the volume discharged in MGD (million gallons per day), the present degree of treatment at each location [2], plus an estimation of the construction costs [14] involved in upgrading every facility to a desirable secondary degree of treatment (85% reduction in BOD).

Installed electrical capacity in 1969 [5] was 2,667,450 kilowatts, with about 98% of this being in steam plants Roughly one-half (1,383,000 kilowatts) was concentrated in a single plant, VEPCO's Chesterfield Plant. Thirteen hydro-electric plants operate along the James and its tributaries, but have only about 1 1/2% of the installed capacity. Breakdown of electrical use is about 40% to industry, 20% to non-industrial commercial, 20% to residences, and the balance to miscellaneous uses such as institutions, street lighting, etc. Table 6.3 [5] summarizes the power plants.

Power demand is expected to increase rapidly. Table 6.4 [5] summarizes a set of predictions for the next 50 years.

Agriculture is varied and extensive, though not as intensive as in other areas,

Table 6.1

Employee numbers for major industries in the James River Basin

Name	Product	Location	Employees
Newport News Shipbuilding	ships	Newport News	19,000
several	cigarettes	Richmond	7,000
Allied Chemical, Fibers Division	fiber	Hopewell	2,600
Westvaco	paper	Covington	2,200
Lynchburg Foundry	metal products	Lynchburg	2,200
Firestone Synthetic Fibers	fiber	Hopewell	1,400
DuPont	fiber	Richmond	1,400
Hercules	chemicals	Hopewell	1,300
Gwaltney	meat	Smithfield	1,160
Smithfield Packing	meat	Smithfield	1,050
Stromberg-Carlson	telephone equipment	Charlottesville	1,000
Dow-Badische	fiber	James City County	900
Sperry Marine Systems	instruments	Charlottesville	900
Continental Can	paperboard	Hopewell	800
Acme Visible Records	metal furniture	Crozet	750
Allied Chemical Indust. Chemical Division	chemicals	Hopewell	600
Glamorgan Pipe & Foundry	metal products	Lynchburg	600
Mead	paper	Lynchburg	550

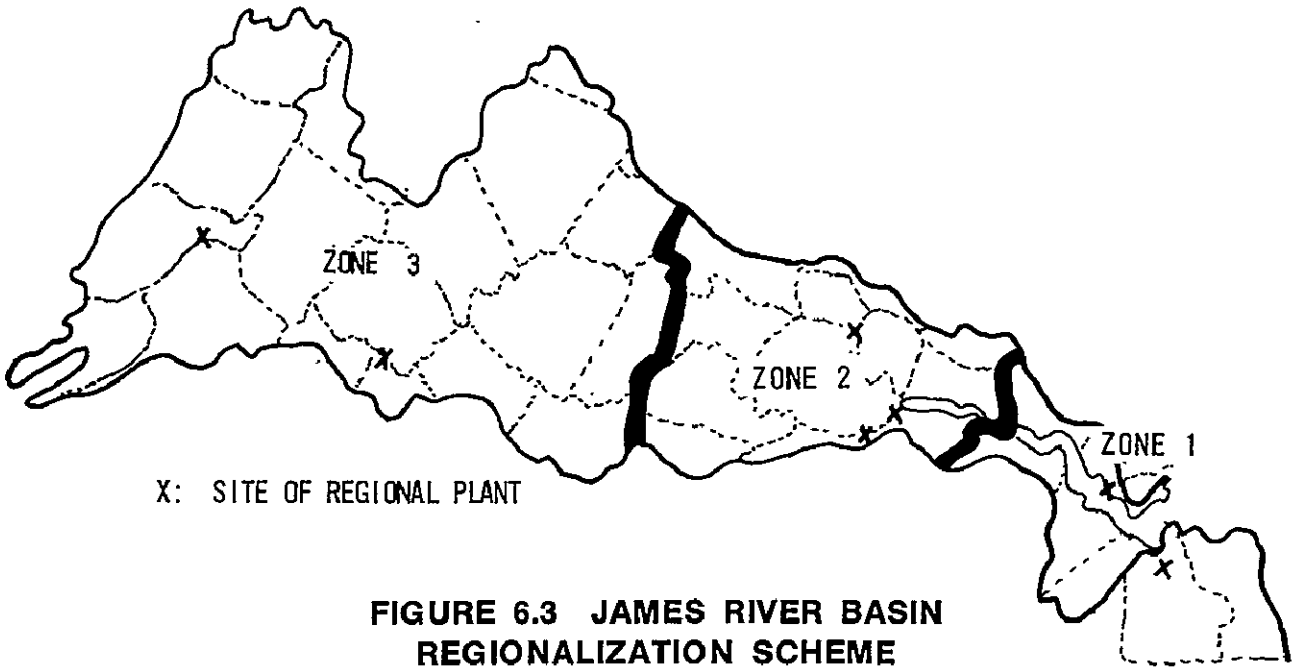


FIGURE 6.3 JAMES RIVER BASIN REGIONALIZATION SCHEME

such as the Midwestern "farm belt." The land area is principally in forest, even in the flat coastal plain Nonetheless, agriculture is a major activity, since much commercial and industrial activity depends on farm products; by the standard of "value added" [5], the trading and manufacturing activities together comprise the largest commercial activity in the James River Basin.

Table 6.5 [5] summarizes the agricultural activity by means of 1964 at-the-farm value [5].

The forestry industry, although not large, is important in the Basin. It is estimated [5] that about 2/3 of the basin area is forested. The principal use of the forest resource is as raw material for the paper-making industry. Table 6.6 [5] summarizes the value and extent of the forest resources.

Navigational-Commercial Activity

Commerce on the river consists principally of the conveyance of building aggregates, petroleum products, seafood, and general cargo.

Building aggregates (sand, gravel and crushed rock) are quarried along the river in the stretch between Hopewell and Richmond; and distributed upstream to Richmond, and downstream to Hopewell and Hampton Roads. Marl for use in cement manufacture is quarried along the Nansemond River, and shipped to Norfolk. All of this traffic moves in barges. In 1969, 2,613,845 short tons [5] of sand, gravel, and crushed rock moved on the James, out of a total of 5,107,135 tons for all commerce. On the Nansemond in 1969, 329,741 tons of marl moved, out of a total commerce of 337,083 tons.

Petroleum products are distributed to the Hopewell-Richmond area, principally by barge from Hampton Roads ocean terminals, or from the Yorktown refinery in the case of American Oil Company. The receiving points are concentrated in the Richmond area, with ten of the fourteen points reported in 1962 [16] being in the 18' channel (above Richmond Deepwater Terminal). Petroleum is also received at Hopewell, Suffolk, Fort Eustis, and at the Dow-Badische plant near Fort Eustis. Total traffic in petroleum products was 1,262,194 short tons in 1969 [15]. The largest single item in this total was residual fuel oil, 548,446 tons, and the principal customer for this was the VEPCO Chesterfield plant. Gasoline at 243,265 tons was the next largest item. Nansemond River (not included in above totals) handled 6,361 tons of petroleum products.

Petroleum traffic has declined since the completion of the Colonial Pipeline in the early 1960's. The Corps of Engineers [17] reports an increasing trend up to that time, there being 1,187,045 tons in 1948 and 2,219,220 tons in 1957. It is apparent that in 1969 traffic had fallen to about the 1948 level. The petroleum traffic moves principally in barges, though there is some delivery direct from coastwise ships. Before the completion

Table 6.2

Major Dischargers in the James River

Locations	lbs. BOD/day discharged in the James River	Volume MGD discharged in the river	Present degree of treatment	Estimated construction cost in millions of dollars)
West Va. Pulp and Paper	9,800	50.0	sec.	x
Covington	2,100	2.149	P*	0.74
Selma	140	.09	P	0.11
Clifton Forge	1,400	1.814	P	0.67
Iron Gate	170	0.10	P	.012
Lexington	1,130	0.850	P	0.43
Buena Vista	1,120	0.560	P	0.33
James Lee & Sons	7,600	1.900	sec.	x
Buchanan	290	0.200	P	0.18
Glasgow	140	0.119	P	0.13
Owens Ill. Co.	15,900	9.015	P†	1.73
Lynchburg (Training School)	5,350	11.5	P*	1.99
Madison Heights	240	0.49	P*	0.31
Mead Corp.	26,900	8.2	P*	1.63
Morton's Frozen Foods	250	0.3	sec.	x
Charlottesville	338	3.0	sec.	x
	382	3.0	sec.	x
American Tobacco	7,800	6.3	sec.	x
Allied Chem. Co.	960	50.0	no	10.60
Colonial Heights	1,350	1.076	P	0.49
Petersburg	8,620	6.199	P*	1.38
Bellwood Depot	240	0.3‡	P*	0.23
Brighton Bon Air	200	0.25‡	P*	0.21
Falling Creek	3,910	2.0	P*	0.71
Richmond	33,900	37.8	P*	3.42
James R. Lagoon	180	0.2	no	0.23
Sanitary District #2 (Henrico County)	150	0.2	P†	0.18
Albemarle Paper	290	.150	P	0.16
Dupont	4,400	33.4	sec.	x
Federal Paper Board (Seaboard Mill)	1,530	1.250	sec.	x
Federal Paper Board (Southern Mill)	2,210	1.5	P	0.78
Standard Paper Mill #1	250	3.5	P*	0.98
Standard Paper Mill #3	1,350			
Hopewell	2,970	—	P*	—
Continental Can	120	—	no	—
Fort Lee	1,200	with Petersburg	P	
Hercules Powder	140		sec.	x
Sanitary Waste (Bailey Creek)				
Allied Chem. Plastics	3,340	75.0	no*	14.1
Continental Can	39,840	15.0	no*	4.6

(Continued)

Table 6.2 (Continued)

Major Dischargers in the James River

Locations	lbs. BOD/day discharged in the James River	Volume MGD discharged in the river	Present degree of treatment	Estimated construction cost in millions of dollars)
Firestone Synthetic Fibers	1,280	.825	no*	0.65
Hercules Powder	39,400	25.0	no*	7.5
Army Base Plant (Hampton Roads)	9,450	52.5	P	
Boat Harbor	18,200	27.25	P	
James River Plant	175		sec.	3.1
Lamberts Point	28,400		P	
Patrick Henry (Airport)	210		sec.	
Western Branch	300		sec.	
Chesapeake	350		sec.	
Portsmouth	12,060	17.203	P	2.52
Suffolk	1,140		sec.	x
Carolanne Farms	228	—	sec.	x
Fort Eustis	4,200	—	P†	—
Williamsburg	375	2.464	sec.	x
Smithfield Packing	800	0.05	sec.	x
Washington Plant (Hampton Roads)	700	—	sec.	x

Estimated for industries using less than 100,000 gpd.

Glossary

*Projected a secondary treatment facility to be in operation in the recent future.
†Estimated by Mr. A. E. Passler, Executive Secretary, Commonwealth of Virginia State Water Control Board
‡Estimated by author.

of the pipeline, there was an increasing trend toward the deep-draft traffic, e.g., 4.1% of the tonnage moved this way in 1948, 16% in 1957. Although data are lacking, it appears from indirect evidence that deep-draft petroleum traffic has since declined For example, of the 137 unbound trips by self-propelled tankers reported in 1969 [15] only 29 were by vessels of 15' draft or greater; 702 trips by petroleum barges were reported.

The present navigational channel is maintained at 25 ft. depth, 300 ft. width, to Hopewell; 25 ft. depth and 200 ft. width to Richmond Deepwater Terminal; and 18 ft. depth, 200 ft. width to the canal lock in Richmond. Dredging of channels to these standards was completed in 1947, but soon became inadequate because of the increasing size of vessels that might use the channel (bend radii, as well as width and depth of channel, are problems). Even T-2 tankers, a now obsolete vessel of the 1940's, that have been delivering petroleum products must go upriver at partial draft. Navigation for large vessels is impractical during fog or darkness.

To alleviate these conditions of inadequacy, a 35 ft. depth, 300 ft. width was authorized in 1962, based on a finding of a 2.2/1 benefit-cost ratio. Perhaps the most impact came from the completion of the Colonial Pipeline to Richmond, radically cutting petroleum traffic on the river. Also significant was the rise in cost of spoil disposal, or maybe it was just the late realization that it couldn't be indiscriminately dumped on the nearest marsh. As a result of such factors, restudy of the project has been authorized, with completion expected in fiscal year 1972. Several individual sources, some close to the study but who cannot be publicly quoted, predict that the new benefit/cost ratio will not support the project. On the basis of this information we assume that channel deepening will not take place in the immediate future.

But irrespective of the present balance of costs and benefits, we should look at the general trends in maritime commerce and possible use of the river to predict and recommend for the future.

The obvious trend in ocean shipping has

Table 6.3

Power Plants of James River Basin

Name of Plant	Location	Owner	Installed Capacity KW	Type
Reusens	Lynchburg, Va.	Appalachian Power Co.	12,500	Hydro
Balcony Falls	Balcony Falls, Va.	Va. Elec. & Power Co.	640	Hydro
Cushaw	Snowden, Va.	Va. Elec. & Power Co.	7,500	Hydro
Park	Richmond, Va.	Va. Elec. & Power Co.	2,100	Hydro
Bremo Bluff	Bremo Bluff, Va.	Va. Elec. & Power Co.	263,500	Steam
Chesterfield	Chesterfield, Va.	Va. Elec. & Power Co.	1,383,000	Steam
Twelfth Street	Richmond, Va.	Va. Elec. & Power Co.	77,500	Steam
Portsmouth	Portsmouth, Va.	Va. Elec. & Power Co.	597,000	Steam
Reeves Ave.	Norfolk, Va.	Va. Elec. & Power Co.	84,300	Steam
Byrd Park	Richmond, Va.	Richmond Dept. Pub. Util.	1,125	Hydro
Hollywood	Richmond, Va.	Richmond Dept. Pub. Util.	2,025	Hydro
Falling Springs	Falling Springs, Va.	BARC Electric Coop.	420	Hydro
Meadow Creek	New Castle, Va.	Craig, Botetourt Coop.	300	Hydro
Holcolmbs Rock	Holcombs Rock, Va.	Owens-Illinois Glass Co.	1,875	Hydro
Big Island	Big Island, Va.	Ownes-Illinois Glass Co.	480	Hydro
Snowden	Bedford, Va.	Town of Bedford	1,000	Hydro
Schuyler	Schuyler, Va.	George Marble Co.	780	Hydro
West Va. Pulp & Paper	Covington, Va.	West Va. Pulp & Paper Co.	69,600	Steam
Norfolk Naval Shipyard	Portsmouth, Va.	Norfolk Naval Shipyard	27,000	Coal, Steam, Boiler
U.S. Navy	Norfolk, Va.	United States Navy	10,000	Steam
Virginia Chemicals Inc.	West Norfolk, Va.	Virginia Chemicals, Inc.	600	Steam
U.S. Air Force	Newport News, Va.	United States Air Force	1,500	Diesel
Allied Chem. Corp.	Hopewell, Va.	Allied Chemical Corp.	20,000	Steam
Continental Can Co.	Hopewell, Va.	Continental Can Co.	14,400	Steam
Kirk Lumber Co.	Chuckatuck, Va.	Kirk Lumber Co.	250	Steam
Hercules, Inc.	Hopewell, Va.	Hercules, Inc.	9,440	Steam
Washington Air Defense Sector	Fort Lee, Va.	United States Army	3,900	Diesel
James River Paper Co.	Richmond, Va.	James River Paper Co.	315	Steam
American Tobacco Co.	Richmond, Va.	American Tobacco Co.	2,300	Steam
David M. Lea Co., Inc.	Richmond, Va.	David M. Lea Co., Inc.	750	Steam
Dupont	Richmond, Va.	Dupont	27,000	Steam
Seaboard	Richmond, Va.	Federal Paper Board, Co.	2,500	Steam
Hull Street	Richmond, Va.	Federal Paper Board, Co.	750	Steam
Miller Manufacturing Co.	Richmond, Va.	Miller Mfg. Co.	800	Steam
U. S. Tobacco Co.	Richmond, Va.	United States Tobacco Co.	800	Steam

Source: Virginia Division of Water Resources

been toward larger ships, and except in the case of bulk shipping, to faster ships. The increase in size has made the James 25 ft. channel obsolete in the sense that many modern vessels just can't go up the river. But there have been countervailing trends. One has been the necessity of increasing the productivity of ships in order to earn a return on the larger investments that they represent. In short, this means that they must be kept moving at sea, with minimum time in port or inland waterways. An aspect of this is containerization, accounting for an increasing part of the general cargo trade; one of its

Table 6.4

James River Basin—Past and Estimated Electric Power Consumption—1968

Annual Kilowatthours Per Capita

Year	High Projection[1] Kilowatthours	Medium Projection[2] Kilowatthours	Low Projection[3] Kilowatthours
1958	—	2,470	—
1960	—	2,900	—
1965	—	4,160	—
1968	5,600	5,600	5,600
1970	6,220	6,220	6,220
1980	9,250	8,200	7,780
2000	15,100	12,200	9,700
2020	21,000	16,200	11,600

1. High projection is on basis of 300 kilowatthours annual increase per capita after 1968
2. Medium projection is on basis of 300 kilowatthours annual increase from 1968 to 1970, then 200 kilowatthours annual increase per capita.
3. Low projections are based on 300 kilowatthours per capita annual increase from 1968 to 1970, an annual increase of 200 kilowatthours between 1970 and 1975 and a post-1975 annual increase of 100 kilowatthours.

Source: Virginia Division of Water Resources and Virginia Electric and Power Company

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Table 6.5

Value of Farm Products Sold—1964—James River Basin

ALL FARM PRODUCTS SOLD	$133,949,516
AVERAGE PER FARM	$ 6,508
ALL CROPS SOLD	$ 58,362,172
FIELD CROPS (OTHER THAN VEGETABLES, FRUITS AND NUTS	$ 42,333,115
VEGETABLES	$ 2,147,394
FRUITS AND NUTS	$ 3,876,929
FOREST PRODUCTS AND HORTICULTURAL SPECIALTY PRODUCTS	$ 10,004,914
ALL LIVESTOCK AND LIVESTOCK PRODUCTS SOLD	$ 75,216,931
POULTRY AND POULTRY PRODUCTS	$ 20,205,813
DAIRY PRODUCTS	$ 24,830,873
LIVESTOCK AND LIVESTOCK PRODUCTS (OTHER THAN POULTRY AND DAIRY)	$ 30,180,215

Source: United States Census of Agriculture, 1964; Preliminary Report, Bureau of the Census

Table 6.6

Forest Resource Estimates—James River Basin

Net Annual Growth of Growing Stock and Sawtimber—1965

	Growing Stock*			Sawtimber**		
	All Species	Softwood	Hardwood	All Species	Softwood	Hardwood
	Million Cubic Feet			Million Board Feet		
Totals:	212.4	70.1	142.3	583.4	197.3	386.1

* All trees 5" DBH and over
**Softwoods 9" DBH and over, and hardwoods 11" DBH and over

Forest Resource Estimates—James River Basin Area

Land Area and Forest—1966

	All Land (M Acres)	Forest (M Acres)	(Percent)	National Forest	Other Public	Forest Industry	Farmer	Misc. Private
					(Thousand Acres)			
Totals:	9,065.3	6,071.0	67.8	702.0	190.7	769.7	2,482.4	1,926.2

Source: Virginia's Timber, 1966; USDA Forest Service, Southeastern Forest Experiment Station, Asheville, North Carolina, 1967

benefits is that it drastically shortens the port time of the ship. Although no general proof, nor one specific to the James River, can be offered here, it seems that part of the general cargo trade moving in large container ships should be loaded and unloaded as near the sea as practicable.

Much the same can be said for bulk trades. The productivity of the ship is essential, so that inland terminals for ocean-going ships are less attractive than in the past. It should be remarked here, however, that the James is a path for distribution of finished petroleum products, and not for the massive trunk movements that typically employ the largest ships (100,000 tons).

Another trend has been toward increased use of barges, especially for coastwise traffic. A flotilla of barges can easily have a length/depth or beam/depth ratio that is completely impracticable for a ship (or single barge) of equal capacity. The result is a lesser need for deep draft, and here is a further weakening of the need for a channel deeper and wider than the present one.

The foreseeable traffic that needs to move on the river ("needs" because of lower shipping costs than by competing methods) is general cargo that is not likely to be containerized, yet moves in ship-sized lots, bulk cargoes for riverside industries, and petroleum products distribution. An example of the first is the import of newsprint to Richmond Deepwater Terminal from Finland and Canada. Examples of the second are deliveries of sulfur to Allied Chemical and Dupont, and the third deliveries of fuel to VEPCO and Dow-Badische. All of this is amenable to movement by barge, except perhaps shift to LASH or SEABEE lighters, or to containers transferred at Hampton Roads to small feeder vessels Thus, it appears that current trends in marine transportation are working against the need for channel deepening, and thus the idea should be laid to rest unless new and more convincing factors enter the picture.

The most likely new factor is the establishment of new industry requiring direct water transportation. Examples are petroleum refineries and steel mills, both of which are now represented in Chesapeake Bay waters, and which depend on imported raw materials in deep-draft ships. Although many potential industrial sites exist close to 25 ft. water, it is likely that competitive factors will require that

any such industry be served by vessels of much deeper draft (authorized channel depth to Baltimore, site of Behtlehem Steel plant, is 42 ft.; to Yorktown, site of an oil refinery, it is 37 ft.). Although many potential industrial sites are available along the river, there are none save those on 25 ft. depth. If such industry does seek to locate on the James, it will therefore almost certainly create a renewed demand for dredging. The case will have to be evaluated on its merits at the time, of course. However, dredging for whatever cause cannot fail to be expensive and harmful to the river or its bordering wetlands.

The James also is used extensively in commercial seafood transport and production. Shellfish of the area consist of oysters, clams, crabs, and turtles. Among these, seed oysters from beds in the lower river are most important in terms of bulk, value, and their uniqueness. In 1969, there was movement of 24,679 tons of shellfish, and 3,500 tons of marine shells [15]. The traffic is principally local shuttling of the catching boats, and movement of seed oysters to other grounds outside the river. Of the 28,482 upbound trips reported in 1969 [15] 25,476, are "passenger and dry cargo," either self-propelled or barge, of 12' or less draft. Most of these trips are doubtless by the small vessels of the seafood (mainly oyster) fleet. A lesser amount of oyster is marketed directly ("soup oysters"). Crab and clams are harvested from the lower James also, and turtles from the Chickahominy.

Oyster beds are found throughout the lower river (including Hampton Roads) up to the Jamestown Island area, with a concentration of seed beds in the vicinity of the James River Bridge. About 20 square miles had been closed because of pollution by 1967, and this is estimated to reduce annual production of shellfish by about $360,000 [18]. Clams are taken from the same area, although the principal grounds are limited to the deep water in the vicinity of Newport News Point.

A 1968 report [18] gives the value of shellfish, except for turtles. (Table 6.7) (All values in 1000's)

Finfish production is significant, though not a major industry. A 1968 report [18] gives the total value of the landings at $368,000. In 1969, 348 tons of fresh fish were moved on the river. Fishing is mainly by fixed net-pound nets and gill nets. Catch is mainly shad in the spring, striped bass in the fall, with some spot and croaker in the summer. River herring are said to be present in commercial quantity but are not exploited [19]. There is a minor fishery for eels and catfish in the Hopewell-Chickahominy area [19]. In general, finfishery seems to be in decline. A census by VIMS [19] shows the number of nets visible in the river to have declined steadily since 1964.

The seafood industry is a prime victim of water pollution, principally because of the resulting closure to direct marketing or shellfish beds. On the other hand, pollution does not appear to be its only significant problem; the decline of the finfishery, for example, cannot be directly attributed to pollution. The key problem is probably the present socio-economic position of the industry.

The increased affluence of the native society has given it the ability to purchase more expensive meats, such as beef. Prices of seafood have consequently not risen enough (or not risen at all) to compensate for the rising cost of inputs—labor, fuel, expendable gear—required by the industry. Further, its

Table 6.7

Quantities and Values of Shellfish for 1968

Item	Quantity	Value
seed oysters, public grounds	1,722 bu.	$1,391
market oysters, public grounds	522 lb.	376
market oysters, private grounds	1,237 lb.	976
clams	50 lb.	24
crabs	1,835 lb.	98
Total		$2,848

(The clam and oyster weight values are for the meat only.)

fragmented family-style organization makes accumulation of capital and technical competence needed for innovation rather difficult. It may well be that the entire Chesapeake seafood industry is approaching collapse.

Saving of the industry by government-supported programs might be accomplished, though perhaps only outright subsidy would be successful. Save for programs relating to water quality, however, such efforts are beyond the scope of this report.

Whether being exploited or not, the seafood resources of Bay and River must be perpetuated. Though the populace may continue to desire other meats, its growing numbers may force it to turn back to marine food sources. In short, the existence of the resource is vital, whereas the presently-constituted industry is not.

General cargo is the "everything else" not previously discussed. About four million tons out of the 5,017,135 tons reported [15] in 1969 have been accounted for, leaving a balance of about 1 1 x 10^6 tons for all others Most of this is accounted for by fertilizer trade (Allied Chemical) at one location in Hopewell, sulfur shipments to Dupont above Hopewell, and the trade in paper products and scrap steel at Richmond Deepwater Terminal. At Hopewell, 259,861 tons of bulk material related to the fertilizer trade were received, and 305,869 tons shipped. Richmond reported trade in 49 commodities, including those already discussed. Among those in the general category, imports of 57,593 tons of sulphur and 31,767 tons of newsprint, and exports of 41,992 tons of steel scrap are most noticeable on a weight basis. Modest exports of tobacco, paper, plastics, synthetic fibers, are also reported, along with some steel product imports. A livestock loading facility was opened at Richmond Deepwater Terminal in April, 1970.

Recreational Activity

The James River is an important recreational facility for Virginia. In the tidal portion of the river, recreational use consists of swimming, fishing, and boating of several kinds. Swimming in the river itself is negligible because of the absence of beaches, the pervasiveness of jellyfish in the lower river, and the presence of pollution. Therefore, this activity is not discussed here.

Boating is mainly sailing, waterskiing, cruising, and fishing. The last is somewhat a separate activity, and is discussed separately. There are many pleasure boats registered by the Virginia Department of Conservation and Development in counties and cities adjacent to the tidal James and tributaries. Included are power boats, including auxiliary sailboats, of 10 HP and above. Most of these are mobile boats, i.e., are kept on trailers, so it is not possible to predict where they are used. In fact, a great many are probably not used on the James. Richmonders, for example, swarm to the Piankatank-Rappahannock-Potomac area for their boating.

Pleasure boats actually moored in the James and tributaries have been surveyed by Woodward [20] who reports the following approximate figures:

Table 6.8

Pleasure Boats in the James and Tributaries—1971

Nansemond River	25
Newport News Creek	50
Deep Creek	150
Jamestown	50
Pagan River and Jones Creek	20
Appomattox River (Hopewell, Colonial Heights, Petersburg)	75
Richmond (James above Hopewell)	120
	490

Newport News Creek is oriented toward Hampton Roads. As a rough estimate, take one-half of the boats there as being users of the James, so approximately 450 pleasure boats are in-the-water residents of the river. Only a few of these are sailboats (there are perhaps 25, of which about 20 are at Deep Creek).

The James is not known as a sailing area. Its general shallowness is a detriment to all but the very small centerboard boats. The main center of such activity is in the area from the James River Bridge at Newport News to Deep Creek. It is, however, fine for water-skiing and general outboard motoring. Again, this activity centers along the Newport News shore. Cruising, especially visits by outside yachts is negligible. Lack of attractive facilities (marinas,) shallow water, polluted upper reaches, absence of "quaint" harbors, and marshy shores are negative factors.

Sewage from vessels presents significant problems due only to naval vessels in Hampton Roads. Standards for maritime sewage promulgated under the 1970 Water Quality Improvement Act are sufficient to remedy this problem, as well as prevent the development of future problems from growth of commercial or recreational activity. Since the Navy is now proceeding under impetus of executive order to obey the standards, and others must by law, no new action need be recommended. However, we expect the provisions of the 1970 Act to be well enforced—let it not become another 1899 Refuse Act.

Oil spills appear to be the only other potentially serious impact of water-craft activity on water quality. Since they are due solely to malfunctions of equipment or of the human operators thereof, they cannot be totally eliminated by rule, law, fiat, or appeals to conscience, intellect, or patriotism. They can be reduced, however, by design of the petroleum-handling equipment to emphasize spill-free operation. For example, the provision of a drip pan under hose connections would be of obvious benefit.

Table 6.9 [5] summarizes the ideas of the states' Bureau of Outdoor Recreation of water sport activity in the region of the tidal river, 1968:

Table 6.9

Water Sport Activity in the Tidal James, 1968

Activity	Activity—Days Annual	Summer-Sunday
Sailing	225,000	3,900
Boating	2,800,000	29,800
Swimming	9,500,000	211,000
Skiing	430,000	6,200
Canoeing	315,000	4,800

It is difficult to picture 211,000 people swimming in the James, at least 210,000 were probably swimming in other bodies of water (swimming pools?) within the area. The other figures are likewise probably high because of nonriver waters being included.

Sport fishing is an important recreation locally (i.e., doesn't attract many outsiders) from piers and small boats. However, it is difficult to assess the magnitude of the sport, mainly because licenses are not required for salt-water fishing.

Profile of the Upper James

Characteristics of the James River above the fall line are quite different from those below. Sailing is essentially non-existent because of the narrowness and shallowness of the river. Motorboats likewise find conditions unfavorable, except perhaps on the impoundments behind dams at Lynchburg and above. Gathright Dam on the Jackson will supposedly be useful for the boat-oriented sports. Canoeing is the most suitable type of boating activity on the upper river and is generally feasible throughout, including many tributary streams.

Fishing is a prominent recreational activity, as attested by sales of approximately 100,000 fresh water fishing licenses annually (1967 figures) in the James basin area, Richmond and above [5].

Table 6.10

Water Sport Activity in the Upper James, 1968

1. Richmond-Lynchburg

Activity	Activity—Days Annual	Summer-Sunday
Sailing	185,000	3,200
Boating	2,300,000	24,400
Swimming	7,750,000	172,000
Skiing	355,000	5,200
Canoeing	260,000	4,000

2. Lynchburg and above

Activity	Activity—Days Annual	Summer-Sunday
Sailing	80,000	1,400
Boating	1,000,000	10,600
Swimming	3,355,000	74,000
Skiing	150,000	2,200
Canoeing	115,000	1,800

Shoreline Use—Development And Preservation

Land bordering the James River has a unique value because of its interfacial location. It is obviously the only land that can be used for harbor facilities and for industries that are intimately associated with water, such as shipbuilding and power generation. Other industries find waterfront location desirable because of the benefits of direct water transportation. Among thses are seafood processors and any industry that uses or produces bulk materials. Parks are enhanced in appeal by waterfront location. Scenic values, status, and private access to the water give waterfront land a premium value as a residential site.

Direct conflict among these uses has been minor, because until recently, at least, enough shoreline along the James has been available for all demands. The following table [21] gives the distribution of uses, circa 1968, of the tidal James shore (including Hampton Roads and its tributaries):

Harbors	12 9
Recreation (federal land)	17.8
Recreation (local government)	1.1
Residential	115.5
Industrial	12.0
Conservation (state government)	5.6
Military	24.9
No present use	768.9

Miles of Shoreline, Tidal James and Tributaries

It appears from this table that about 75% of the tidal shore is not in identifiable use (though farmland is included in this category). More specifically, surveys published about 1960 [32], [33], [34], show 29 vacant (i.e., not in industrial use) industrial sites directly on the 25-ft. portion of the river in Henrico, Chesterfield, Prince George, and Surry Counties. Sizes range from 2 to 3300 acres, with all but one being larger than 100 acres. Some have since been occupied, the VEPCO plant at Hog Island, and the Hopewell airport being notable examples, but many of these sites are still available for industrial purposes. Many of them are indeed poor sites for heavy industry; most are several miles from a railroad or major highway, and some are not on the navigational part of the river, but on the shallow cut-off bends above Hopewell. Additional sites could doubtless be located along the undeveloped stretch of the river, but they would likewise be remote from rail and highway transportation.

The situation above the Falls is somewhat different, since the water is not a transportation medium. Except for the scattered urban centers, the land is largely undeveloped, and little prospect is evident for conflict among uses.

Along the tidal river, it appears that ample industrial land is available, but this is distinctly not true for industries that involve modern, deep-draft shipping, and shortage of this category may cause conflicts. For example, the location of any such industry above Hampton Roads will doubtless renew the pressure to dredge the James channel. Future shortage of shore may bring direct conflict between users, and indeed, an example of this is already in prospect at Newport News. Here Newport News Shipbuilding is planning an expansion of about 1.5 miles northward along frontage that has traditionally been residential. [35]

The Craney Island spoil disposal area in Hampton Roads is an example of a potential deep-water (within 1/2-mile of a 45-ft. channel) industrial site that might seem to avoid potential conflict with other shore uses, since it is "made" land. However, further attempts to provide such sites may bring conflicts that more directly affect the river itself since they may destroy shellfish beds and fish-breeding areas and require filling of wetland. The last process has been freely pursued in the past, but now is subject to controversy

Residential development has placed the most severe pressure of all on the available shoreline, especially in Newport News The remaining fragments of vacant land along the river in this area are alleged to be priced on the order of $400 per front foot, with the price on a square-foot basis to be twice that of adjacent property **not** on the waterfront This increment in price appears to be based more on flatulence than on tangible value, for the land has little extra utility beyond affording a view of the water Great status is seemingly implied and conferred by living on the bank of the James, perhaps through some imagined identification with the semi-mythical colonial planters (who **needed** to live on the water).

With the present condition of affluence, this demand for residential sites on the river is apparently to be the land-use factor that contains the most severe threat to the river and other neighboring waters. The Newport News shore, with development having reached the Ft. Eustis area, is essentially saturated. The south bank of the river is only scantily developed, however, and is being eyed with appreciation of future profits by developers and speculators. They anticipate a bloom of activity following the proposed 1973 removal of tolls on the bridge to this area. Unfortunately, much of the land near the south landing of the bridge (Chuckatuck Creek to Pagan River) is wetland and thus unsuited, as is, for construction. According to C & GS chart 529, there are about 8 miles of James-front shore in this vicinity, and about 4 miles more on the wider waters of Batten Bay. All but 2 miles of this shore is shown as wetland, and is wetland (marsh, tidal creek, wetland woods) for 1-2 miles inland in some places. Bulkheading, dredging, filling and draining can rapidly and irreversibly transform it into a residential area, however. It thereby comes directly into conflict with the intrinsic value of these wetlands in their natural state.

The value of wetlands has been explored by the Virginia Institute of Marine Sciences [31], and the case well-made for at least imposing rational controls on further wetland development. Their report lists recommendations for changes in policies and laws and for reserach into wetland value. We endorse these recommendations by repeating them here, as follows:

VIMS Recommendations on Wetlands Management Recommendations

1. A definition of wetlands should be adopted by the State for use by those governmental units, particularly counties, which wish to zone their wetlands as conservation lands.
2. Since zoning powers derive from the State, it should prepare a series of guidelines for zoning of wetlands, shorelines and shallows. Where local or regional zoning authorities fail to act in an adequate manner, the State should be prepared to assume zoning responsibilities directly.
3. Steps should be taken at once to halt, by any means possible, uncontrolled or unncesssary alteration of wetlands. This policy should be followed until such time as a mechanism is established to protect public values from damage by these alterations.
4. The Marine Resources Commission, as the present legal lead agency for management of coastal resources, should be given the statutory authority to approve, modify, or disapprove plans for all proposed modifications or alterations to

coastal wetlands, whether governmental or privately owned. Such modifications and alterations should include dredging, ditching, diking, filling, bulkheading, constructing of piers and wharfs, and any other activities which affect the ecology of coastal wetlands or the estuarine flora and fauna associated with coastal wetlands.

The Virginia Institute of Marine Science should be required to advise the Marine Resources Commission of probable consequences of modifications and what, if any, changes can be made to proposed modifications or alterations to mitigate or eliminate environmental and ecological damages.

Those portions of the Code of Virginia which specifically prevent the Marine Resources Commission from effectively regulating activities such as dredging and disposal of sand and gravel or channel dredging by riparian owners, and marina and boatyard construction should be changed so as to permit effective protection of these public values

A review board, composed of the heads of the Commission of Game and Inland Fisheries, State Water Control Board, Virginia Department of Health, Department of Conservation and Economic Development, Department of Agriculture, Department of Highways, Commission of Outdoor Recreation, Virginia State Ports Authority, Division of State Planning and Community Affairs, and the Virginia Institute of Marine Science, should be constituted as an avenue of appeal from decisions of the Marine Resources Commission pertaining to other public agencies or subdivisions where coastal wetland issues are involved. Appeals from decisions involving private individuals and businesses should be made through the civil courts, rather than through the review board. We are of the opinion that Federally-sponsored projects (excluding those for defense) should be subject to joint State-Federal review.

5. The ownership and boundaries of wetlands in many areas are unclear or of doubtful validity. It is suspected that a considerable area of wetlands may be in State ownership without State cognizance of such ownership. Immediate action should be undertaken to locate precisely those coastal wetlands owned by the State. Action by the General Assembly should be taken to place the burden of proof of ownership of disputed lands on private claimants rather than on the State.
6. Tax-delinquent coastal wetlands should revert to the Commonwealth upon the satisfaction of tax liens by the Commonwealth to the municipalities. These lands should not be offered by tax sale until each of the State agencies listed above shall approve of the sale. In addition, an immediate moratorium should be placed upon disposition of all wetlands currently in the hands of the State government or the courts.
7. New land created by nature which does not accrete to riparian land, such as the sizeable island at Dawson Shoals in Accomack County, should be retained in the possession of the State. Especially to be prohibited are accretions which have resulted from unauthorized obstructions of normal channels.
8. Acquisition of wetlands by the State should proceed as rapidly as possible. This effort should concentrate at the present on those wetlands which are of particular ecological value.

   Provisions should be made in the statutes to prevent speculation on those wetlands designated as high priority for purchase. To adequately protect the rights of owners, the anti-speculation provisions should have a definite time limit when applied to specific tracts

   Since many coastal wetlands are bordered by sub-aqueous lands leasable for various purposes by the Commonwealth, the Marine Resources Commission should be requested to be extremely cautious in leasing bottoms near areas designated as high priority for acquisition by State or other governmental agencies. The Commission should also be requested to notify those State agencies which may be concerned with wetland acquisition, preservation, or development, whenever applications for leasing in high priority areas are pending.
9. Certain shallow areas immediately adjacent to coastal wetlands are as highly productive as the adjacent wetlands. These areas should not be leased by the Commonwealth for any purpose that would reduce their productivity. The Virginia Institute of Marine Science should be directed to inform the Marine

Resources Commission of the location of such productive shallow, sub-aqueous areas.

10. A fund for purchase of coastal wetlands should be instituted. This fund could be financed by:
    1) General Fund appropriations
    2) Bonds
    3) Increased commercial user fees
    4) Recreational user fees (salt water angling licenses, boat registration fees, etc.)
    5) Unrefunded taxes on fuel used in motor boats
    6) Gifts
    7) Specific appropriations
    8) Joint State and Federal programs for land acquisition and management

    Monies should be appropriated at once from the General Fund and should continue until other sources are available. Continuing Special Fund or General Fund appropriations may be necessary to provide matching monies. This fund could also be used to compensate those individuals for lands deemed by the courts to be taken as a result of regulations imposed on prospective alterations by the Marine Resources Commission. Title to lands acquired under this program should initially be vested in an appropriate State agency.

11. Sound management of Virginia's wetland resources requires a continuing knowledge of their status through surveillance of these resources, particularly in those areas where rapid changes are occurring. Once original survey data are acquired, the information should be handled by an automatic data processing system. Information should be in such format as to allow rapid sorting and retrieval for comparative purposes, i.e., comparison of current survey data with the original base line data. In accordance with the intent of the Resolution authorizing this investigation of wetlands, it is important that the Virginia Institute of Marine Science develop and maintain an inventory of all coastal wetlands (now being done under provisions of H.R. No. 69) in as much detail as possible. Funds for this work must be augmented and continued. The inventory should be kept current and should include such items as the specific conditions of wetland areas, their contribution to estuarine productivity, their vulnerability to alteration and their current economic status.

Research Recommendations

1. It is clear that estuaries and littoral waters are closely dependent upon adjacent wetlands and that a proper balance must be preserved as the coastal zone is developed by man in order to maintain vital features of both. Not clear are certain details of dependence and of the vital values and features. Interactions between estuarine and coastal waters and wetlands must be more carefully delineated and established.

   The role of wetlands in the productivity of the estuary must be more clearly documented, especially with regard to species of economic and social importance. Documentation will indicate the most fruitful avenues of approach in wetland management, and will permit more accurate evaluation of the importance of different types and tracts.
2. Several species of small crustaceans occupy a critical position in the food webs of wetland-dependent fishes. The ecology of these crustaceans is poorly understood although it appears that they subsist largely on plant material of wetland origin. An understanding of this aspect of wetland ecology could indicate means of maintaining or increasing desirable species. Also important is an understanding of the susceptibility of these crustaceans to pesticides.
3. Problems associated with artificial organic enrichment are becoming increasingly severe and it appears that in the near future large sums of money must be spent on sewage treatment facilities designed to remove nutrient materials. Information regarding the ability of wetlands to assimilate nutrients and means of augmenting such assimilation may, by reducing the treatment facilities needed, reduce the amount of funds required for facilities. This information may also indicate means of increasing the productivity of the estuary through intelligent disposal of organic wastes.
4. Research is needed to ascertain methods of stabilizing shorelines and barrier island dunes through the use of vegetation. There is evidence that this may be much less costly and much more effective than physical structures currently employed.

Power generating station on James at Chesterfield.

Results of gravel stripping operation below Richmond.

The Cowpasture River at Rt. 39, Va.

A paper company in Covington, Va. on the Jackson River.

5. Deliberate burning of wetlands is commonly practiced in Virginia. Employed judiciously, it may reduce fire hazards. Although fire is a useful tool in fire prevention or wetland management in some areas, its ecological effect in Virginia is largely unknown. This should be investigated to determine if regulation is needed.
6. Several introduced species have appeared in Virginia within the last century (Carp) or within the last two decades (Marsh Clam, Nutria, Cattle Egret, Glossy Ibis). These animals, while all of commercial value or aesthetic interest, could be interacting unfavorably with species that have long existed in the State. The ecology of these species should be better known.
7. A Japanese sedge has become locally established in Virginia. It should be carefully studied to evaluate its effect on native species. This sedge may prove superior to some native species for dune stabilization. A hybrid cordgrass is rampant and regarded as a pest in England; however, this species may prove useful in areas that do not support native cordgrass. In light of the experience with other introduced plant species, introductions cannot be advocated without exhaustive research, no matter how promising the initial evidence may appear. In addition, native species, such as Live Oak and Sea Oats, not now found on seaside of the Eastern Shore should be investigated.
8. Large areas devoid of vegetation often occur in marshes. The cause of these is unknown, but it has been observed that erosion proceeds rapidly in their vicinity. It is not clear whether these areas are a recent development. This phenomenon should be investigated. If only one group of plants is involved, the underlying cause may be a specific disease.
9. Old corduroy roads are being uncovered in some marshes. In addition to being of scientific interest as indicators of rates of sediment deposition, they are of historic value. Steps should be taken to obtain the information that these artifacts offer before they are destroyed.
10. Mosquitoes and Green-head Flies are abundant in some places, especially where salinity is high. The use of biocides

as control measures has had severe effects on non-target species, such as birds, fishes and crabs. A better understanding of the life cycle and ecology of noxious species could indicate control measures which do not involve such hazards.

11. Swamps are the least understood component of the coastal wetlands. Their role as sediment traps, sanctuaries for rare and unusual species, and primary producers should be investigated so that appropriate management procedures may be formulated for them.

We should add that, viewed rationally, the case for preservation of the wetlands is overwhelming. The principal threat to them in the James, and throughout the Chesapeake Bay area is from residential development, yet there is no real need for living in wetland areas or along the shore. The Chesapeake and its tributaries are a resource of immense value as a source of human food. It will be a grave mistake if the affluent society of today, preferring to eat high on the hog and steer, rather than low on the fish and oyster, should turn it into a liquid desert. Further, such action will be folly, perhaps a crime against the future, if it is done knowingly just for the sake of indulging in the inflated pleasures of living on the edge of the water.

Demographic and Socio-Cultural Aspects of Water Quality in the James River Basin

An earlier statement in this document, delineating sociological apects of the water problem at the national level, demonstrates that the problem has critical and very broad social dimensions. Unfortunately, most of the useful data that are implied by our understanding and statement of the problem at the national level are not available for the James or in fact for any river basin. For example, water resource management, not pollution per se, is the focus of most existing research. [26] Therefore, after a brief summary of what is known about water problems in the James River region, we will discuss the information needs.

Our basic premise with respect to the major socio-cultural forces bearing on proposed changes in water use and Quality Standards is essentially the same for the James River region as they are for the nation. The problem is compounded by basic cultural outlooks toward man and nature no longer suitable to current environmental realities. Secondly, it is a problem of powerful interests communicating principal features of an opposing ideology. The intent here is to show how available sociological evidence pertaining to the James River water problem reinforces our basic theme. The following demographic and employment projection helps describe the region and demonstrate the pending pressure on water resources.

Demographic Picture:

Topographically and geologically, the basin has been divided into three regions as shown on Table A and the Map. It is not unusual that these three regions—the mountain, piedmont and coastal areas—correspond roughly to major zones of economic activity. The mountain regions have considerable agricultural activity (livestock), forestry and related wood product industries, and some heavy industry around Lynchburg. The Piedmont region has a great deal of agricultural activity (mostly crops), but increasing concentrations of medium to heavy industry (chemicals, equipment manufacturing, tobacco and steel) especially in the Richmond-Petersburg-Hopewell area. The coastal region has a heavy concentration of truck farms (tomatoes, beans, peanuts) but is predominated by one of the largest urban centers in the State—Hampton Roads. Heavy industry and military installations provide much of the employment in this area. [5] The transition in significant types of economic activity is usually a good indication of major differences in other institutional spheres, e.g., political, religious and familial. Meaningful data on these differences are not available, but based on scant evidence, we confront problems both in mobilizing public desire to solve water problems, as well as problems in maintaining the necessary public interest to maintain management programs over time. However, we will have to discuss these implications at a later point since we must recommend several kinds of investigation in order to solve these problems properly. Nevertheless, the demographic information available does contain some noteworthy implications useful for understanding the problem.

Two professional demographic projections are utilized in order to maximize the validity of the interpretation. The estimates are taken from the Virginia Dept. of Conservation and Economic Development, and the

Table 6:11

Population Projections for the James River Basin
(Thousands of People)

County	Cities Included	1960 VA.	1968 VA.	1980 VA. Low	1980 VA. High	1980 NPA	2000 VA. Low	2000 VA. High	2000 NPA	2020 VA. Low	2020 VA. High	2020 NPA
Alleghany	Clifton Forge Covington	28.5	29.6	29.4	34.1	29.2	30.7	44.0	30.0	31.5	54.7	37.6
Amherst		23.0	26.5	29.3	36.6	44.6	34.6	58.3	95.5	40.8	89.2	170.5
Bath		5.3	5.2	5.3	5.9	4.8	5.5	7.0	3.8	5.7	8.0	4.1
Bedford		31.0	33.9	33.8	40.7	36.1	35.9	55.3	42.0	38.4	72.9	56.6
Botetourt		16.7	18.0	18.4	22.2	19.9	19.5	30.2	23.8	23.1	39.4	32.2
Campbell		33.0	41.5	52.7	63.5	67.0	73.6	113.6	151.7	92.0	195.5	268.1
Craig		3.4	3.4	3.5	4.0	3.4	3.6	4.9	3.4	3.7	5.8	4.2
Highland		3.2	2.9	2.5	3.1	2.5	2.7	3.9	1.7	2.9	5.0	1.8
Nelson		12.6	12.3	12.5	14.0	13.2	12.9	16.6	13.2	13.3	18.8	13.2
Rockbridge	Buena Vista, Lexington	30.3	32.0	33.6	39.3	30.3	36.1	52.8	30.3	38.8	65.7	30.3
Lynchburg	Lynchburg	54.8	54.9	55.9	70.5	69.0	57.6	86.7	69.0	59.3	102.6	69.0
"REGION I"		**241.8**	**260.2**	**276.9**	**333.9**	**320.0**	**312.7**	**473.3**	**464.4**	**349.5**	**657.6**	**687.6**
Albemarle	Charlottesville	60.4	77.3	96.4	118.3	85.0	117.4	193.7	100.0	143.5	313.9	100.0
Amelia		7.8	8.3	8.5	9.9	7.9	8.7	12.7	14.2	9.0	15.9	35.0
Appomattox		9.1	10.1	11.1	13.6	12.5	11.8	12.2	15.5	12.3	23.7	20.3
Buckingham		10.9	10.9	11.1	12.6	10.7	11.4	15.2	9.5	11.7	18.0	10.6
Chesterfield	Colonial Heights	80.8	125.7	154.4	207.8	238.0	258.8	411.1	382.7	392.1	857.0	418.0
Cumberland		6.4	6.7	6.9	8.1	6.1	7.1	10.4	5.4	7.3	13.0	5.9
Fluvanna		7.2	7.6	7.8	9.3	7.7	8.0	12.0	7.7	8.2	15.0	8.0
Goochland		9.2	10.5	18.0	22.1	12.1	23.2	42.0	19.8	28.5	61.6	50.0
Henrico	Richmond	117.3 220.0	160.6 216.5	179.5 220.3	220.1 252.8	416.4	222.8 227.0	343.7 305.3	506.4	263.0 233.8	526.2 361.5	606.9
Powhattan		6.7	8.1	10.0	16.0	10.3	14.4	26.0	28.0	20.8	41.4	75.0
Prince Edward		14.1	14.4	14.5	16.4	14.9	14.9	22.2	14.3	15.4	29.7	16.4
"REGION II"		**549.9**	**656.7**	**738.5**	**907.0**	**821.6**	**925.5**	**1412.5**	**1103.5**	**1145.6**	**2276.9**	**1346.1**

(Continued)

Table 6.11 (Continued)

Population Projections for the James River Basin
(Thousands of People)

County	Cities Included	1960 VA.	1968 VA.	1980 VA. Low	1980 VA. High	1980 NPA	2000 VA. Low	2000 VA. High	2000 NPA	2020 VA. Low	2020 VA. High	2020 NPA
Charles City		5.5	6.5	6.9	8.3	7.8	8.1	12.4	19.9	9.0	17.4	60.0
Isle of Wight		17.2	19.0	20.8	25.0	20.0	24.3	37.5	20.0	27.1	52.4	20.0
James City		10.4	16.0	18.2	24.2	22.2	28.5	44.0	22.2	42.6	82.5	22.2
Nansemond	Suffolk	44.0	47.9	53.5	64.1	55.0	62.8	94.5	55.0	71.1	131.4	55.0
New Kent		4.5	5.1	5.6	6.9	4.8	6.6	10.2	7.3	7.3	14.7	16.1
Prince George	Hopewell	38.2	52.0	70.9	75.5	64.5	107.6	166.0	144.0	153.0	301.1	320.0
Surry		6.2	6.0	6.1	6.8	4.0	6.2	8.2	2.1	6.4	10.1	1.9
York	Williamsburg	29.5	43.4	62.1	74.8	43.4	99.8	154.1	65.0	156.5	303.0	150.0
(North Peninsula)	Newport News	113.7	136.4	151.0	172.9	141.0	187.6	260.4	184.8	221.5	411.0	260.0
	Hampton	89.3	120.6	139.7	161.2	124.1	180.4	251.3	142.5	221.6	411.2	142.5
(South Peninsula)	Virginia Beach	85.2	158.5	185.9	283.6	177.8	283.6	622.7	370.1	414.3	999.6	557.9
	Norfolk, Portsmouth, Chesapeake	493.3	518.6	543.9	611.9	540.0	592.3	793.8	590.0	640.6	1096.4	750.6
"REGION III"		**937.0**	**1130.0**	**1264.6**	**1515.2**	**1204.6**	**1587.8**	**2455.1**	**1622.9**	**1971.0**	**3830.8**	**2356.2**
TOTAL		**1728.7**	**2046.9**	**2280.0**	**2756.1**	**2346.2**	**2826.0**	**4340.9**	**3190.8**	**3466.1**	**6765.3**	**4389.9**
										*69%	231%	115%

Sources: (1) April, 1970, Va. on Table A in James River Basin Comprehensive Water Resources Plan, Vol. II—Economic Base Study, Ba. Dept. of Conservation and Economic Development Planning Bulletin 214.
(2) May 1968. NPA on Table A in Economic Base Study, Chesapeake Bay Drainage Basins, National Planning Association, Washington, D.C.
*Proportionate increase in total population 1968-2020

National Planning Association. Both population projections (Table 6.11) show what might be expected in growth levels. The existing urban centers in all three regions are getting more populous, while the rural areas show declining population or a leveling of growth. In addition, the larger urban areas continue to show the largest concentration of population.

The NPA data in Table 6.12 demonstrates the projected distribution of employment between the years 1970 and 2020. The greatest proportionate increases are in the finance-insurance-real estate business, the construction industry, and the service trades. In an absolute sense, the greatest employment in 2020 will be in the service trades, manufacturing industries, and retail trades.

The totals for the NPA data in Tables 6.11 and 6.12 show the population growth in the region will be approximately 2.4 million or about 115%, whereas, the total labor force growth is expected to exceed its 1970 level by 140%. The reason these sources project higher rates of employment relative to population growth is not clear, but for the sake of estimate we conclude the employment activity will increase as fast if not more quickly than the population growth rate. Employment in manufacturing (and in transportation-communication-utilities) is predicted to rise more slowly than the total population (to increase about 70% while population increases about 115% over the next 50 years.) This is not a good measure of the potential increase in industrial pollution, however. Productivity in output per/employee may be expected to increase steadily despite some reduction in the length of the work week. Productivity is a measure of the potential rate of production of industrial waste as well as industrial goods.

Table 6.13 in both NPA and VDCED data gives a closer look at employment projections in manufacturing. These figures indicate proportionately little change for the rate of employment demand in any single category, i.e., all are projected to grow at about the same rate, somewhere between 67% to 76% (high range estimate) by 2020. Food processing, chemicals, and transportation equipment manufacturing are expected to

Table 6.12
Total Civilian Employment Estimates
(Thousands of Persons)

Employment Category		1970	1980	1990	2000	2020	% of increase 1970-2020
(01-09)	Agriculture	20.0	19.6	19.7	20.2	21.4	7%
(10-14)	Mining	1.2	1.2	1.2	1.3	1.4	17%
(15-17)	Construction	39.4	53.9	71.5	89.4	139.8	255%
(19-39)	Manufacturing	164.5	188.0	206.1	226.2	271.2	65%
(40-49)	Transportation, Communication Utilities	51.2	56.7	64.9	73.1	92.6	81%
(50)	Wholesale Trade	36.2	46.3	58.9	71.5	100.6	178%
(52-59)	Retail Trade	102.2	118.1	135.3	153.0	211.4	107%
(60-67)	Finance, Insurance, Real Estate	27.3	35.7	45.9	59.6	101.9	273%
(70-89)	Services	171.2	129.7	292.8	356.2	556.7	225%
(91-93)	Government	51.6	54.7	61.0	70.4	105.3	104%
	Total Civilian Employment	**664.9**	**803.8**	**957.2**	**1120.8**	**1602.4**	**191%**
							X=131%

Source: Economics Base Study, Chesapeake Bay Drainage Basins, National Planning Association, Washington, D. C.

Table 6.13

Manufacturing Employment Estimates for the James River Basin
(Thousands of Employees)

	National Planning Association (1)		VIRGINIA (2)						
	1970	1990	1968	1990		2020		% increase 1968-2020	% increase 1968-2020
				Low	High	Low	High	Low	High
20 Food	18.7	22.8	17.6	19.6	20.1	22.6	30.2	28%	72%
21 Tobacco	8.6	7.9	11.7	13.0	14.7	15.1	20.1	29%	72%
22 Textiles	7.2	7.0	4.5	5.0	5.6	5.8	7.8	29%	73%
23 Apparel	10.3	12.5	12.4	13.8	15.6	16.0	21.3	29%	72%
24 Lumber	4.4	3.7	8.2	9.1	10.3	10.5	14.0	28%	71%
25 Furniture	5.8	7.1	2.9	3.2	3.6	3.7	4.9	28%	69%
26 Pulp and Paper	9.3	10.6	8.6	9.6	10.8	11.1	14.8	29%	72%
27 Printing & Publishing	9.3	15.1	8.8	9.8	11.0	11.3	15.1	28%	72%
28 Chemicals	16.9	20.1	18.0	20.1	22.6	23.2	31.0	29%	72%
29 Petroleum Products	0.5	0.5	0.1	0.1	0.1	0.1	0.1	29%	71%
30 Rubber and Plastics	3.4	6.0	3.2	3.5	4.0	4.1	5.4	28%	69%
31 Leather Products	3.4	3.4	2.8	3.1	3.5	3.6	4.8	29%	71%
32 Stone, Clay & Glass	4.5	6.2	3.3	3.7	4.2	4.3	5.7	29%	73%
33 Primary Metals	6.7	11.1	4.6	5.1	5.7	5.9	7.8	28%	76%
34 Fabricated Metals	5.8	7.6	4.6	5.2	5.8	6.0	8.0	30%	74%
35 Machinery (Except Elec.)	2.5	3.2	3.2	3.6	4.1	4.2	5.6	31%	75%
36 Electrical Machinery	6.3	14.8	8.6	9.5	10.8	11.0	14.7	27%	71%
37 Transport Equipment	38.9	44.0	25.0	28.0	31.4	32.2	42.9	29%	72%
38 Instruments	0.5	0.8	1.8	2.0	2.2	2.3	3.0	28%	67%
39 Misc. Manufacturing	1.3	1.6	2.0	2.2	2.5	2.6	3.5	30%	75%
Total Manufacturing	**164.5**	**206.1**	**151.6**	**168.8**	**190.5**	**195.4**	**260.6**	**29%**	**72%**
								X–29%	X=72%

(1) Source: Economic Base Study, Chesapeake Bay Drainage Basins, National Planning Association, Washington, D. C., May 1968, page V-70

(2) Source: James River Basin Comprehensive Water Resources Plan. Vol. II Economics Base Study, Virginia Department of Conservation and Economic Development Planning Bulletin 214, April 1970, pages 51-53. Data includes 10 counties and one city not in NPA study.

continue to be the largest employment markets.

Regarding water quality, the data suggest some interesting points. First, population will continue to put pressure on the most vulnerable areas, e.g., Richmond-Petersburg-Hopewell. Secondly, the employment figures indicate there will be a continued concentration of building and manufacturing in the region. The manufacturing picture continues to suggest the increase of traditionally heavy polluters such as the chemical, heavy equipment, and wood products industries. This potential pollution load, will be concentrated in or near those areas under heavy pressure from human effluent discharges. This picture is compounded by the NPA's predictions that many kinds of commercial and industrial activities with a high pollution pattern will grow at rates (inferring from employment predictions) exceeding population growth.

It must be recognized, however, that no matter how sophisticated these growth projections are in terms of the nature and number of variables considered, they are all based on trend analysis. In other words, growth is predicted in terms of some combination of long and short term units of historical growth patterns. This means the projections assume more of the same, "stacked still deeper." Of course, there may be some basis for technical criticism regarding the trend/methodology involved, but it is felt that in most instances these differences would not be large enough to disturb the total picture. Nevertheless, at a later point, we do wish to examine the assumption that current growth patterns need be continued unchecked.

Socio-Cultural Outlook

We are going to rely largely on the impression of social and cultural aspects of water quality problems made earlier and view society in the James River region as a microcosm of the national case. There are bound to be exceptions and adjustments to the more general case in this particular region. However, we have very little sociological information pertaining to the James River region at the cultural or social organizational level, particularly with respect to water institutions and the problems of water use. Therefore, we must rely on the limited, but useful studies of the James River Basin area that are available.

Ibsen and Ballweg [28] conducted a survey in Montgomery county on the social factors related to the public's perception of water resource problems. Montgomery county in largely rural, so the results should not be interpreted to reflect the thinking of the whole basin. The major findings of this survey are unsettling to those interested in clean water. Only 3% of the respondents saw water as a **major** problem facing the world today; however, only 34% indicated they had ever considered water a problem. The study showed that the people most likely to be familiar with water as a problem are people under 44, those who have resided at their present address a short time, who live in multiple dwelling, who are educated beyond high school, who are employed in professional or managerial occupation, and have an income in excess of $10,000 per year. The most important medium of water information for these individuals is television, and the water topic they discussed most frequently was pollution. [28]

The public's view of what can or should be done is encouraged by the fact that only 3% of the respondents felt that water resource problems could not be solved. [28] However, 41% of the respondents declined to suggest a solution to water resource problems. [28]

A significant finding is that "the majority of respondents who offered a solution to water resource problems felt that there was a need to enact more effective legislation." [28] In addition, "the majority of respondents felt that the private citizen and appropriate federal agencies were primarily responsible for initiating action to cope with water resource problems." [28]

Despite awareness on the part of some respondents as to the need for legal reorganization and new action on the problem, most of this suggest points of caution in our approach to the problem. Water problems, including pollution, are not high priorities in this largely rural area. National samples, which include a larger metropolitan representation, are more encouraging [29] but the former survey demonstrates a need for more public awareness in rural and small urban areas in Virginia.

A more recent study done by Ballweg, et al. (in press) focused on a similar question in Roanoke Ballweg reports that in his samples, pollution was the water problem discussed most frequently in public meetings or clubs. However, he discovered once again that very few people (10%) were aware of water as a problem.

Clearly, a change in cultural orientation,

i.e., shifts in value priorities with respect to some new idea, does not come without an awareness of the problem, and an opportunity of engaging in some kind of an initial evaluation of the problem and the relative benefits of alternate solutions. [31] As we pointed out in the national case, there are some strong socio-cultural forces blocking adoption of a new approach, but until the public is aware of the problem significant action may be many years off.

There are other important sociological aspects of the problem discussed and implied in our statement of the national case. Many of these involve accessible information useful at many stages of problem action—from the stage of initial arousal of interest through program execution and maintenance. But, since the data are not available, it will be necessary in other sections [300] to detail and justify the nature and types of sociological data that will be useful for creating intelligent policy. There are things we know from the national picture, however, that provide useful guidelines for shaping some much needed policy for the immediate future. These will be pursued in connection with our recommendations.

LEGAL AND POLITICAL FACTORS CONCERNING THE JAMES RIVER BASIN

Introduction: After a cursory view of the problem of water pollution on the James River, one may easily conclude that technology and economics are the only real snares which need to be overcome. Unfortunately, the crux of the matter goes far deeper. In a highly structural society such as ours, institutional factors must be considered. Our technology is rather advanced Scientific solutions exist and can be implemented if people are willing to spend the money. And theoretically, at least, the money is available.

It is the function of this section to examine the major institutional attempts being made in the James River Basin to apply available resources to water quality control. We will be looking at the legal and political systems of the basin in an effort to see what they are, how well they work, and how they may be changed.

The general heading, "political and legal system," embraces a vast array of organizations, laws, and processes. It is beyond the scope of this study to examine every source of political input. The working of the following forces within the sytem will not be discussed, although the political importance should not be underestimated:

a—municipal officials (mayors, city councils, sewage treatment managers, etc.)

b—industrial lobbyist (company officers, stockholders, etc.)

c—pressure groups (League of Women Voters, Council for Environmental Quality, Citizens Against Pollution, etc.)

d—local ordinances (zoning laws, littering, etc)

e—municipal court decisions

Since common law principles and federal statutes have been covered in the body of the report, we will limit discussion of them to situations peculiar to the James River Basin. Special attention will be given to state agencies and statutory law. Besides outlining what forces are at work, we will make an effort to show how various institutions interrelate, and how effective they are at curbing water pollution in the James.

State Legislation:

All of Virginia's water statutes have, up to now, been geared toward preventing further degradation of waters rather than toward taking affirmative steps to clean up pollution that is already there. While State water quality and affluent standards have helped to clean up state waters, no laws force polluters to take specific measures to alter production and treatment practices.

State Water Control Act

By far the most important water legislation in Virginia is the State Water Control Act of 1946 (SWCA). [32] The acts provides the framework for all water pollution control in the state.

Basically, the act disallows all discharges which are deleterious to state water (all waters within the state) unless such discharges have been certified by the State Water Control Board.

The Board is comprised of seven members from various parts of Virginia All members are appointed to four-year terms by the Governor. Meetings are held once each

month. (*) As in most states, board members largely rely on their staff, headed by a full-time executive director. The leg work called for by the permit system is done by the pollution abatement division, the director of which coordinates agreements reached between dischargers and the staff and reports findings and recommendations to the Board. Other staff functions are funding, planning, and enforcement. [see Fig. 2.1]

In order to obtain certification, discharges must submit reports and plans which comply to state standards. The Board sometimes grants such certification to dischargers who do not meet water quality standards; such certification is conditioned on future compliance. If certification is denied, the Board must explain what steps must be taken to get a permit.

The process of certification consists, in practice, of negotiation between the Board's permanent staff and the industry. The staff makes a recommendation, based upon the compromise reached, which is accepted by the Board in virtually all cases. [33]

Certificate holders are required to submit progress reports every three months to the staff of the Water Control Board. In addition, they are required to report all unusually excessive discharges, including a statement of probable environmental effects, to the Board by telegram or telephone. Plans for sewerage systems designed to serve more than 400 people must be submitted to the Department of Health. The Board, upon recommendation of the Health Dept., either approves or disapproves the plans. Systems serving less than 400 people are under local control. Municipalities supply the Dept. of Health with data on quantities and character of sewage being discharged and on operation of treatment plants. The Board may obtain such information from the Dept. of Health upon request.

While secondary treatment is required as of July 1, 1970, municipalities have a "reasonable" time to comply. The Board may no longer require municipalities to construct new or expanded treatment facilities unless it provides 80 of the necessary funds. [34] (The Board's budget for this purpose is $11-$13 million annually). [35] Federal funds generally match those given by the state, so that in practice, "only" 40 must come from the state. The federal government still has power to enforce water standards against municipalities, but it does not exercise this power. [33]

It is the policy of the Board to refuse to issue certification on all new construction (except for essential projects) where municipal treatment plants for expanded treatment facilities [36]. Additional sewer hookups, for instance, are prohibited in Fairfax.

In addition to its authority over municipal and industrial discharges, the board has jurisdiction over boats, both private and commercial. The Board may issue specifications in conjunction with the state Dept. of Health, the Commission of Game and Inland Fisheries, and the Marine Resources Commission. Violations constitute a misdemeanor.

Staff members investigate all large-scale fish-kills and make a settlement with the guilty party for the costs of investigation and replacement of fish. If a settlement cannot be reached, the Board may sue for these costs.

The Water Control Act mentions a fund to pay for replacement for fish when there is doubt as to who caused the kill. To date, no such fund has been established. (According to Holmberg, [33] expenses for fish kills come out of the running budget of the SWCB and are repaid by industries.) However, according to the Board, industries have been willing to make payment for the costs of investigation and replacement even when guilt has not been established. [33] There is no guarantee, however, that the money collected will actually be used to replace the fish.

The Board approaches water pollution problems on a piecemeal basis. (While growth problems are discussed as dischargers apply for certification, agreed-upon guidelines do not exist.) There are no detailed plans or priorities for future basin development, although the federal requirements for water quality standards and an implementation plan have been satisfied.

Progress in cleaning up state waters is severely retarded by the Board's fear of moving too fast. (At the July, 1971 Board meeting, for example, a construction moratorium which was to go into effect in Roanoke was dropped for no apparent ecological reason. Roanoke is still operating its treatment plants beyond the 95% cutoff point for such moratoriums.) Its policy is to increase slowly its effectiveness without overly incensing polluters, and more importantly the legislature. (According to Holmberg [33],

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*SWCA 62.1-44 calls for meetings at least 4 times per year. It is the practice of the Board, however, to meet for two consecutive days each month.

there is constant pressure on the staff as well as the Board. (Telephone conversation, July 28, 1971). In controversial situations, the Board has a tendency to issue conditional certificates or recommend further study, thus sanctioning continued violation of state standards.

From all reports, industries seem more willing to commit themselves to pollution abatement than do municipalities. This may be due to such factors as available finances, desire for good public relations, and rapid decision-making mechanisms.

Official enforcement action in Virginia is rare. From this, one may conclude that compliance is almost universal. Even if this is true, it does not mean that the picture is rosy. Permit standards are compromised, and water quality standards have been minimal in the past [37]. The standards have duplicated minimum water quality standards acceptable to the federal government. Moreover, enforcement procedures are extremely time-consuming. Notification of all interested parties is required at least two weeks before the enforcement hearing. Anyone who wants to testify may do so. In most situations, the Board is forbidden to take action until a full and open hearing has been conducted.

On paper, the Board has tremendous enforcement power. It may revoke or modify certificates, issue cease and desist orders, order construction of appropriate facilities, or order compliance with a Board directive. If dischargers are severely threatening health, safety, or welfare (including animals and aquatic life), the water supply, or recreational, agricultural, or industrial uses, the Board may issue special emergency orders which go into effect without a hearing. In addition, the Board has the authority to sue violators, seeking an injunction or a fine. Fines of not less than $100 nor more than $5000 may be imposed for each offense. (Each day of continued violation constitutes a separate offense.)

Industrial pollution on the James River at Hopewell, Va.

Discarded barges and boats in the James.

VEPCO Chesterfield power station.

Industrial waste lagoons near Hopewell.

NOT REPRODUCIBLE

In the past, however, the Board has hesitated to crack down, relying primarily on less oppressive tactics. [33] As a result, extreme delays have been tolerated as water quality on the James, especially near Richmond and Hopewell, remains low.

Other Legislation

In addition to the basic water control law, Virginia has enacted several criminal statutes which pertain directly to controlling water pollution. The following offenses are all misdemeanors (penalties are included in parentheses) which are contained in Virginia Code, as amended in 1970:

1. Sec. 62.1-194.1. Casting debris into state water (fine of not more than $100 or jail for not more than 30 days for both);
2. Sec. 62.1-194.1. Discharging any substance into water which may reasonably be expected to endanger, obstruct, or otherwise impair the use of water by others (fine of $100-$500 or jail for up to one year or both); civil actions in equity may also be brought under the statute;
3. Sec. 62.1-194.2. Obstructing boats or fish continuously for over one week; after the 10th day, each day of violation constitutes a separate offense;
4. Sec. 62.1-195. Discharging oil from non-governmental vessels, except in emergencies (fine of $500-$2500 or jail for 1-12 months or both; liquidated damages to city or county of $1.00/gallon, up to $15,000).

Virginia offers a tax incentive to industries who install pollution equipment. A five-year deduction is allowed on a percentage of the cost of such equipment. (Where lagooning is used, an accelerated deduction rate applied.)

Since the deduction may not exceed the cost of the device, industries have little incentive to purchase pollution equipment. Moreover, there is no assurance that dischargers will use the devices for treating their discharges (the deduction applies to devices which treat intake water as well), or will put them into operation at all.

Political Factors

Important political actors in the James River Basin can be broken down into two groups—private and public.

Private actors include 1) individuals and groups concerned with sporting and recreational uses of the river, 2) conservation groups such as the Sierra Club, the Conservation Council of Va., and the Council for Environmental Quality, 3) Political organizations such as the League of Women's Voters, and 4) those with a research interest in river quality in the academic community.

Industries (including agriculture and fisheries as well as manufacturers and processors) are by far the most influential of the private actors. For them, use and abuse of the river is a constant 24-hour-a-day concern both for water supply and for subsequent disposal of waste. The interest of the other groups noted generally varies in intensity over time and cannot approach the financial dependence of industry.

The main actors of a public nature involved in river water management are the governmental agencies on local, state, and federal. In terms of needs and dependence, the local municipalities probably surpass industries in their use and abuse of the river basin. The chief functions of the river are water supply and location of sewage discharge. In many areas along the James and other river basin systems, the major source of pollution is not from industry, but from municipal sewage. State and federal authorities concerned with river water quality have frequently found local governmental entities the greatest obstacle—often more recalcitrant than industry—in cooperating to attain quality standards criteria.

Improvement in water quality on the part of municipalities is retarded by several factors. Money for treatment plants must come from taxes. A well-known political fact of life is that voters almost invariably defeat bond issues which entail expending sums of money. Other users, in contrast, are able to use money which has already been raised. In addition, bureaucratic delays and administrative pressures help to postpone implementation of sewage treatment plan.

From a practical standpoint, municipalities have little to lose by delaying their clean-up as long as possible. Towns which pollute the James are not affected directly—it is the downstream user who suffers. Bad publicity may spur industries to clean up their effluent, but it does little to harm a municipality economically.

Perhaps the most important difficulty, at least as far as enforcement is concerned, is that municipalities are extremely difficult to

castigate. The major blames the city council; the city council blames the voters; and voters are sacrosanct.

While the board may take decisive action in serious situations (such as the construction moratorium in effect in Fairfax) it is careful not to press too hard. The Virginia legislature has already proven that it can curtail the authority of the State Water Control Board. (See, e.g., House Bill No. 192, July, 1970, which limited the authority of the Board in enforcing water quality standards against municipalities to those times that the Board could provide funding for treatment plants.)

Agencies

The State Water Control Board is not the only actor in the field of water resources regulation in the state. In a variety of matters it shares jurisdiction with a number of other state agencies, the most important of which are: the Department of Health, the Department of Conservation and Economic Development, the Marine Resources Commission, the Virginia State Ports Authority, and the Virginia Institute of Marine Science.

Within the **Department of Health**, the Division of Engineering has two Bureaus whose activities are especially important to the State Water Board. The Bureau of Sanitary Engineering supervises water supplies to the cities, inspects sewage treatment plants, and forwards its findings with recommendations to the Board. The Bureau of Shellfish Sanitation surveys the growing areas and planting grounds for shellfish for signs of pollution and has power of approval of such areas for subsequent marketing activity.

Within the **Department of Conservation and Economic Development**, the Division of Water Resources prepares comprehensive plans for water resources development and makes recommendations for river basin management. However, in actual practice the purpose of the Department's charge to "develop and advertise" the resources of the Commonwealth seems to take precedence over its charge to "preserve" the resources. A functional division of responsibility has arisen over the years with the Division of Water Resources in the Department planning for the economic development of the river basin, and the State Water Control Board looking out for the resulting water quality content on the river.

The Marine Resources Commission enforces state laws relating to fish and shellfish in the Tidewater area. It licenses commercial fishermen, and maps and leases oyster grounds to citizens. The primary purpose of the **Virginia Ports Authority** is to promote the development of, and to solicit cargo through, the ports of Virginia. Within its broad powers (stated as the authority to "do and perform any act or function not contrary to existing law") the Authority constructs and controls port facilities with an eye to increasing commerce through Virginia's harbors and seaports.

In addition to these five agencies (there are others not mentioned such as the Commission of Game and Inland Fisheries, The Virginia Soil and Water Conservation Committee, the Department of Agriculture and Commerce which, though involved with water resources, do not have them as their area of **primary** involvement) with rather obvious direct concern with water resources, there are three agencies not specifically involved with water, but which possess the power to override the water-related departments. The Division of Industrial Development—a super-Cabinet level agency not embodied within the traditional departmental structure of Virginia state government,—is charged with the duty to "promulgate and advance programs through the State for purpose of encouraging the location of new industries and the expansion of existing industries." The State Corporation Commission which issues charges to all industries doing business in the state, has authority paramount to the Water Control Board with regard, for example, to flow releases from dams for hydroelectric power. The Division of Planning and Community Affairs is attempting to develop a coordinated system of planning for growth and expansion among state agencies and localities. The Division gives assistance to local governments in many areas, including such water-related public works programs as regional waste treatment facilities.

Finally, there are a number of regional water management commissions such as the Potomac River Fisheries Commission, the Atlantic States Marine Fisheries Commission, the Potomac River Basin Commission of Virginia, the Ohio River Valley Water Sanitation Commission, the Virginia Beach Erosion Commission, and the Hampton Roads Sanitation District Commission which have primary authority within the geographic and functional areas delineated in their charters. (See outline of selected State agencies in Appendix L).

In an effort to provide some coordination with a focus upon environmental concerns among such a plethora of departments, agencies, commissions, boards, and authorities, the Governor in 1970 created a Council on the Environment whose precise impact is too current to be evaluated at this time. It is not entirely unlikely that, following the precedent of its analog on the federal level in 1970, it may recommend something similar to a state-level environmental protection agency.

Modeling

A comprehensive James River model could be of great value in planning the development and managing of the resources throughout the entire James River Basin. Some potential uses which would be particularly helpful are the prediction of: "before and after" effects of changes such as channel deepening, thermal outfalls, etc.; effects of upstream changes in river flow—for example by dam or reservoir operation; release dates for impounded water; flood stages and controlling them; sedimentation and shoaling; capacity of the estuary for receiving wastes; effects of erosion; effects of pesticides and fertilizer run-off; long term biological effects in James River and estuary resulting from all contributions coming into the system; and economic consequences associated with various water quality standards.

While modeling is no panacea for solving all of the problems encountered in resource planning, it can provide contra-intuitive insights into the possible effects of actions in a basin. Other portions of the U.S. have been targets of significant modeling efforts [38], [39] and have benefited from the added insight gained by both developing the models and making studies on the completed model. One significant fact discovered in past model studies is that in general scale models are more expensive and less useful than mathematical models [38].

To date, modeling of the James River consists of a scale model located at Vicksburg, Mississippi [40] and a mathematical model which predicts flood stages [41]. A model of water quality in the tidal portion of the James River is reportedly under development at the Virginia Institute of Marine Science (VIMS). The mathematical flooding model uses the unsteady open channel flow equation of continuity and momentum to study and predict river stages (i.e., river flow rates) at various stations. Storm data for 1967 were used to verify the model, and agreement is fairly good. The model is one dimensional, and it is not clear how it can analyze flooding after the river overflows its banks. It seems that such predictions would require at least a two-dimensional model.

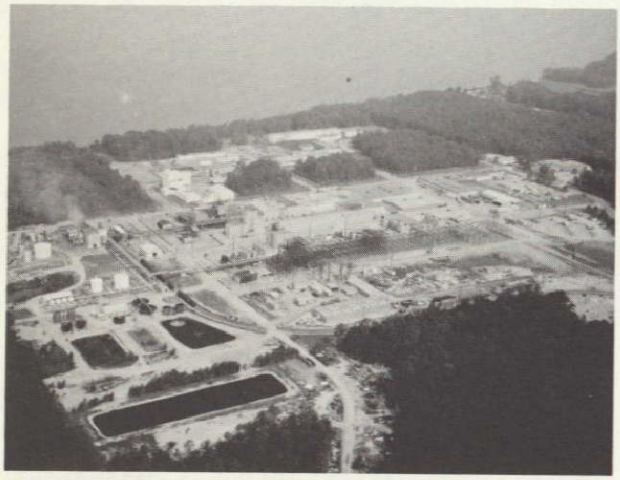
The Virginia Electric and Power Company (VEPCO) has used the result of a thermal study on the Vicksburg model to justify the building of a nuclear power plant just upstream from the major oyster seedbeds in the James River estuary. The study concluded that the thermal rise in the water would not be of sufficient magnitude to harm the seedbed; however, due to the non-uniform scaling of the Vicksburg model as well as the very little verification of this model in non-hydraulic phenomena, any thermal study results should be regarded as highly undependable [42].

In addition to the study by VEPCO, several studies have been made of the tidal portion of the James by VIMS using the scale model. They include channel deepening, location of sewage treatment plant outfalls, and some very preliminary studies of salinity intrusion and sedimentation [43]. As noted above, all of these studies are for the tidal portion of the James River and for good reason. Although the model has been in existence since 1964, only the tidal portion has been verified." That is, some attempt at matching model results to measured data have been made for the tidal part, but no such attention has been given to the portion of the model above Richmond. No mathematical model can be efficiently implemented and trusted if it is not verified with actual data. This is a measurement of its applicability and efficiency; therefore, enough data must be available in order to verify the predictions made by the model. On the other hand, the models will be able to predict parameters in time and space, and obviously the computational difficulties will increase with the number of parameters and the dimensionality of the model. Therefore, the more parameters that can be measured physically and can be incorporated into the model as data, the better the model will operate.

In building a mathematical model it is desirable to relate as many factors contributing to the problem as possible. The limitations in the number and relations of these factors are given by the availability of efficient numerical methods that can possibly solve highly complicated mathematical relations. Up to the present, mathematical models have been developed with several

Industries on the James at Hopewell.

Shipbuilding industry on the James at Newport News.



Industrial plant with waste treatment lagoons on the James at Denbigh.

An industrial water intake.

degrees of success in specific areas of water quality, hydraulics, economics, and so on, but no effort has been made to integrate those areas.

Piecemeal efforts at modeling any river system as large as the James River will be largely ineffective. A concerted effort is needed to develop a comprehensive model system taking into account hydraulics (including run-off and ground water), water quality, biological systems, economics, and interactions thereof. Concurrent with the model development should be an educational program which will portray how the model can be used to potential users of the system.

Most fundamental is the mathematical model of the hydraulic phenomena which should include the entire basin and not just the portion below Richmond. While such hydraulic modeling is indispensable, other facets of the problem must also be included, namely: biological models of fin fish, crabs, oysters, clams, zoo-plankten, etc., (i.e., some chain of life type models); water quality models including the BOD-DO parameters, but also including carbon, organic nitrogen, ammonia, nitrate-nitrite, phosphorous, salinity, and coliform; sedimentation; and finally economics. Interactions among these facets are complex, but detailed knowledge about them is necessary for intelligent planning purposes.

Concurrent with the model development, a continuing data acquisition program is necessary. The data required can be determined as modeling progresses. It may be used to evaluate model parameters, to validate the model, and to help establish basic model patterns.

The system of models should be designed so that it can be used efficiently at various levels of sophistication. With this built-in hierarchy of sophistication, it will be possible to consider only those factors pertinent to a

given problem. When there is doubt about which factors are pertinent, the most sophisticated version of the model can be invoked to establish sensitivity relationships. For example, the estuary portion of the river requires a dimensional representation due to the salt wedge intrusion.

Economic Models

The application of existing economic models to the James River Basin has not been attempted primarily because of the necessity of having a good water quality model that describes the effects of waste disposal at a given location as a function of time and space. Secondly, this lack of significant effort in solving the overall problem in the more economically efficient form is due to the nonexistence of a River Basin agency that studies the problems of the river. Thirdly, economic data are not available in usable form.

Lack of Data and Effluent Charges

The various parts of the James basin seem to fall rather easily into three outfall zones. (Fig. 6.3) The first includes all of the basin to a point just above Richmond. The outfalls in this part of the basin are more dispersed than are those in the lower reaches of the river. The main dischargers are the West Virginia Pulp and Paper Company and the cities of Lexington, Clifton Forge and Lynchburg.

The second zone includes mainly the Richmond and Hopewell areas and the river below them down to about Jamestown. The city of Richmond, Continental Can Corporation, and Hercules Powder Company are by far the largest dischargers in this zone.

The third zone extends to Chesapeake Bay with the Hampton Roads Sanitation District being the main discharger. The outfalls in this area are also reasonably well dispersed.

Most of the material discharged into the James basin has been subjected to primary treatment. However, substantial amounts are untreated while others have had secondary treatment. The City of Richmond, one of the largest dischargers, is making slow progress toward secondary treatment. The large industrial dischargers in the Hopewell area remain, though long-range plans for treatment are being developed.

The cost data needed are the additional costs of upgrading the current treatment levels (no treatment, primary or secondary) to higher levels as well as the probable BOD removal for each level of treatment. Some data are available for Richmond and also for the Hopewell area. The needed cost data for these and the other parts of ohe James basin could be developed at little expense. The lack of a suitable water quality model thus remains as the primary bottleneck to the use of effluent charges in the James basin. To implement a water quality model, much data collection will be necessary.

Unfortunately, water quality management data for the James River Basin are practically nonexistent. There are only two locations in the basin where water quality data are collected by the U.S.G.S. and put in STORET; both of these are in the non-tidal portions upriver from Richmond.

The data base problem is compounded in that five state agencies (Virginia Department of Health; Virginia Marine Resources Commission; Virginia Institute of Marine Science; Virginia Water Pollution Control Board; and Virginia Division of Water Resources) collect river data independently of each other and retain them in their own files. In addition to the state agencies, several academic institutions collect James River data at various times of the year. None of the collected data is shared in a computer storage and retrieval system and thus is not readily available for water quality management studies. Much of the data collected by these agencies is research data and often is not applicable to water quality management programs.

An examination of STORET data shows that less than 1% of the water quality data currently on file for James River is more recent than 1964. The only data in the system appear to be historical data extracted from reports when the system was set up. This seems to indicate that none of the many state and federal agencies collecting water quality data on the James, submits the data to STORET. This is particularly depressing since there is no other automatic storage and retrieval system for James River data.

Regionalization Scheme Applied To the James River Basin

As a matter of illustration of the applicability of the schemes outlined in Chapter 5, the example of regionalization is applied to the James River basin. The basin was divided in three major regions on the basis of concentration of the current polluters (Fig. 6.3).

A paper plant's effluent.

An industrial outfall area littered with other waste.

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Region 1 involves all the dischargers located in James City, Surry, York, Nansemond and Isle of Wight counties. The approximate BOD discharge into the river in this zone is 88,000 lbs/day with an approximate volume of 100 mgd (million gallons/day). The polluters are concentrated around the Chesapeake Bay in the Nansemond and Isle of Wight counties.

Two approaches can be used in applying the regional scheme. A 100 mdg plant can be built at a central point in the region and pipe all discharge to the plant, or the region can be subdivided in subregions and plants built at convenient points in the subregion the decision being made by an economic analysis. Although the capital and operating costs of building higher capacity plants favor the first scheme, the cost of piping favors the second scheme. Obviously, there is an optimal point of clustering the dischargers in subregions. Based on economic data [14] a rough estimation of the optimal regionalization scheme involves the construction of a 75 mgd plant in either Norfolk or Portsmouth and 25 mgd plant in Fort Eustis. The cost involved in this scheme assuming that all polluters will discharge to this plant is presented in Table 6.14. Region 2 involves all the dischargers located in Prince George, Charles City, New Kent, Henrico, Chesterfield, Dinwiddie, Nottoway, Powhatan, Goochland, Amelia and Hanover counties. The total BOD discharged in the river was estimated at 118,000 lbs/day with a volume of approximately 250 mgd. A good way to operate this region will be by building 100 mgd plants at Hopewell and Richmond and a 50 mgd plant at Petersburg. Cost figures are presented in Table 6.15.

Region 3 contains the dischargers of Fluvanna, Buckingham, Appomattox, Albemarle, Nelson, Amherst, Rockbridge,

Table 6.14

Capital and Operating Cost of Waste Treatment Plants vs. Size

	Capital (millions of dollars)		Yearly Capital Costs (millions of dollars)	
Size	Level Sec.	Tertiary (Drinking water)	Level Sec.	Tertiary (Drinking Water)
10	3.7	10	0.32	1.0
25	8.0	20	0.75	2.1
50	13.5	34	1.35	3.7
75	18.0	45	1.8	4.9
100	23.0	58	2.5	6.2

Table 6.15

Capital Cost of Regionalization in the James River

Zone	Level of Treatment	Capital Cost of Plants (millions of dollars)	Approximate Cost of Piping	Total Cost
1	sec.	26.0	6.2	32.2
	Tertiary (drinking water)	65.0	6.2	71.2
2	sec.	59.5	15.5	75.0
	Tertiary (drinking water)	150.0	15.4	165.5
3	sec.	36.5	12.4	48.9
	Tertiary (drinking water)	92.0	12.4	104.4

Botetourt, Craig, Alleghany, Bath, Highland and Augusta counties. The total discharge in this zone amounts to 73,000 lbs/day of BOD with a volume of approximately 150 mgs. A good regionalization scheme for this zone will be to build a 100 mgd plant at Lynchburg and a 50 mgd plant at Covington or Clifton Forge. The approximate cost of this regionalization scheme computed from economic data presented in [14] is outlined in Table 6.15. The cost is presented in capital cost including the approximate cost of piping the dischargers at any point in the region to the regional plant. Advantage of existing plants should be taken in consideration in the location of regional plants.

Recommendations

In addition to endorsing the general recommendations presented elsewhere in this report, the following specific recommendations for the James River Basin are proposed.

—Water quality must, at **all times** and at **all places** in the James River Basin, be maintained at a level to insure preservation of clean water flora and fauna.

—A James River Basin Authority must be established by the Federal Government.

a) This authority must be composed of people from the basin and will report to the Federal Government and to the citizens of the Commonwealth.

b) The primary responsibility of the Authority will be the assurance of clean water in the James through comprehensive long-range planning.

—Until the establishment of the James River Basin Authority, the power of the State Water Control Board must not be undercut—Virginia House Bill No. 192 must be repealed and replaced with provision that enforcement may not be contingent on providing funds.

—The State Water Control Board must step up its public education function.

—The State Water Control Board must issue an annual report, to be published in every newspaper in the Commonwealth, summarizing actions taken and giving profiles of major polluters This report must also include the history of the polluters since 1946 (quantity and quality of discharges efforts and plans to clean up, etc.)

—There must be a cooperative effort on the part of all colleges and universities in the James River Basin to collect socio-economic, political, physical, chemical, and biological data, and make this data readily available to anyone interested.

—All data collected on the James River must be stored in one system which can readily retrieve it for any user.

a) The data must be incorporated quarterly.

b) Since no other system presently exists, the STORET system must be used immediately.

c) It must be mandatory that all projects supported in part or entirely by Federal funds submit data collected to the STORET system.

—There is an immediate need for a comprehensive mathematical model of the entire James River Basin.

a) This model must include economic, social, hydrological, biological, and ecological inputs.

b) The modeling must be handled by the James River Basin Authority in order to insure inclusion of the proper data. The modeling should not be entrusted to any solely estuarine group.

—The recommendations of the Virginia Institute of Marine Science for saving the wetlands must be adopted.

—The existing 25' navigation channel to Richmond must be maintained and not deepened to 35'.

The James River Basin Epilog

The James River Basin of Virginia is an area steeped in history and natural beauty Throughout history, the river has been used by man with little regard for the future. This future now faces us. The James River is dirty and polluted—between Richmond and Chesapeake Bay it runs like a waste trough to the sea. Those fishermen who make their livelihood from the river often find their products dead or dying just like their industry. Commercial shipping, industrial complexes, and municipal sewers have driven much of the life from the river.

Virginia, legally dragging belatedly out of the 19th century, has failed to write meaningful anti-pollution laws or to enforce those which already exist. The time is past to allow political appointees to mismanage anti-pollution in the Commonwealth of Virginia; only through a massive upheaval in political and legal thinking will the James River once again run clean to the sea.

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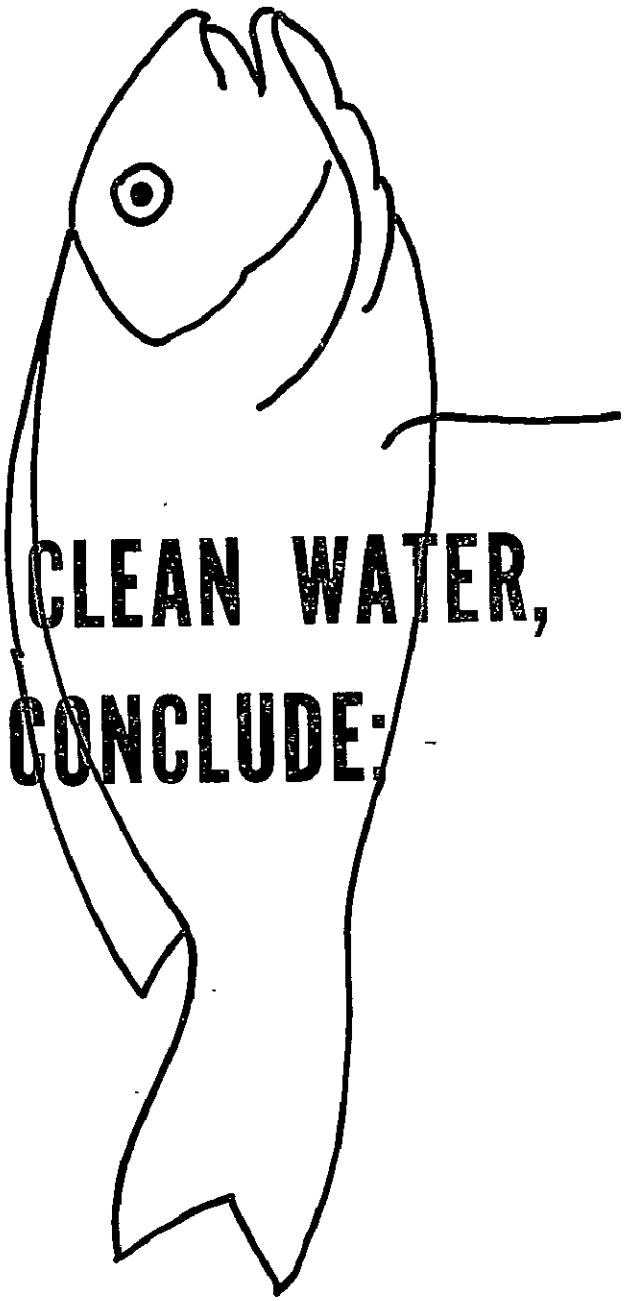

FOR CLEAN WATER, WE CONCLUDE:

7

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Conclusions and Recommendations

In a design study as comprehensive as this one, it is natural that a large number of conclusions and recommendations, both general and detailed, have arisen. They are organized here under several subject areas for easier reading.

First, we conclude that political commitment, stronger laws, and vigorous enforcement are the major needs to achieve water quality. About twenty recommendations concerning these vital areas are found in Section A. Next, we conclude that river basin management authorities are necessary for an effective water quality program, and discuss this in Section B.

Standards and waste treatment methods must be geared for water quality; these are discussed in Section C. Sections D and E consider important economic and organizational aspects of a successful water quality program. Selected technical areas that require special discussion appear in Section F. Finally, research needs in water quality are treated in detail in Appendix Q and summarized in Section G.

Conclusions and recommendations in this chapter are meant to apply generally to the entire country. Specific conclusions about the James River, our case study area, appear in Chapter VI

One final note of caution must close any comprehensive analysis of the problems of our environment. Just as the earth cannot feed or provide energy for an ever-expanding population, it cannot accommodate its wastes either. Effort to clean up the environment will ultimately be futile unless it is paralleled by successful stabilization of the population of this nation and the world. The Federal government should immediately initiate studies to develop an effective plan for stabilizing the population of the U.S. and cooperating nations.

A. Commitment and Enforcement

Most of the technology to clean up our public waters is at hand; the cost of pollution abatement is affordable. We have putrid, dying rivers and lakes because of past political inaction and public apathy. It will require a continuing commitment on the part of government and the private citizen, stronger laws, and vigorous, determined enforcement to clean up our public waters and keep them that way.

Water pollution will not be taken seriously by many industries and municipalities until our political leaders show a clear and complete commitment to clean water.

Rec. A1: There must be a clear and continuing commitment to clean water on the part of the President, the Congress, and State leaders. This commitment must recognize that the nation's waterways are a public trust, and that no water user may render the public water unhealthy for aquatic life or unsuitable for public use and enjoyment.

The seriousness of government commitment to clean water is in doubt when the activities of government agencies pollute the public waters.

Rec. A2: Federal and State installations must set the example in water pollution abatement. Abatement facilities must take precedence over routine construction in Federal and State agency budgets.

Rec. A3: The current plan of the U.S. Navy to substantially eliminate harbor pollution from Naval ships in port by 1975 must be scrupulously carried out.

The enforcement mechanism built into present law involves "conferences" followed by long (six month) waiting periods; dischargers find it easy to delay compliance for long periods.

Rec. A4: Mandatory waiting periods in the present law must be reduced to the absolute minimum necessary to provide dischargers an equitable hearing. Once compliance schedules are in effect, violations should be subject to immediate abatement order.

The Administrator of EPA has almost complete discretion to delay enforcement as he sees fit. EPA has been slow in demanding compliance or in compelling state or interstate agencies to do so.

Rec. A5: The wide discretion given the Administrator of EPA to act or not to act must be drastically reduced.

Rec. A6: Although EPA may delegate enforcement authority to state or river basin agencies, EPA must exercise its ultimate responsibility to assure this enforcement is effective and timely.

Enforcement of water quality is inhibited by the difficulty in obtaining data from dischargers, as well as the frequent need to prove a discharge is harmful and to underwrite abatement.

Rec. A7: The right of inspection and access to information from industrial dischargers by EPA and state or river basin water quality officers must be strengthened in the law.

Rec. A8: Federal legislation must shift the burden of proof to the discharger by making him show that his discharge is not harmful to the environment.

Rec. A9: Government funding of abatement facilities must not be a prerequisite to enforcement.

Although citizen support is essential to successful pollution abatement, most citizens are poorly informed and have difficulty in obtaining accurate information when they wish it.

Rec. A10: Public information effort on the part of EPA and State agencies must be increased to promote public awareness and support of pollution abatement. Additional funding and publicity for the Environmental Education Act (PL 91-516) is required.

Rec. A11: Full public disclosure must be made of the identity of all dischargers, their level of abatement, and their schedule (if any) for compliance.

Rec. A12: Citizen access to effluent data must be assured.

When the citizen has a choice to make (such as a bind referendum) for clean water, often the cost (higher taxes) is more apparent than the benefit.

Rec. A13: Municipal water pollution programs should focus on the quality of urban life and incorporate imaginative provisions for in-city dweller a personal stake in clean water.

Presently private citizens must prove personal damage before they may sue dischargers, and have no effective means of enforcing action by administrators. Further, their actions are entirely at personal expense.

Rec. A14: Legislation must permit citizens to sue dischargers for environmental damages without proving personal financial loss.

Rec. A15: Citizens must have the right to sue pollution control officials to force them to fulfill their obligations.

Rec. A16: Courts must be required to award litigation costs to successful citizen plaintiffs.

Incentives are necessary to encourage private citizens to provide the information necessary for enforcement of water quality.

Rec. A17: A fixed percentage of any fine assessed against a violator should be awarded the person(s) providing necessary information.

Rec. A18: Employees providing water quality data must be protected against recrimination.

Rec. A19: Guidelines must be provided to citizens and conservation groups describing the most effective ways of collecting evidence against violators.

Rec. A20: A telephone "hot line" should be available for citizens complaints (including anonymous ones).

B. River Basin Planning and Management

Effective water pollution control cannot be achieved on a local basis; pollution interacts throughout the entire drainage basin of a river. Institutions planning and managing water quality in a river basin must be equal in scope and authority to the task.

Rec. B1: Every major river basin should have a river basin authority (or its functional equivalent) with full power to plan, implement, and enforce water quality programs.

Rec. B2: The boundaries of river basin authorities should generally follow U.S. Geological Survey watershed areas, modified as necessary to meet special local conditions. The largest rivers (e.g., the Mississippi) would have to be divided into several interrelated sub-regions.

Rec. B3: Comprehensive river basin plans that meet rigorous EPA water quality planning standards must be a prerequisite of construction grants.

Rec. B4: Water pollution abatement plans must be reviewed by authorities responsible for air pollution and land use planning, since each problem impacts the others.

Rec. B5: EPA should provide each river basin authority with "master" mathematical models including instructions on how to adapt them to specific river systems. Any

river basin model developed with public support must be available with complete instructions to any qualified user.

Rec. B6: Every river basin authority should include a central data repository; all agencies producing water quality data at public expense should be rquired to submit it to this repository. Such data must be quickly available (through STORET if possible) to any qualified user.

Rec. B7: River basin planning must include provision for updating plans periodically to reflect population and water use changes.

Rec. B8: River basin plans should incorporate the impact of economic development on sediment run-off and on the ground water table, and should identify flood plains from which development should be excluded.

C. Standards and Waste Treatment

To assure the protection of aquatic life and the public use and enjoyment of public waters, rigorous minimum water quality standards are necessary.

Rec. C1: All water quality standards must meet rigid Federal minimum standards or the Federal standards should be substituted. Initially, Federal standards should at least meet the criteria itemized in the U.S. Department of the Interior *Water Quality Criteria*. 1968.

Rec. C2: In order to assure continued environmental protection, Federal standards should be updated at least annually. For pollutants about which insufficient information exists, no net addition to the stream can be permitted.

To meet these high standards, increasingly high levels of waste treatment will be necessary.

Rec. C3: Waste water treatment for most dischargers, including all major dischargers, must incorporate at least 90% removal of Biochemical Oxygen Demand (BOD).

Rec. C4: As our technology for waste treatment improves, effluent criteria must be increased until stream standards are met or exceeded.

Rec. C5: Industrial dischargers should seek plant process changes to reduce their effluent quantity, and must essentially eliminate from their effluent heavy metals and toxic materials so they will not be concentrated in the aquatic food chain.

Rec. C6: Sewered fluids from storm run-off, whether in combined or separate sewers, should be treated before discharge, especially the first flush which tends to sweep sewers clean.

Even when adequate treatment plant capacity exists, inadequately treated sewage often pours into our rivers through mechanical failure or operator error.

Rec. C7: Rigorous Federal design standards must provide redundancy and "fail-safe" concepts in treatment plant design.

Rec. C8: Qualified, licensed operators and maintenance staff must be used in sewage treatment plants.

Rec. C9: Periodic inspection of treatment plants by the States and EPA must be maintained.

Increased numbers of trained persons, both professionals and operators, will be needed to build and operate treatment plants and to plan and enforce our water quality program.

Rec. 10: Increased Federal support of training programs from the technician to the graduate level is needed.

Rec. C11: Where practical, training programs should be integrated with efforts to reduce the unemployment problems of returning veterans, minorities, and engineers.

D. Economic Considerations

Federal, state, and local funds that will be made available to abate water pollution will be finite. Each billion spent on water pollution is a billion not available for air pollution, mass transportation, urban problems, or other public or private usage. Strict attention must be paid to getting the most for the water pollution dollar, to assure that we will actually achieve water quality with the billions we appropriate.

Specifically, we find that the overwhelming bulk of Federal water pollution funds is budgeted for construction grants, a potential pork barrel that offers "something for everyone" in Congress and our State houses. Funding for related activities that might assure that these billions are spent wisely is disproportionately small.

Rec. D1: A greater portion of pollution abatement resources must be allocated to:
(a) river basin planning, modeling, and management,
(b) monitoring and enforcement,
(c) innovative, comprehensive research and demonstration programs,
(d) comprehensive systems analysis of environmental problems.

Although it is clear that water pollution is primarily a political and social problem, almost all research and development funds are expended on technical problems.

Rec. D2: An adequate proportion of research and development funds must be expended on study of enforcement procedures (especially the political factors involved) and on societal attitudes towards water pollution and enforcement.

In many municipal or regional treatment plants now proposed, the substantial majority of wastes to be treated come from industrial plants; government construction grants thus provide a subsidy to industry fortunate enough to participate in such an arrangement. Also, many municipalities do not charge industry the full cost of waste treatment. Both conditions artificially underprice high-pollution products relative to low-pollution products.

Rec. D3: Industry should repay that proportion of Federal construction grants associated with industrial waste treatment into a Federal Environmental Trust Fund for further use in environmental programs.

Rec. D4: Waste treatment districts receiving Federal grants must be required to impose on industry the full operating cost of treating industrial waste.

Rec. D5: Dischargers must pay the full monitoring and enforcement costs made necessary by their effluents.

Construction grant funds are allocated to the states on a formula basis. EPA and its progenitors have shown an unwillingness to be sufficiently critical of programs nominated by the States against their allocations. As a result, the taxpayer often does not get the improvement in water quality he deserves from the construction grant dollar.

Rec. D6: EPA must insist in its review and approval policies and practices on efficient use of water pollution control grant funds.

Rec. D7: EPA has the power to insist on consolidation of small water treatment districts into more efficient regional plants, and must exercise this power where Federal funds are involved and economy dictates.

Rec. D8: EPA should conduct comprehensive systems analysis to evaluate opportunities for economy through standardized plant design, construction techniques, and sewage plant components and control systems.

The survival of industrial plants that remain profitable only by continuing to pollute is not in the interests of society.

Rec. D9: Marginal plants which cannot economically afford pollution abatement must be allowed to close; government programs may be needed to ease the adjustment for employees and communities.

Inadequate capability of municipalities to float bond issues for pollution abatement must not be allowed to prevent water quality.

Rec. D10: A Federal agency empowered to guarantee and/or acquire municipal bond issues for environmental purposes must be established.

The concept of effluent charges has been developed in theory, and applied first in Europe and now in Vermont. Effluent charges provide a direct economic motivation to reduce discharges and to implement waste treatment.

Rec. D11: EPA should carry out an intensive and immediate study to define the most appropriate form of effluent charge system for nationwide application, culminating in a specific proposal and recommendation (pro or con) for Congressional decision.

Construction labor traditionally shows only limited mobility, and their wage rates have been increasing about 45% faster than other non-agricultural workers in the last decade. The danger exists that too much of the funding for pollution abatement construction programs will be swallowed up in excessive labor costs and contractor profits.

Rec. D12: EPA must participate with other Federal agencies in evaluating the relative supply and demand for construction labor and contractors, and in formulating programs to mitigate any excessive imbalances.

Rec. D13: In particular, construction labor

rates should not be allowed to rise faster than the salaries of college professors!

E. Organizational Considerations

Responsibility for water quality control is fragmented throughout government. Furthermore, many of the important "political actors" are not as effective as they ought to be.

For example, enforcement of water quality under the 1899 Refuse Act is shared between the U.S. Army Corps of Engineers and EPA, providing opportunity for confusion and administrative delay.

Rec. E1: Responsibilities of the Corps of Engineers under the 1899 Refuse Act should be transferred to EPA by Presidential executive order if the Congress fails to do so by statute.

Past reorganization of the progenitors of EPA's water pollution control effort have had a disastrous effect on the Federal government's ability to obtain water quality.

Rec. E2: Future reshuffling must be kept to the absolute minimum.

EPA functions related to water quality have been scattered throughout the first level functional divisions of the agency.

Rec. E3: EPA must institute and practice careful systems management to assure that planning, standards, grants, enforcement, research, and other effort related to water quality are coordinated efficiently toward a common goal.

About $720 million in grants, loans, and guarantees for domestic water systems for rural, urban, and depressed areas are fragmented in three Federal Department. Agriculture (Farmers Home Administration), Housing and Urban Development, and Commerce (Economic Development Administration). Much of this money is for sewer facilities (other than treatment works), and should be carefully integrated with EPA's own construction grant program in a unified program to achieve water quality.

Rec. E4: Sewer program funding must be transferred from the Departments of Agriculture, HUD, and Commerce to EPA to centralize the major Federal funding for waste water transport and treatment.

The Council on Environmental Quality is now charged with review of "environmental impact statements" related to projects of Federal agencies under Section 102 of the National Environmental Protection Act of 1969. Unfortunately, they lack the appropriation or personnel to do this effectively.

Rec. E5: Authority to review "Section 102" statements should be transferred from the Council on Environmental Quality to EPA.

Numerous thoughtful observers have pointed out that Congressional committees lack the professional staff capability to adequately fulfill their necessary role in Federal decision making. The underwriting by a private environmental group of two young scientists to assist the Congressional Committees on Public Works was helpful, but is not an adequate solution.

Rec. E6: Congress must assure itself of qualified staff advice by instituting fellowships for competent scientists and engineers (without conflicts of interest) in Congressional staff effort at Federal expense.

Congressional legislation is molded in committee and staff processes. Unfortunately, conservation groups appear to present their point of view only late in the process, when most political commitments have already been made.

Rec. E7: To be effective, representatives of conservation groups must lobby actively throughout the formative process of legislation.

F. Special Technical Considerations

A number of specific subject areas present special problems regarding water quality and the environment, leading to special recommendations for action. These areas include wetlands, transfer of oil and chemicals, electrical power generation, water-borne sediment, and agricultural pollution.

The intertidal areas we call "wetlands" are vital to many types of life, and exert a poorly understood but important influence on our total ecology. Unfortunately, much of our nation's wetlands are near population centers, and our wetlands are rapidly being converted to industrial, residential, and commercial use.

Rec. F1: Immediate, comprehensive, and systematic study of the ecology, types, and importance of wetland areas and the impact of various types of economic

development on them must be instituted and supported at the Federal level. States and/or river basins containing significant wetlands should categorize them carefully by extent and type and expeditiously develop comprehensive plans and policies, subject to EPA approval.

Rec. F2: During this policy formulation period a moratorium must be declared on conversion of wetlands to other uses.

Rec. F3: Government must be prepared to purchase wetland areas identified for permanent retention or restricted in use.

Where oil or hazardous chemicals are transferred from ship to shore the potential for ecological tragedy is always present. Special action is necessary to minimize the incidence and the impact of spills.

Rec. F5: Design standards for ship-to-shore handling equipment for petroleum and hazardous materials must be developed, then promulgated and enforced by the Coast Guard and/or EPA.

Rec. F6: All municipalities where marine transfer of oil takes place must have a contingency plan for oil spills with equipment available for an immediate action capability, and their plans should be integrated with regional and Federal plans to provide reinforcement. A similar contingency plan should exist wherever the danger of major toxic spills is present.

Electrical power generation impacts our environment in many ways. We cannot elimiate this impact, but must attempt to minimize its total effect.

Rec. F7: A total systems approach must be taken to minimize the overall effect of electric power generation on natural resources, air and water pollution, and radioactive and solid waste disposal problems. Nuclear, fossil fuel, water, and new solar sources of power must be considered in this approach, as must innovative locations for power generating stations.

The major solids load in our rivers is sediment, which muddies our waters, fills our reservoirs, and smothers essential animal life. These effects have received inadequate study and corrective action. A portion of the sediment load is natural, but a major portion of its is due to poor practice, particularly in forestry and urban development.

Rec. F8: The U.S. Soil Conservation Service should expand its soil conservation educational program and field technical services to other activities such as highways and urban construction.

Rec. F9: All aspects of erosion and sedimentation affecting water quality must be subject to final review and action by EPA.

Rec. F10: All economic activities contiguous to waterways must have controls to minimize sediment transfer from the site; where other effective provisions are not made, a buffer zone of natural vegetation must be required on the river bank.

Rec. F11: "Clear cutting" of forest land must be prohibited on Federal and State land. It should be discouraged on private land.

Rec. F12: Base-line data on total sediment flux must be developed for all major rivers.

Rec. F13: Areas for disposal of dredging spoil must be chosen to minimize ecological effects. Because of pesticide and nutrient content, agricultural run-off presents special hazards to the environment

Rec. F14: EPA and/or the Department of Agriculture must fund extensive systems analysis of the total agricultural run-off problem and its potential solutions, support demonstration projects to develop promising solutions, and implement effective corrective action.

Rec. F15: EPA must develop and implement effective means to minimize pollution from animal feed lots.

G. Critical Research Needs

Research has been inadequately funded in many areas relative to the pressing needs of water pollution. In addition, too much research has been fragmented and short term in nature, aimed at immediate problems. Research is critically needed in many areas, and these are itemized in some detail in Appendix Q. The most pressing general areas for research effort, not in any order of priority, are:

1. Estaurine and coastal zone research, including intensive study of wetlands to provide a basis for political decision.
2. Water-borne virus and disease vectors and interrelationships.
3. Thermal effects on aquatic life, with implications for design performance codes for power generator plants.
4. Automatic sensors and sensors that will measure additional parameters.
5. Biological monitoring systems.

6. Modeling research to incorporate economic, biological, and sociological factors.
7. Methods for restoration of pollution-damaged areas.
8. The sedimentation process and its interrelationship with pollution, nutrients, and burrowing and filter feeding organisms.
9. Household appliances (water closets, washing machines, garbage disposals) that impose less load (volume and waste) on sewage systems.
10. Sociological and political science research into the factors determining public acceptance of environmental programs, and into the relative effectiveness of alternative enforcement policies.
11. Development of techniques which will permit better quantification of subjective costs and benefits of governmental projects in general and pollution abatement in particular.

Epilogue

We cannot live in urban concentrations, nor live by means of agriculture, without causing some degradation of the waters of our land For all of that land is a watershed, and water is a potent solvent and eroder that will somehow move into its gathering places much of the products and wastes of human activity. If we live in small and scattered concentrations, and live without use of exotic and noxious substances foreign to nature, the degradation is small because the water is able to accept humanity as part of its burden in the varied cycles of nature. But when the urban concentrations grow large and thickly clustered, when poisons of various kinds become essential to industry and agriculture, when large areas must be paved and then befouled with drippings of the automobiles, the beer can, and the popsicle, when other areas must be bulldozes for this and that, then the degree of degradation rises, perhaps to deadly levels. The immediate consequences may be an offended eye or nose, a ruined source of domestic water, a silted creek, or a condemned oyster bed. The ultimate result will be a dead river, a dead estuary, a dead bay, and even perhaps a dead ocean.

A hungry human population, grown beyond the capacity of its land to raise sufficient food, may find the rich marine resource that its careless ancestors enjoyed no longer in existence. Meanwhile, the perpetual cycling of vital elements and compounds among ocean, atmosphere, and land may have been distorted in less obvious, but no less detrimental, ways.

This report has pointed out the many dangers that threaten our rivers, those essential links between land and sea, and has recommended steps to ameliorate the abuses and perhaps to repair past damage. We are reasonably optimistic in believing what needs to be done **can** be done. However, we have pessimistic feelings also. These arise in the belief that much of the problem is due to the pervasiveness of attitudes toward water that began in days when humanity lacked the means of impinging heavily on its environment, allowing the water to accept man's inputs as just another part of balanced nature. These attitudes, carried over into our era of concentrated urbanization, of intensive agriculture, and heavy industrial production, account for apathy and ignorance among the public, and the assumption of the "right to pollute" among the captains of affluence who benefit from free use of the rivers as sewers.

Non-equilibrium situations abound, but they must lead either to a restored equilibrium or to disaster. The affluent American populace is distinctly out of equilibrium with the ability of its share of the planet to support life, and more specifically with the ability of its watersheds to receive the wastes of life. We hope that a realization of this situation will spread through the people, and so wipe away those traditional attitudes that are the source of past trouble and the base of present attempts at reform. All of our non-equilibrium problems cannot be solved at once, but the water problem is one requiring immediate attention. The recognition of the problem is a fundamental first step, for when we know that we need clean water, we will want to pay the price of clean water.

APPENDICES

A. List of Participants and Secretarial Staff, NASA-ASEE Engineering Systems Design Program, 1971.

B Acknowledgements.

C Visiting Lecturers and Consultants.

D. Group Organization

E Contingency Plans.

F Inorganic and Thermal Waste Treatment Facilities.

G Annual Investment Required to Reduce the Existing Industrial Waste Treat Deficiency in Five Years

H Annual Operating and Maintenance Costs, 1968-1973

I Summary of Industrial Waste Its Orgini, Character, and Treatment.

J Sediment Erosion, Transport, and Deposition in Basin Waterways

K Water Resource Extractions and Returns

L Virginia State Agencies Involved in Water Resources.

M. Tributaries of James River

N A Day on the James

O. Marching to a Different Drummer.

P Improvement of Water Quality Through Effluent Charges

Q Research Needs

R Glossary

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APPENDIX A

FACULTY FELLOWS AND ASSOCIATES NASA-ASEE ENGINEERING SYSTEMS DESIGN PROGRAM

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Thomann, Robert V	Associate Professor of Civil Engineering Department of Civil Engineering, Manhattan College, Bronx, New York
Tunney, Gene	Senator from California, Washington, D C.
Walker, Mrs Catherine	Newport News School Administration, Newport News, Virginia

Ward, Jr., George H	Ocean Sciences and Water Rescources, Tracor, Inc., Austin, Texas
Wastler, Mrs L C DeGuerrero	Environmental Protection Agency, Washington, D C
Wengert, Norman	Colorado State University, Department of Political Science, Ft Collins, Colorado
Wilkenson, Ken	USDA Extension Grant Service, Washington, D C.
Williams, George	Environmental Protection Agency, Regional Office, Charlottesville, Virginia
Willment David	NASA-Langley Research Center, Hampton, Virginia
Wood, Gordon	Chief Counsel, Minority Delegation, Committee on Public Works, House of Representatives, Washington, D.C
York, Mike	Georgia Tech, School of Psychology, Atlanta, Georgia

APPENDIX C
VISITING LECTURERS AND CONSULTANTS

Date	Lecturer's Name, Address and Affiliation	Subject
June 8, 1971	Mr. L R. Wasserman, Jersey City State College Dr W S Galler, N. C State University	"A Water Pollution Primer"
June 8, 1971	Dr Franklin D Hart North Carolina State University Mechnaical and Aerospace Engineering Broughton Hall Raleigh, North Carolina 27607	"Systems Approach to Solving Problems of Society"
June 9, 1971	Dr William J Hargis, Jr Virginia Institute of Marine Science Gloucester Point, Virginia 23062	"General Involvement on Water Quality - James River"
June 10, 1971	Mr William M. Colony Environmental Protection Agency Route 3 Charlottesville, Virginia 22901	"EPA's Plans for Water Quality - Abatement on James River"
June 11, 1971	Mr Newton Anacarrow 921 South Gaskins Road Richmond, Virginia 23233	"The Rape of the James"
June 18, 1971	Mr Seymour P Gross Water Resource Engineer Delaware River Basin Commission P. O Box 360 Trenton, New Jersey	"Delaware River Basin Quality Management"
June 21, 1971	Colonel James H Tormey Corps of Engineers 803 Front Street Norfolk, Virginia 23510	"Functions of the Norfolk Engineering District U. S Army"
June 24, 1971	Dr Clifford Russell Resources for the Future 1755 Massachusetts Avenue Washington, D C 20036	"Economics of Water Pollution"
June 25, 1971	Dr. Kenneth Wilkinson U S Department of Agriculture (Cooperative State Research Services) Washington, D. C. 20250	"Sociological Perspectives In Natural Resources Research"
June 29, 1971	Dr Henry R. Thacker Environmental Protection Agency Region 3 918 Emmet Street Charlottesville, Virginia 22901	"The E P A Water Pollution Research and the Development Program"
June 30, 1971	Dr. William J Hargis, Jr Virginia Institute of Marine Science Gloucester Point, Virginia 23062	"Summary of the Technical Date Base of the James River"
July 1, 1971	Mr. Mahlon Rudy U. S Department of Agriculture Virginia State Office 400 North Eighth Street Richmond, Virginia 23240	"Conservation and Pollution Abatement Activities in the James River Basin"

July 2,.1971	Mr Ethan T Smith Environmental Protection Agency Office of Water Programs Edison, New Jersey 08817	"An Outline Stretegy for Water Quality Management"
July 6, 1971	Mr Carmen Guarino Deputy Commissioner City of Philadelphia Water Dept 1140 MSB 15th and JFG Boulevard Philadelphia, Pennsylvania 19107	"The Realities of a Waste Treatment Plant and Implementation - a Large User's View"
July 7, 1971	Dr Peter A Krenkel, Chairman Environmental and Water Resources Engineering Box 1670 Station B Vanderbilt University Nashville, Tennessee 37203	"State of the Art of Waste Treatment Industrial and Municipal Primary"
July 8, 1971	Mr. Louis D. Hoblit Vice President and Technical Director Dow Badische Company Williamsbrug, Virginia 23165	"The Importance of Base Line Survey's"
July 9, 1971	Mr. J. D Ristroph Executive Director of Environmental Services VEPCO P O Box 26666 Richmond, Virginia 23261	"VEPCO Environmental Program"
July 19, 1971	Mr Roy Insley Virginia Marine Resources Commission 17 Kelsor Drive Poquoson, Virginia 23362	"Role of Waterman in Virginia"
July 20, 1971	Dr Ella Filippone Environmental Research Associates 25 Holmesbrook Road Basking Ridge, New Jersey 07920	"The Passaic River Coalition - A Citizen's Action Group"
July 21, 1971	Mr A H Paessler Executive Secretary State Water Control Board P O. Box 1143 Richmond, Virginia 23230	"The Past, Present and Future Water Quality Management in Virginia"
July 22, 1971	Mr. Peter Jutro House of Representatives Public Work Committee Room 2165 Rayborn House Office Bldg. Washington, D C. 20515	"Ecology in the Congress"
July 23, 1971	Dr. John C. Ludwick Director, Institute of Oceanography Old Dominion University Norfolk, Virginia 23508	"Evolution of Sediment Shoals in Entrance to Chesapeake Bay"
July 26, 1971	Mr Morris Deutsch Chief Office of Remote Sensing U.S.G.S W.R.D Room 210 801 19th Street, N W Washington, D. C. 20242	"Remote Sensing Devices"
July 29, 1971	Mr. Gunther Redmann Mr. Terry Heald Jet Propulsion Laboratory 4800 Oak Grove Drive Pasadena, California 91103	"Remote Sensing Devices"

July 30, 1971	Dr. Harold A Bolz Dean, College of Engineering Ohio State University Columbus, Ohio 42310	"Interdisciplinary Design Programs at the University Level"

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APPENDIX D

In order to proceed as efficiently as possible toward ultimate goals, the study-design activity was organized during successive phases of the program in the following manner

Initially the participants organized themselves into three basic groups for preliminary study and to survey needs These three groups were

Establishment of Water Quality Criteria

J. T Wyatt, Chairman
Ralph G Crum
Richard W Faas
Don M Ingels
Albert E. Millar, Jr
Chester A. Peyronnin
John B. Woodward, III

Instrumentation for Water Quality Monitoring

Karl B Schnelle, Chairman
James E Brandeberry
Victor V Cavaroc
Harold N Cones
William S. Galler
Richard D. Swope
Lary P. Wasserman

Enforcement of Water Quality

D L Babcock, Chairman
Jess C. Crumbly
Jorge A Marban
Robert R Reynolds
Kathryn R. Smith
Michael J. Sullivan
James F. Thompson

The Steering Committee was established during the second week The purpose of this committee was to further delineate study tasks

Steering Committee

D L Babcock, Chairman
R G. Crum
Karl B Schnelle

In order to proceed toward ultimate goals, new tasks groups were created which served to complement the original three groups. These new groups functioned from week 3 to week 7 Their purposes and composition were as follows

Why Water Quality Management

L P Wasserman, Chairman
D. L Babcock
R G Crum
R W Faas
A E Millar
J T Wyatt

Institutional and Cultural

K B. Schenlle, Chairman
J. C. Crumbley
R. W Faas
R R. Reynolds
K. R Smith
M J Sullivan

Economic Consideration

J. F Thompson, Chairman
R G Crum
W S. Galler
D. M. Ingels
J A. Marban
R D Swope

Technical and Management

V V Cavaroc, Chairman
J E Brandeberry
W S. Galler
C A Peyronnin
K. B Schnelle
K. R Smith
M J. Sullivan
R D Swope
L P Wasserman
J B Woodward
J T Wyatt

Systems Design (What Can Be Done)

R. G Crum, Chairman
J E. Brandeberry
W S Galler
M. J Sullivan
J. F. Thompson
L P Wasserman

Case Study (The James River)

H N. Cones, Chairman
R. W. Faas
D. M. Ingels
J A. Marban
R R. Reynolds
K R Smith
R D Swope
J F Thompson
J B Woodward
J. T Wyatt

During the 9th, 10th, and 11th weeks, the results of these task groups were incorporated into the major sections of this report The following "section editors" coordinated this material.

Prologue

The Affluence of our Society (A E Millar, Jr.)

We Recommend (R R Reynolds)

I Water Quality Management
The Approach to Clean Water (L P Wasserman)

II The Societal Influence on
Clean Water (K B Schnelle, Jr)

III. Treating the Effluents
The Technology for Clean Water (J. T. Wyatt)

IV Bottlenecks and Boondoggles
Impediments to Clean Water (D M. Ingels)

V System Design for Clean Water (R G. Crum)

VI. A Case Study
Clean Water for the James River (H N. Cones, Jr.)

VII. For Clean Water, We Conclude (D. L Babcock)

Epilogue (J. B. Woodward)

Appendix (W. S Galler)

The following standing committees functioned during the last weeks of the program

Editorial Staff

A E. Millar, Editor-in-Chief
J D. Gibson
R. K. Klafter

Illustrations Committee

R D. Swope
J B. Woodward

APPENDIX E

CONTINGENCY PLANS

I. Introduction

A management plan provides for the orderly control of processes within a river basin Often an unexpected event will cause more damge to the ecology of a river basin than several years of uncontrolled pollution activities Such an unexpected event may be natural, such as a storm or flood; or unnatural such as the escape of polluting or toxic agents from a vessel transporting such agent if it is involved in an accident Other such unnatural acts would be the mechanical failure of equipment within a plant, the rupture of pipe lines, severe fires on land with subsequent run-off of fire water carrying chemical agents into a stream, and must include the intentional act of some disturbed person deliberately injecting toxic agents into the water

II. Contingency Plans

Plans to handle such a contingency should include provisions for the prompt detection of such hazards and notification of all affected parties, procedures to cope with the situation so as to minimize the damage, and procedures for expediting the recovery and restoration of the area as rapidly as possible. The plans should be formulated on both a basin and a federal basis. The basin organization should exist because a local body can respond to local situations quickly and can keep current on local changing conditions within the basin. This would be somewhat of a first-aid type organization The Federal participation should be, and in fact is by law, a broader treatment agency in that it can be expected to have the expertise and equipment to cope with large scale happenings.

The Water Quality Improvement Act of 1970 made provisions for a National Contingency Plan under the sponsorship of the U.S Coast Guard in cooperation with the U S Army Corps of Engineers The plan consists of a series of regional plans and is directed primarily at oil pollution control for the present although the control of hazardous chemicals will become a part of the final plan These regional plans are very comprehensive in scope, but there are a few areas outside of the jurisdiction of these agencies or situations which may occur too rapidly for these agencies to respond For instance, the spill of a toxic chemical on the wharf of a dock would constitute a situation in which immediate action would be necessary to warn the water supply points in the area of the hazard and to take immediate steps to control the hazard The response to this situation would have to be much faster than that possible of a Federal agency, although the Federal response will probably be prompt

III. Contingency Plan Implementation

In order to implement a contingency plan the following general steps should be taken. For sake of brevity these are not necessarily complete but are indicative of what a good plan should contain

A Discovery and Notification. There are several channels through which notification of a spill can be received. The most direct is through notification by the person or group who caused the spill. Present Federal law places a criminal fine of up to $10,000 or up to 1 year in jail for failure to report an oil or hazardous chemical spill. This will very likely insure that the vast majority of spills will be reported This requirement should be given considerable publicity by local groups, particularly if there are transient users of the area

The other main source of information would be from a monitoring system installed in the waterway The unfortunate fact is that monitoring systems are not capable of detecting all toxic substances through field type analytical procedures In port areas there are many exotic chemicals of this type and some for which there are analytical procedures to detect but no countermeasures to control the damage Since this is the situation the only plan of action to prevent damage from the spills of such agents is to prevent the spill through stringent procedures for such handling Many ports and transportation centers do have such requirements, but not all

The industrial plants, shipping agents, boat leasing facilities, commercial fishing groups and many other special groups as well as the general citizenry should be informed as to the necessity for reporting any spills. There should be a clearly indentifiable, easily found number, to which spills can be reported This number should be reached by collect calls as well as paid calls if necessary so that no one will hesitate to telephone. This central agency should then place into operation a notification system which will call all interested parties, as well as the Coast Guard if this is not the agency so acting Arrangements should be made with a central testing laboratory for the emergency indentification of unknown agents or suspect chemicals

Containment and Countermeasures.

Although the federal plan provides for a task force of skilled technicians for emergency duty, this force will not be on stand-by alert and must be mobilized. Because of the time lag involved in mobilization and travel to the scene there should be local forces organized, very much as industrial fire brigades are organized, to cope with the immediate problem. Fire departments should add spill control techniques to their skills Adequate equipment and material should be stockpiled in strategic areas Because of the cost involved in stockpiling many items, it would be desirable to pool resources provided such pooling does not remove critical supplies too far from each area

Cleanup and Disposal.

The cleanup and disposal problems are critical because they should not in themselves cause greater damage, although of a different type, than the spill At the present time, cleanup and disposal techniques are the least developed procedures associated with the pollution effort. There are many agencies, such as the Coast Guard, Manufacturing Chemists Association, National Safety Council, and National Fire Protection Association, to name only a few, that have expertise, any knowledge related to hazardous chemicals. The major needs are in the hardware area wherein newer devices are needed for actual clean-up in water with wave activity or in fast moving streams

In general, the procedures are based upon the following concepts. All flow should be stopped by either shutting off the pollutant or physically removing it to some safe area, which in itself may be hard to find. Total containment is possible for drums amd small tanks. Damming is possible for large land tanks and for water borne equipment booms. In the case of floating chemicals, it is possible to mechanically remove them from the water In the case of water soluble chemicals it is possible to neutralize, precipitate, or change the pollutant to a less toxic one by the addition of other chemicals. This is always a specific process and must be done by persons who have knowledge of the chemicals involved and their effect on biota, both before and after the action

Floating oil can either be dispersed with agents which will emulsify or render the oil suitable for dispersion, sunk using agents that will cause the oil to physically sink below the surface to the bottom, or collected using agents that will form gels or change the oil mass into a form suitable for simple mechanical handling. Under certain conditions the oil can be burned if a suitable wicking action can be formed using straw or other floating devices Burning will cause air pollution and must be considered an undesirable action. The use of chemicals is generally discouraged unless the oil is a specific hazard to wildlife or constitutes a fire hazard

Restoration.

Once a spill has been contained and the contaminant cleaned up, the restoration of the area must begin Because the recovery of any damaged natural area is generally such a long time process if left to nature, man must inject himself into the cycle and aid nature. In the case of vegetation kill, it may be that newer types of vegetation should be introduced in order to hold soil until permanent growth of natural shrubbery can take over. This implies that some form of long term management must be used Fish and other forms of animal life can be reintroduced to the area, but care must be taken to nourish them to insure survival There is a strong temptation for managers to "improve" the area dedicated to the restoration and in some cases this should be studied and perhaps done This is particularly true if the area was of the deprived type before the spill incident

Recovery of Damages

Legal provisions should be made to charge the offending parties with the actual costs of clean-up and restoration In the event that a specific charge cannot be sustained against a group or individual there must be some financially responsible organizations able to pay. In cases of major spills this will be the responsibility of the Federal government which will maintain a revolving fund for such occasions, bill the offending party, and absorb the charges for which payment cannot be collected for any reason

APPENDIX F

Inorganic and Thermal Waste Treatment Facilities

Average Statistics of Inorganic Industry

Average production = 280,734 tons per year.

Water use per plant = 27,034,619 gpd.

Wastewater discharge per plant = 4 697 mgd

Average treatment efficiency = 85%

Average capital costs of treatment facilities = 1,048,578

Average Operating Costs of treatment facilities = 274,730 per year

Average Capital Cost = $233/1000 gpd

Average Operating Cost = $58.49 per year/1000 gpd

Average Wastewater flow = 16 73 gpd/annual ton of production

Average capital cost of production = 3.74/annual ton of production

Average Operating Cost of Production = $0.98 per year/annual ton of production

A brief description of the economic models used in the cost.

Cost of Unit Wastewater Treatment Practices

In this section the cost models used in estimating the cost of wastewater treatment practices will be briefly discussed. The following practices will be discussed

Neutralization
Deepwell Disposal
Reverse Osmosis
Electrodialysis
Ion Exchange
Multiple Effect Evaporation
Solar Evaporation
Cooling Towers

1) **Neutralization:** The process of neutralization involves the addition of some form of lime to neutralize the acidic wastes or the addition of sulfuric acid to neutralize the alkaline wastes Usually hydrated lime has been used in the neutralization of acidic waste although recent research studies claim that the use of limestone is better. Cost for hydrated lime treatment of acid drainage including sludge disposal by thickening and disposal of the slurry in ponds can be obtained in reports published by Rice and Company (1) and by Barnard (2). The general overall cost for neutralization thickening and sludge holding ponds haven't been proved to be proportional to the flow rate and the acidity of the waste The capital cost of neutralization can be calculated from

Capital Cost = $172\ Q^{0.83}\ A^{0.79}$
(in millions)
Where Q = flow rate in million gallons per day
and A = acidity in milligrams per liter

Deep Well Disposal

Disposal of wastes containing dissolved organic matter by injecting them into deep wells has been successful in areas of low or non-existent stream flow, especially when wastes are odorous or toxic and contain little or no suspended matter. The factors that need to be considered in the design and cost calculations of deep well disposals are.

1) Depth required
2) Subsurface geological formations
3) Injection pressures
4) Volume and characteristics of waste

Capital and operating cost curves for different injection pressures at different flow rates are tabulated in (3).

Reverse Osmosis:

The factors affecting the design and cost of this process are

1) Membrane characteristics
   a) area
   b) salt rejection
   c) porosity
2) Applied pressure
3) Water characteristics
4) Feed flow.

The capital cost since to follow the following economic model

Capital cost = $1.20/Q + 10^6\ Q$

Q = Flow rate in gallons per day.

Operating Cost[1] = $1 33/1000 gal. of treated water. This cost does not include pre-treatment to remove undesirable pollutants such as iron, manganese, organics, etc., and does not consider ultimate disposal of the brine.

Electrodialysis

Electrodialysis is a partial demineralization of brackish and saline waters through a membrane process. This is a physical process in which the most important element is the membrane Since the membrane has ion exchange properties that is why the process is called electrodialysis. Capital cost curves for D C. Rectifier for electrodialysis and operating cost of D C. Energy required for specific total dissolved solids removal can be found in (4).

Ion Exchange

Ion Exchange is basically a process of exchanging certain undesirable cations and anions of the waste water for sodium or hydrogen ions in a resinous material. The resins both natural and artificial are commonly referred to as zeolites The ion-exchange process was originally developed to reduce hardness in domestic water supplies, but has recently been used to treat industrial waste water such as metal-plating wastes The cost of ion exchange plants is dependent on the total volume of waste treated but also to a large extent on the total amount of dissolved solids removed or exchanged. The regenerant chemical cost will also be in direct proportion to the rate of electrolyte removal Cost curves indicating capital cost as a function of plant capacity and chemical cost as a function of influent dissolved solids can be found in (3)

Multiple Effect Evaporation

Evaporation is a process of bringing the waste water to its boiling point and vaporizing pure water. Major factors in the selection of the evaporation method are:

1) Economics
2) Initial dissolved solids in waste
3) Foreign matter quantity and character

Most evaporators operate with a slight vacuum on the vapor side. Evaporating a waste presents many problems, which include concentration changes during evaporation, forming temperature sensitivity, scale formation and type of material which are used in evaporator construction

Solar Evaporation

Solar or pond evaporation is used only in areas where the land is cheap and the net evaporation exceeds the net rainfall by a big margin so as to keep the evaporation ponds within reasonable limits

Thermal Pollution

The state of the art in analytical techniques is adequate to handle all thermal design considerations Analytical techniques are readily available (3) and the state of thermal modelling is such that either mathematical or physical models are adequate for design purposes.

The basic approach to all thermal analysis can be summarized by the following specific approach. (4) The output of such analysis can then be used as an input to a biological model to determine and limit the impact upon the biota of the discharge reach It will of course be necessary to use a trade-off or limiting procedure on the plant thermal output depending upon the justifiable biological requirements

Simulation Model "Colheat"

$Q = Qt = (As - Qr) - Qb - Qe \pm Qh + Qv$ where

Net insolation Qs = incoming short wave radiation

Qr = Reflected short wave radiation from the water surface

Back radiation $Qb = 0.970\ (Tw - Ta)\ tv/ft^2/$

= Stefan Boltzmann radiation constant

=Atmospheric radiation factor derived from cloud cover and vapor pressure

Tw = Temperature of water surface in °K

Ta = Temperature of air in °K

Evaporation $Qe = 13.8\ u\ (Iw - Ia)$ Btu /ft²/hr.

U = wind speed in mi/hr

Iw = vapor pressure of water in inches of mercury

Conduction $Qr = 0.00466\ Dpv\ (ta - tw)$ Btu/hr/spft

0.00466 is a constant derived from the Bowen ration for quiescent lakes

K=Correction factor varying between (1 - 3) for rapid streams

U = Wind velocity in mph

p =atmospheric pressure in inches of mercury

ta = mean air temperature in °C

tw = mean water surface temperature in °C

Advected energy

Q = varies with heat source - term used to input heat from thermal effluent and in special cases to handle ice, sheet, rain, etc The water temperature for a section is determined by means of the equation

$$Tw = [\frac{1}{Vr}\ \frac{Q + A\Theta}{62.5} + Vi\ (Ti - Tw)]$$

Where Vr = mean river section is reservior volume

A = mean river section or reservior surface area

Θ = time increment

Ti = mean temperature of inflowing water

Tw = mean temperature of water in a given section of river or reservior

Vi = inflow for time increment

Qt = the net heat transport for tire

References:

1 Rice and Company, Engineering Economic Studies of Mine Drainage Control Techniques. As cited IN The Economics of Clean Water. Summary Report USDI, FWPCA, March, 1970, p. 401.

2. Barnard, J. L "Treatment Cost Relationships for Wastes from the Organic Chemical Industry," M S Thesis, The University of Texas at Austin, June 1969

3. The Economics of Clean Water, Vol 3, U.S Department of the Interior, Federal Water Pollution Control Administration, March, 1970

4. Electrodyalisis in Advanced Waste Treatment, FWPCA. Publ. No WP-20-AWTR-8 Water Pollution Control Research Service (1967)

Appendix G

Annual Investment Required to Reduce the Existing Industrial Waste Treatment Deficiency in Five Years (Wastewater Profiles and Estimates)

Industry	Annual Investment to Reduce Existing Requirement	Total Investment to Reduce Waste Treatment Requirements and Meet Growth Needs				
		1969	1970	1971	1972	1973
Food and Kindred Products	57.9	83.3	86.2	92.1	92.3	92.1
Meat Products	9.2	13.3	14.8	14.8	15.4	15.3
Dairy Products	6.1	6.7	7.5	7.2	7.2	7.2
Canned and Frozen Foods	8.8	15.0	16.3	16.6	17.0	17.1
Sugar Refining	17.8	25.4	24.3	29.8	28.2	28.3
All Other	15.9	22.8	23.3	23.7	24.4	24.1
Textile Mill Products	7.0	12.9	14.4	14.6	14.5	15.3
Paper and Allied Products	19.9	25.2	33.6	34.3	34.8	35.6
Chemical and Allied Products	73.8	99.8	101.4	102.4	104.6	102.7
Petroleum and Coal	20.3	20.3	23.9	40.2	41.8	42.3
Rubber and Plastics, n.e.c.	8.2	9.2	10.4	9.4	9.5	9.4
Primary Metals	39.4	110.2	120.3	123.0	126.8	128.9
Blast Furnaces and Steel Mills	25.8	69.1	77.9	79.2	83.0	83.0
All Other	13.6	41.1	42.4	43.8	45.1	45.9
Machinery	6.6	9.1	9.1	9.4	9.4	9.6
Electrical Machinery	2.2	4.7	5.0	5.0	5.3	5.4
Transportation Equipment	10.9	15.4	15.7	16.1	15.9	16.2
All Other Manufacturing	31.0	42.6	43.0	43.5	44.2	44.5
All Manufacturers: By Wastewater and Profiles and Estimates	277.2	432.7	462.9	489.9	499.0	502.0
(By Census Municipal Projections)	(696.6)	(892.2)	(930.2)	(964.1)	(975.6)	(979.4)

Source: The Economics of Clean Water, Vol. 3, USDI, FWPCA, March 1970.

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Appendix H

Annual Operating and Maintenance Costs

1968-1973

Industry	Annual Operating and Maintenance Costs (Millions of 1971 Dollars)					
	1968	1969	1970	1971	1972	1973
Feed and Kindred Products	112.6	126.4	141.0	156.4	171.9	187.3
Meat Products	20.2	21.6	23.3	25.0	26.8	28.5
Dairy Products	21.2	22.5	24.1	25.6	27.0	28.5
Canned and Frozen Foods	23.6	26.2	29.0	31.9	34.9	37.8
Sugar Refining	25.2	29.7	34.0	39.3	44.2	49.2
All Other	22.4	26.4	30.6	34.7	39.0	43.4
Textile Mill Products	51.4	55.0	59.0	63.1	67.2	71.6
Paper and Allied Products	43.9	47.3	51.8	56.4	61.2	65.9
Chemical and Allied Products	27.8	49.0	70.5	92.3	114.4	136.1
Petroleum and Coal	79.7	83.8	88.6	96.6	104.9	113.5
Rubber and Plastics, n.e.c.	2.4	4.0	5.8	7.5	9.2	10.8
Primary Metals	181.6	193.1	205.5	218.4	231.6	245.0
Blast Furnaces and Steel Mills	118.8	125.9	133.9	142.2	150.8	159.5
All Other	62.9	67.2	71.6	76.2	80.8	85.5
Machinery	3.3	4.9	6.5	8.2	9.9	11.5
Electrical Machinery	6.3	7.2	8.0	9.0	9.9	10.8
Transportation Equipment	38.7	41.4	44.0	46.8	49.4	52.2
All Other Manufacturing	20.2	27.7	35.3	43.0	50.7	58.7
All Manufacturers:						
By Wastewater Profiles and Estimates	567.9	639.8	716.1	797.7	880.3	963.3
By Census Municipal Projections	(459.6)	(597.8)	(745.5)	(896.1)	(1057.2)	(1214.8)

Source: The Economics of Clean Water, Vol. 3, USDI, FWPCA, March 1970.

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APPENDIX I

Summary of Industrial Waste: Its Origin, Character, and Treatment

Industries producing wastes	Origin of major wastes	Major characteristics	Major treatment and disposal methods
Food and Drugs Canned Goods	Trimming, culling, juicing, and blanching of fruits and vegetables	High in suspended solids, colloidal and dissolved organic matter	Screening, lagooning, soil absorption or spray irrigation
Dairy products	Dilutions of whole milk, separated milk buttermilk, and whey	High in dissolved organic matter, mainly protein, fat, and lactose	Biological treatment, aeration, trickling filtration, activated sludge
Brewed and distilled beverages	Steeping and pressing of grain, residue from distillation of alcohol, condensate from stillage evaporation	High in dissolved organic solids, containing nitrogen and fermented starches or their products	Recovery, concentration by centrifugation and evaporation, trickling filtration; use in feeds
Meat and poultry products	Stockyards, slaughtering of animals, rendering of bones and fats, residues in condensates grease and wash water, picking of chickens	High in dissolved and suspended organic matter, blood, other proteins, and fats	Screening, settling and/or flotation, trickling filtration
Beet sugar	Transfer, screening and juicing waters, drainings from lime sludge condensates after evaporator, juice, extracted sugar	High in dissolved and suspended organic matter, containing sugar and protein	Reuse of wastes, coagulation, and lagooning
Pharmaceutical products	Mycelium, spent filtrate, and wash waters	High in suspended and dissolved organic matter, including vitamins	Evaporation and drying, feeds
Yeast	Residue from yeast filtration	High in solids (mainly organic) and BOD	Anaerobic digestion, trickling filtration
Pickles	Lime water brine alum and tumeric, syrup, seeds and pieces of cucumber	Variable pH, high suspended solids, color and organic matter	Good housekeeping, screening equalization
Coffee	Pulping and fermenting of coffee bean	High BOD and suspended solids	Screening, settling, and trickling filtration
Fish	Rejects from centrifuge, pressed fish, evaporator and other wash water wastes	Very high BOD, total organic solids, and odor	Evaporation of total waste, barge remainder to sea
Rice	Soaking cooking, and washing of rice	High in BOD, total and suspended solids (mainly starch)	Lime coagulation, digestion
Soft drinks	Bottle washing, floor and equipment cleaning syrup-storage-tank drains	High pH, suspended solids and BOD	Screening, plus discharge to municipal sewer
Apparel Textiles	Cooking of fibers, desizing of fabric	Highly alkaline, colored high BOD and temperature, high suspended solids	Neutralization, chemical precipitation biological treatment, aeration and/or trickling filtration
Leather goods	Unhairing, soaking deliming and bating of hides	High total solids, hardness, salt, sulfides chromium, pH, precipitated lime and BOD	Equalization, sedimentation, and biological treatment
Laundry trades	Washing of fabrics	High turbidity, alkalinity, and organic solids	Screening, chemical precipitation flotation, and absorption

SOURCE: Nemerow, N L 1963 Theories and Practices of Industrial Waste Treatment Addison-Wesley pp 270-274

APPENDIX I

Summary of Industrial Waste: Its Origin, Character, and Treatment

Industries producing wastes	Origin of major wastes	Major characteristics	Major treatment and disposal methods
Chemicals Acids	Dilute wash waters, many varied dilute acids	Low pH low organic content	Upflow or straight neutralization, burning when some organic matter is present
Detergents	Washing and purifying soaps and detergents	High in BOD and saponified soaps	Flotation and skimming, precipitation with $CaCl^2$
Cornstarch	Evaporator condensate, syrup from final washes, wastes from "bottling up" process	High BOD and dissolved organic matter, mainly starch and related material	Equalization biological filtration
Explosives	Washing TNT and guncotton for purification, washing and pickling of cartridges	TNT, colored acid, odorous, and contains organic acids and alcohol from powder and cotton, metals, acid oils and soaps	Flotation, chemical precipitation, biological treatment aeration, chlorination of TNT, neutralization
Insecticides	Washing and purification products such as 2,4D and DDT	High organic matter, benzene ring structure, toxic to bacteria and fish acid	Dilution storage activated carbon absorption alkaline chlorination
Phosphate and phosphorous	Washing, screening, floating rock, condenser bleed-off from phosphate reduction plant	Clays, slimes and tall oils, low pH high suspended solids phosphorous silica and flouride	Lagooning, mechanical clarification, coagulation and settling of refined waste
Formaldehyde	Residues from manufacturing snythetic resins, and from dyeing snythetic fibers	Normally has high BOD and HCHO, toxic to bacteria in high concentrations	Trickling filtration absorption on activated charcoal
Materials Pulp and paper	Cooking, refining washing of fibers, screening of paper pulp	High or low pH, colored, high suspended, colloidal, and dissolved solids, inorganic fillers	Settling, lagooning, biological treatment, aeration, recovery of by-products
Photographic products	Spent solutions of developer and fixer	Alkaline, contains various organic and inorganic reducing agents	Recovery of silver plus discharge of wastes into municipal sewer
Steel	Coking of coal washing of blast-furnace flue gases, and pickling of steel	Low PH, acids, cyanogen, phenol, ore, coke, limestone, alkali, oils, mill scale and fine suspended solids	Neutralization recovery and reuse chemical coagulation
Metal-plated products	Stripping of oxides, cleaning and plating of metals	Acid, metals, toxic, low volume, mainly mineral matter	Alkaline chlorination of cyanide reduction and precipitation of chromium and lime precipitation of other metals
Iron-foundry products	Wasting of used sand by hydraulic discharge	High suspended solids mainly sand, some clay and coal	Selective screening, drying of reclaimed sand
Oil	Drilling muds salt, oil and some natural gas, acid sludges and miscellaneous oils from refining	High dissolved salts from field, high BOD, odor phenol, and sulphur compounds from refinery	Diversion recovery, injection of salts, acidification and burning of alkaline sludges
Rubber	Washing of latex, coagulated rubber, exuded impurities from crude rubber	High BOD and odor high suspended solids variable pH, high chlorides	Aeration chlorination sulfonation biological treatment
Glass	Polishing and cleaning of glass	Red color, alkaline non-settleable suspended solids	Calcium chloride precipitation
Naval stores	Washing of stumps, drop solution, solvent recovery, and oil recovery water	Acid, high BOD	By-product recovery, equalization recirculation and reuse, trickling filtration

APPENDIX I

Summary of Industrial Waste: Its Origin, Character, and Treatment

Industries producing wastes	Origin of major wastes	Major characteristics	Major treatment and disposal methods
Energy Steam power	Cooling water boiler blow-down, coal dr ''age	Hot, high volume, high inorganic and dissolved solids	Cooling by aeration storage of ashes, neutralization of excess acid wastes
Coal processing	Cleaning and classification of coal, leaching of sulphur strata with water	High suspended solids, mainly coal; low pH, high H^2SO^4 and $FeSO^4$	Settling, froth flotation, draining control, and sealing of mines
Nuclear power and radioactive materials	Processing ores, laundering of contaminated clothes, research-lab wastes, processing of fuel, power-plant cooling waters	Radioactive elements, can be very acid and "hot"	Concentration and containing, or dilution and dispersion

APPENDIX J

Sediment Erosion, Transport, and Deposition in Basin Waterways

Waters of the earth's hydrosphere are continually being transferred from one environment to another At the present time in the earth's history, the distribution of this water between environments has been estimated [1] to be

Environment	Total Mass (10^{15} tons)*	% of Total
Oceans	1,400	80.0
Pore (Ground) Waters	360	18 8
Ice	22	1 2
Rivers, Lakes	0 03	0 002
Atmosphere	0.014	0 0008
Total	1,782	100

*i e, in millions of billions of tons

Although considerable exchange of water takes place between groundwater and the surface waters of a drainage basin, it is apparent that the actual volume of water available at any one time for multiple water uses is very limited

Erosion and deposition, natural processes in all stream basins, result directly from interaction of the earth with the hydrologic cycle Water which serves as the active agent of sedimentation is introduced throughout the basin via precipitation, then either runs directly off the land surface into stream networks or percolates into soil openings and underlying bed-rock to form groundwater. Waters discharged from the drainage basin by stream and groundwater flow directly into the sea, as well as pass into the atmosphere by evaporation and transpiration Groundwater, and to a lesser extent impoundments, act as buffers to the stream system by accumulating water during times of heavy precipitation and releasing water to the streams in dry periods The result of this continual movement of water is to remove material from the higher elevations of the basin and transport it down the basin to deposit in lower levels, and, ultimately, the adjacent sea

Erosion

Within individual stream basins, particulate and dissolved materials are dislodged and transferred into the waterways primarily by surface run-off The rate, as well as type of material introduced, is dependent on three interacting variables 1) the type of bed-rock being weathered, 2) the topographic relief of the area, and 3) the climatic conditions in the basin. Of the major bed-rock types, igneous and metamorphic rocks will undergo chemical decomposition and mechanical disintegration to contribute· 1) roughly equidimensional grains of framework silicates (esp. Quartz) dominately in the sand- and silt-size; 2) flakes of alteration-product-layered silicates (clay minerals) dominate in the clay-size range, and 3) assorted elements in solution (esp. cations K, Na, Ca, Fe, Mg, Si). Sedimentary rocks composed of detrital grains predominately contribute their component grain types to the water system again. Likewise, chemical-precipitate sedimentary rocks typically contribute elements in solution upon leaching (e g., Ca, Mg, Fe, Na) in addition to minor amounts of quartz, silt, and clay mineral grains

The influence of the second variable, topography, is reflected most strongly in the rate at which weathered material is transferred into the waterways Climatic conditions, the third major variable, extends a major control on the type of weathered material actually introduced into the waterway by influencing the manner in which the bed-rock is weathered Additionally, it determines the amount of water physically present to removed, transport and deposit the eroded materials Abundant water provides a condition favorable to chemical alterations, while temperature influences the rate of these reactions A cold/arid climate therefore favors slow mechanical breakdown of particles for transport with little chemical alteration to clays. Conversely, the warm/humid climate favors extensive chemical weathering combined with mechanical disintegration Were there not a natural counterbalancing relation between climate and vegetation, the warm climate with high rainfall should produce the greatest input of material into the basin waterways While this is generally true for dissolved materials, the maximum particulate sediment introduction actually occurs where precipitation is about 15 inches (Figure J 1) Table J.1 illustrates several examples of the particulate and dissolved materials from several rivers of different climatic regions of the United States

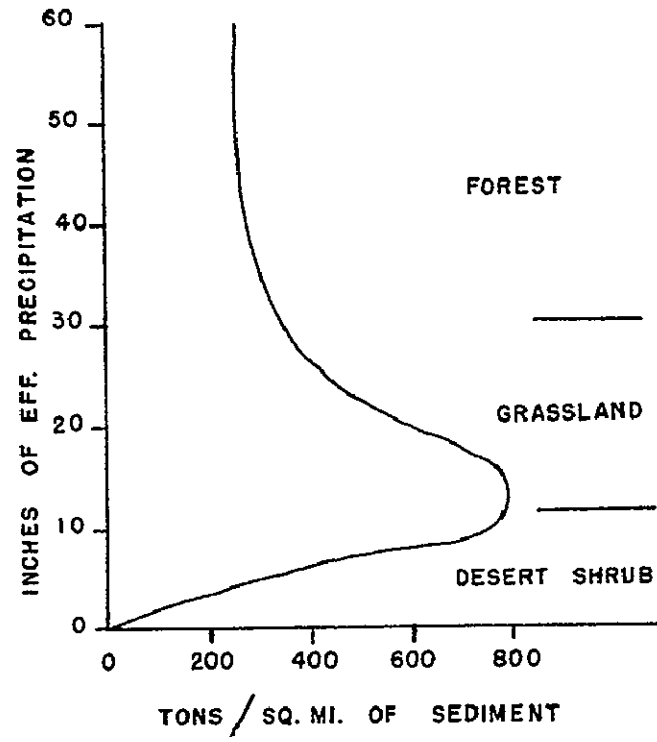


FIGURE J.1 CLIMATIC VARIATION OF YIELD OF SEDIMENT (FM. LANGBEIN, SCHUMM, 2)

Table J.1

Dissolved and Suspended Load in Selected Rivers in Different Climatic Regions of the United States

River and Location	Elevation (ft)	Drainage Area (sq mi)	Average Discharge, Q (cfs)	Discharge + Drainage Area (cfs/sq mi)	Years of Record in Sample[a]	Avg. Suspended Load	Avg. Dissolved Load (millions of tons/yr)	Total Avg. Suspended & Dissolved Load	Total Avg. Load + Drainage Area (tons/sq mi/yr)	Dissolved Load as Percent of Total Load (%)
Little Colorado at Woodruff, Ariz.	5,129	8,100	63.3	.0078	6	1.6	.02	1.62	199	1.2
Canadian River near Amarillo, Tex.	2,989	19,445	621	.032	1	6.41	.124	6.53	336	1.9
Colorado R. near San Saba, Tex.	1,096	30,600	1,449	.047	5	3.02	.208	3.23	105	6.4
Bighorn River at Kane, Wyoming	3,609	15,900	2,391	.150	1	1.60	.217	1.82	114	12
Green River at Green River, Utah	4,040	40,600	6,737	.166	26-20	19	2.5	21.5	530	12
Colorado River near Cisco, Utah	4,090	24,100	8,457	.351	25-20	15	4.4	19.4	808	23
Iowa River at Iowa City, Iowa	627	3,271	1,517	.464	3	1.184	.485	1.67	510	29
Mississippi River at Red River Landing, Louisiana		1,144,500[b]	569,500[b]	.497	3	284	101.8	385.8	337	26
Sacramento River at Sacramento, California	0	27,000[c]	25,000[c]	.926	3	2.85	2.29	5.14	190	44
Flint River near Montezuma, Ga.	256	2,900	3,528	1.22	1	.400	.132	.53	183	25
Juniata River near New Port, Pa.	364	3,354	4,329	1.29	7	.322	.566	.89	265	64
Delaware River at Trenton, N. J.	8	6,780	11,730	1.73	9-4	1.003	.830	1.83	270	45

[a]Computation of load, dissolved or suspended, depends on discharge for same period. Years of record pertain to number of years used for related values of discharge and of suspended and dissolved load. Where two figures are shown, the first is for suspended load and the second is for dissolved load.

[b]From USGS records for Vicksburg, Mississippi station.

[c]Estimated.

Transportation

Once into the basin's waterways, material is transported in either the dissolved or solid state The stream's dissolved load usually flows with the water uninterrupted to the sea Exceptions may involve ion exchanges with the solid load (esp clay minerals), marked alterations in the river water's physical properties (often resulting in chemical precipitation), or evaporation of the stream's water in arid regions The magnitude of dissolved load from several selected waterways is indicated in Table J.1

The transport mechanism of solid load by the stream network operates more intermittently and depends primarily upon the particle size and stream velocity The rate of particle settling is controlled by gravity and in part related to water viscosity, density of the grain, and radius of the grain. Opposing the gravitational settling is the "lift" provided to particles by internal turbulence of the flowing stream. Figure J 2 illustrates how, in a mixture of grain sizes introduced into a steady current, the finer particles will be carried further downstream This "by-passing" of finer material (plus natural wearing away of coarser grains by mechanical abrasion in the channel) leads to decrease of total stream load particle size downstream Figure J.3 illustrates this change for the Mississippi River

The clay minerals and quartz silts then comprise the bulk of a stream's suspended load, while larger grains of the bed load typically move along the bottom by sliding, rolling and siltation As velocity increases, larger particles become incorporated into the suspended load; and particles, originally too large to move, begin movement as bed load. Conversely, as the stream slows, much of the material initially in motion settles out Except for the very finest clays, therefore, transport of a stream's solid sediment load is quite discontinuous and dependent on the stream velocity Figure J 4 shows the generalized relationship between current velocity and ability to transport grains of varying sizes An individual grain, therefore, may be involved in many events of deposition and re-entrainment before transportation brings it to the sea

Deposition

Among the shorter period depositional events are those associated with the water stage of the river or stream Stream discharge (cubic feet per second—cfs) is directly proportional to the velocity and cross-section area of the channel. With increased discharge during wet seasons, velocity is increased resulting in an increased sediment load. Likewise, increased discharge is usually also accommodated by increased channel cross-section area through rise in water level, and, in cases of unconsolidated stream beds, physical enlargement of the channel sides and bottom (see Figure J 5) with decrease in discharge, the coarser sediment is re-deposited to await the next period of high discharge when transport will be renewed This relationship, combined with increased run-off transportation into the waterways during wet seasons, accounts for the characteristic sediment discharge

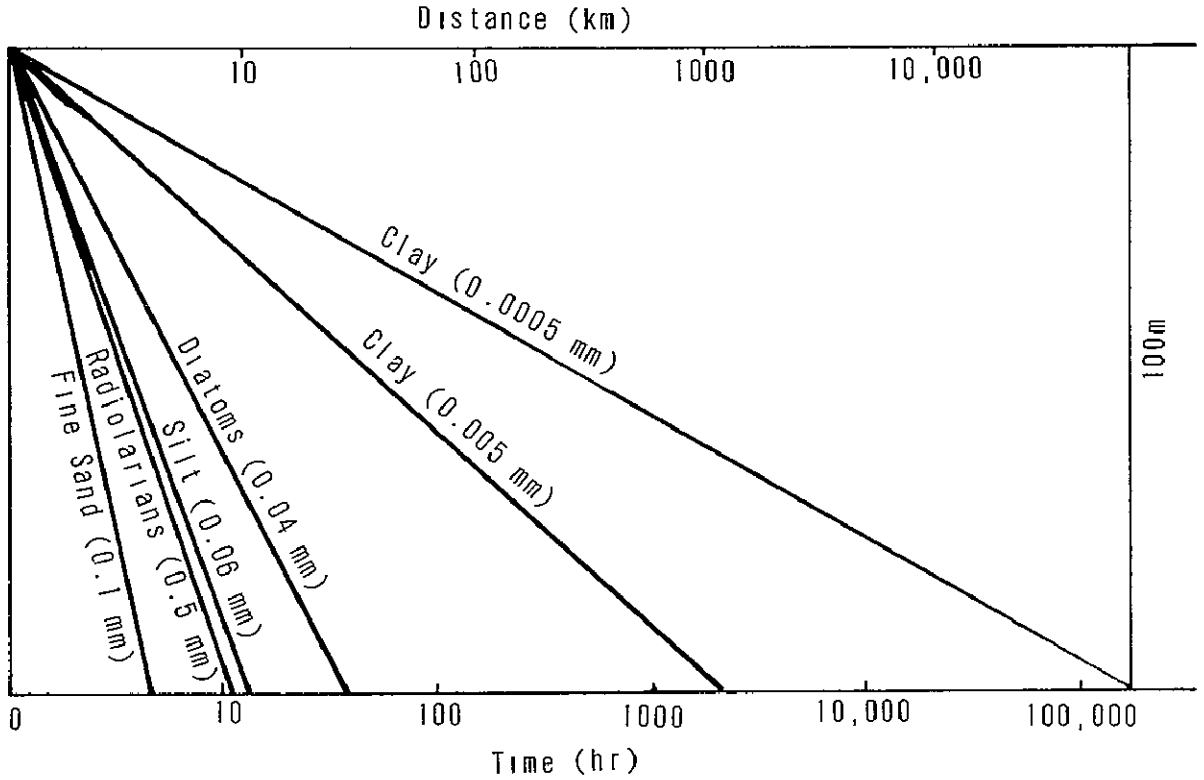


FIGURE J.2 TRANSPORT TIME AND DISTANCE FOR VARIOUS SIZED PARTICLES TO SETTLE 100 M. IN CURRENT OF 10 CM/SEC. (AMER. GEOL. INST., 4)

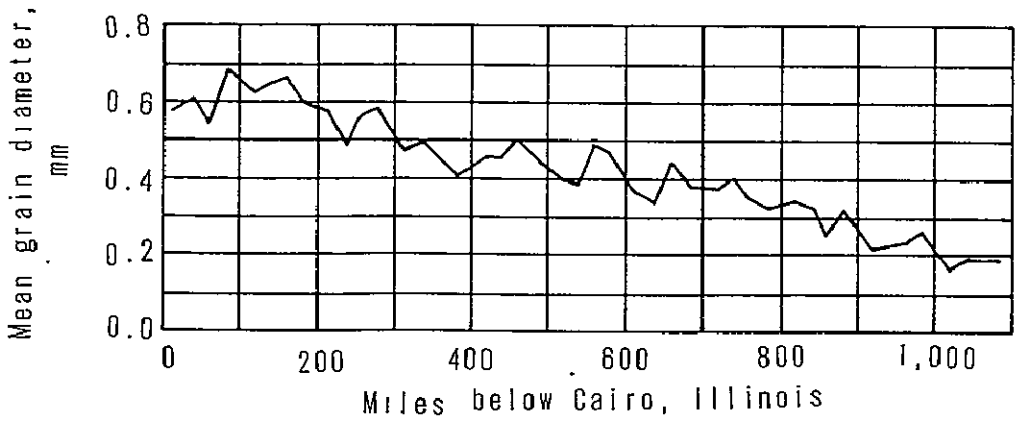


FIGURE J.3 GRAIN SIZE CHANGE DOWNSTREAM IN LOAD OF MISSISSIPPI RIVER (FM. MISS. RIVER COMM., 5)

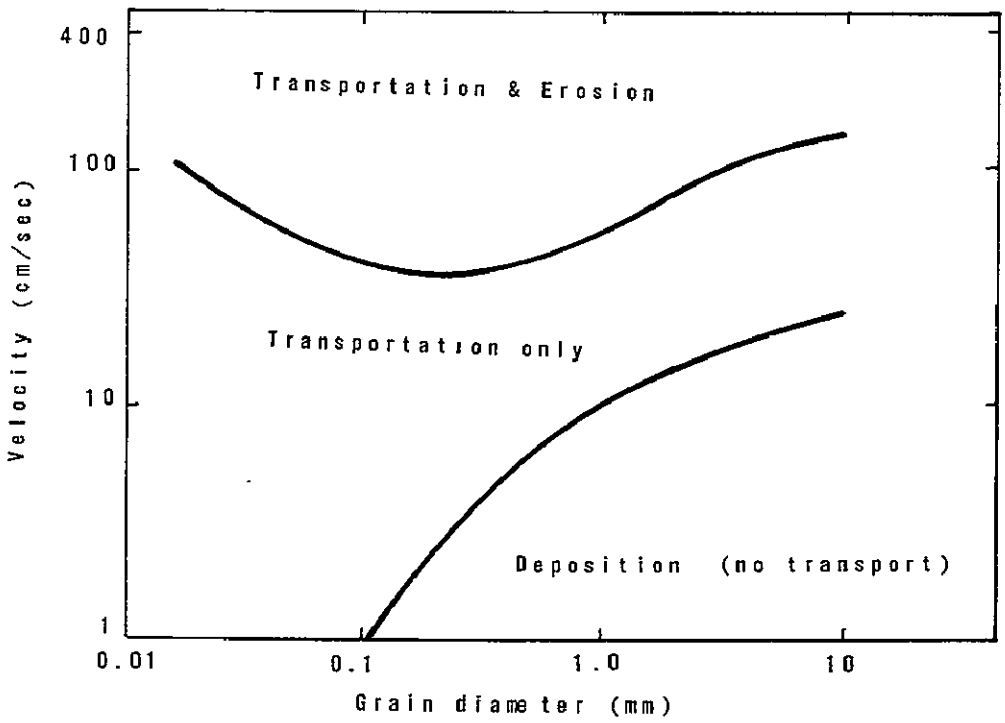


FIGURE J.4 EXPERIMENTAL CURVES RELATING STREAM VELOCITY AND GRAIN DIAMETER TO PARTICLE EROSION, TRANSPORTATION, AND DEPOSITION (FM. HJULSTROM,6)

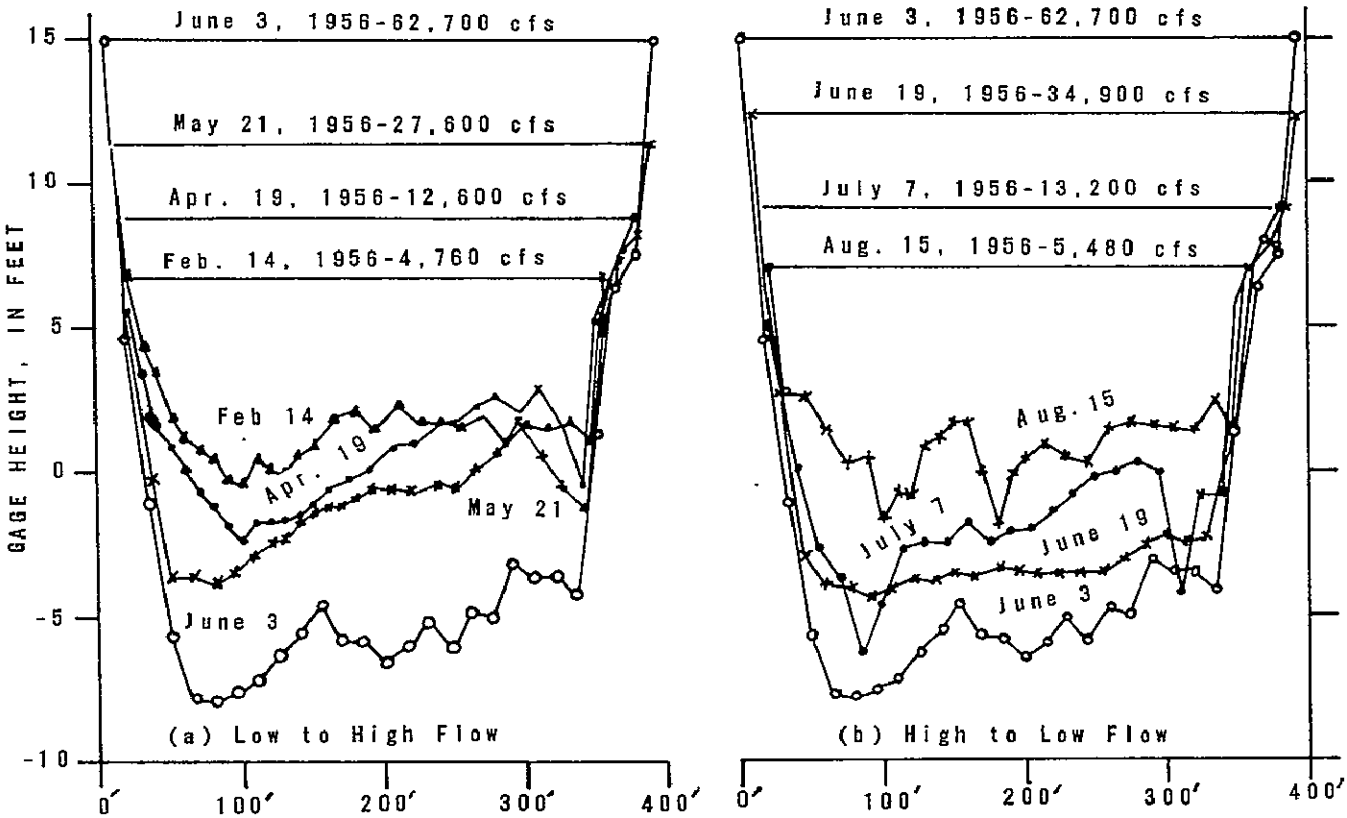


FIGURE J.5 SCOUR AND SUBSEQUENT FILL OF STREAM CHANNEL, COLORADO RIVER AT LEES FERRY, ARIZONA, YEAR 1956 (FM. LEOPOLD, WOLMAN, MILLER, 3)

distributions such as Figure J.6 Data indicated in the latter figure and Table J 2 emphasize the importance of the periodic (non-catastrophic) flood in flushing accumulated sediment out of the stream network

Other, more permanent sediment deposits also occur which are closely associated with stream channels. The best known, of course, occur as sediment-laden waters in flood stage leave the high velocity channels to overflow onto the stream flood plain An equally common example results from non-uniform velocities within the channel. As seen in Figure J.7, higher velocities impinge near the concave side of the channel at a bend, removing and entraining sediment Concurrently, at the convex side lower velocities are associated with deposition and accretion of the bank A less spectacular and slower process is a form of stream silting resulting from successive decrease in annual discharge Due perhaps to a changing climate or loss of a portion of its headwaters, a stream channel will gradually decrease its cross-section area to accommodate the reduced flow. This is accomplished by sediment slowly accreting to the side as well as shoaling of the channel bottom

Where a stream enters a lake or other large body of water, an abrupt decrease in velocity occurs in a very short distance. Coarser sands and/or silts are deposited almost immediately and accumulate to form a bar at the channel mouth Finer sediments are carried out into the open body of water beyond the stream mouth. As noted above, most sediment accumulation is associated with higher river stages and, if the river transports sufficient material annually, considerable land can be built up as delta deposits into the open water body.

Ultimately the waterways of a drainage basin empty into the marine waters of the oceans and contiguous seas. Additional complexities are introduced at this junction due to oceanic tidal effects and mixing of the fresh and marine waters. The first of two common cases is characterized by rivers of the eastern coast of the United States These basins, characterized by relatively short rivers draining the adjacent Appalachian mountains, empty into large, brackish to marine, physiographic estuaries. The embayments were carved by river or glacial activity when sea level stood about 450 ft lower during the last glacial stage Sediment loads introduced since the return to present ocean base level have been insufficient to refill the estuaries. This open estuary infilling process is actively, but slowly continuing today Figure J 8 illustrates this type of estuary. Coarser sediments, as in lake junctions, tend to be concentrated, initially at least, near the head of the estuary Finer silts and clays are carried out into the open water in the wedge of fresh water flowing out above the higher density salt waters The coarser fraction of this finer sediment will settle out. Fine clay particles, which would normally remain in suspension for long periods of time, when brought into contact with the marine waters at the interface between the salt and fresh water, flocculate and settle out Tide effects in the estuary, depending on the tidal range, may markedly rework the sediments being introduced and redistribute them throughout the embayment. The flood

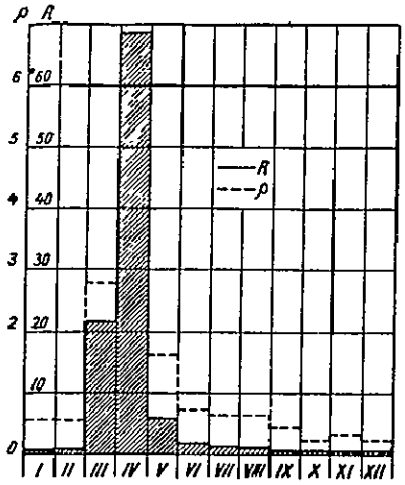


FIGURE J.6 DISCHARGE OF MEAN MONTHLY SEDIMENT LOAD R AND SILT CONTENT P FOR THE OKA RIVER (FM. SOKOLOVSKII, 7)

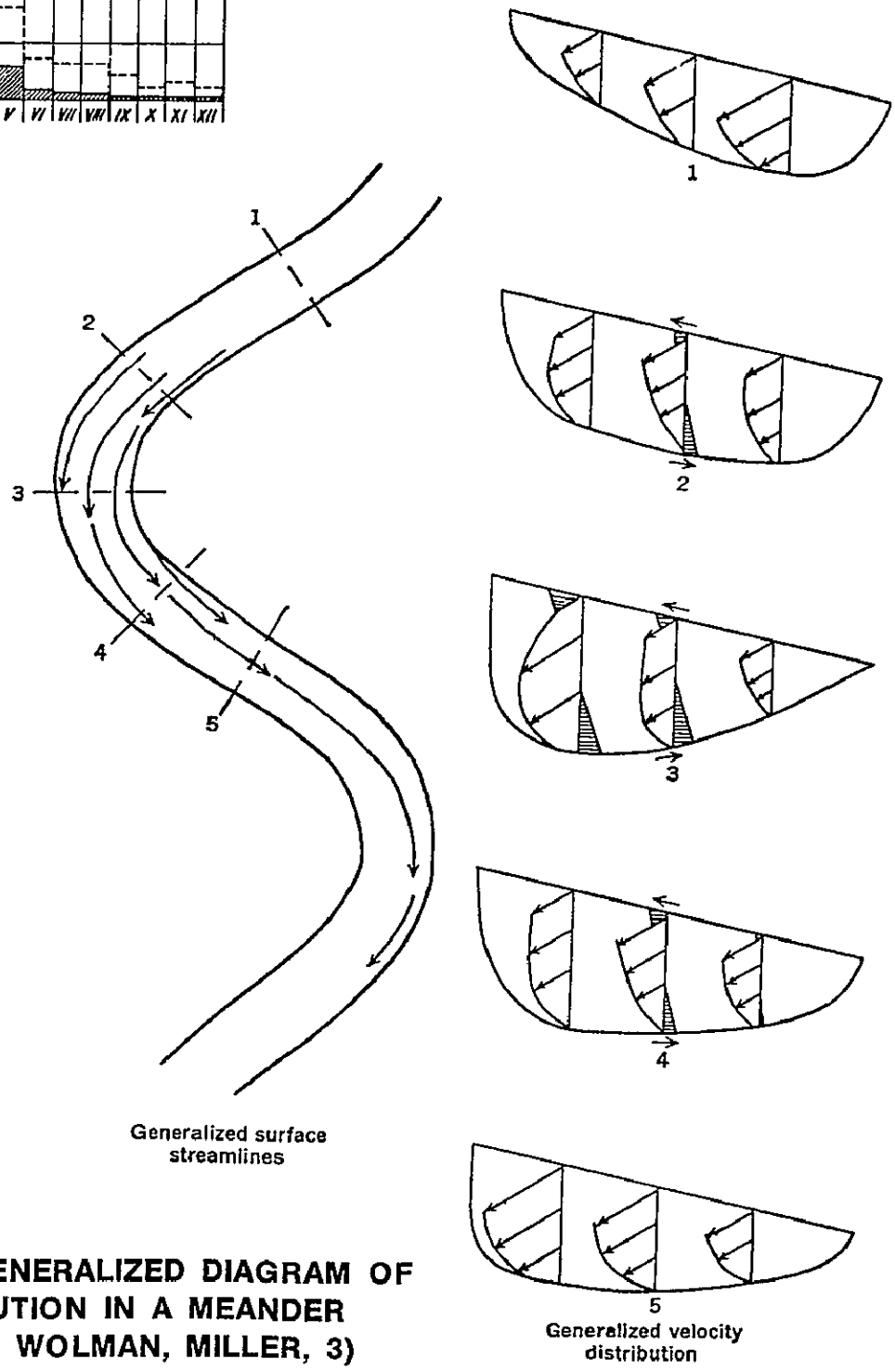


FIGURE J.7 GENERALIZED DIAGRAM OF FLOW DISTRIBUTION IN A MEANDER (FM. LEOPOLD, WOLMAN, MILLER, 3)

Table J.2a

Time Required to Transport Various Percentages of Total Suspended Load

River and Station	Drainage Area (sq. mi.)	Percentage of Total Suspended Load Carried During: Maximum Day	10 Maximum Days	Events Which Recur 1 Day/Yr	Days/Year Required to Transport 50% of Load
Colorado River at Grand Canyon, Arizona	137,800	0.5	4	92	31
Rio Puerco at Rio Puerco, New Mexico	5,160	5	31	82	4
Cheyenne River near Hot Springs, South Dakota	8,710	5	28	78	4
Niobrara River near Cody, Nebraska	3,000*	2	7	95	95

*Approximate.

Table J.2b

Values of hydraulic parmeters at the same discharge (5,000 cfs) on rising and falling stage of flood of Sept.-Dec. 1941, San Juan River near Bluff, Utah

Parameters	Units	Rising Stage	Falling Stage
Discharge	cfs	5,000	5,000
Width	feet	182	189
Velocity	feet/second	8.6	6.0
Depth	feet	3.2	4.4
Suspended load	tons/day	1,000,000	100,000
Elevation of bed above arbitrary datum	feet	5.3	3.3

tide likewise may transport sediment into the estuary from the seaward end

The second major class of river and ocean junction is characterized by rivers with large drainage basins and a heavy annual sediment load. In this class, exemplified by the Mississippi River, sediments have completely filled its Pleistocene carved estuarine valley The mouth of these rivers advances seaward by accretion of large deposits of deltaic sediments Fresh water encounters the sea usually from multiple, well defined distributary channels, depositing its load at each mouth as indicated in Figure J.9 Low lying ponds, marshes, and open embayments between the seaward moving channels, are maintained or filled through introduction of sediment by channel overflow during flood stages of the river Opposing accretion of this deltaic land is the constant coastal erosion associated with impinging wave trains and, locally, gradual subsidence due to compaction and/or crustal warping.

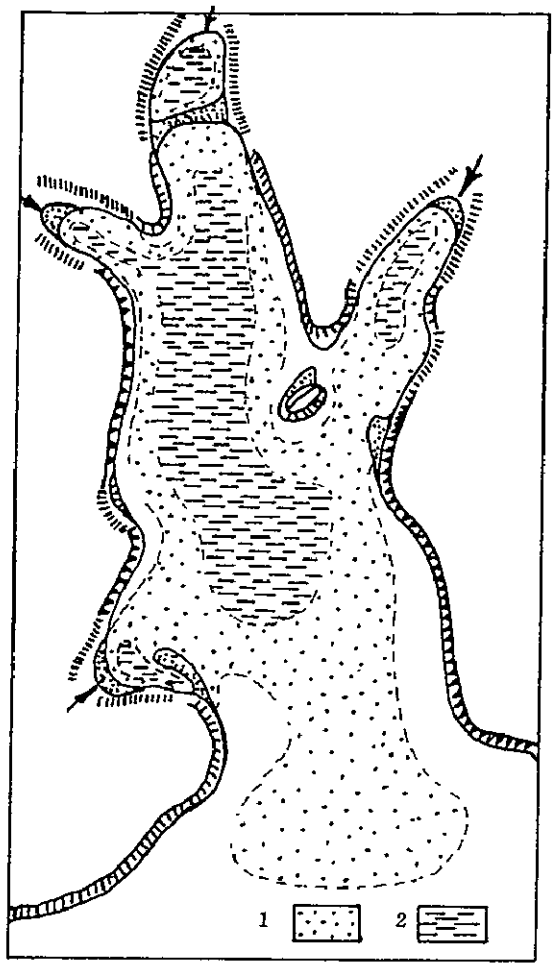
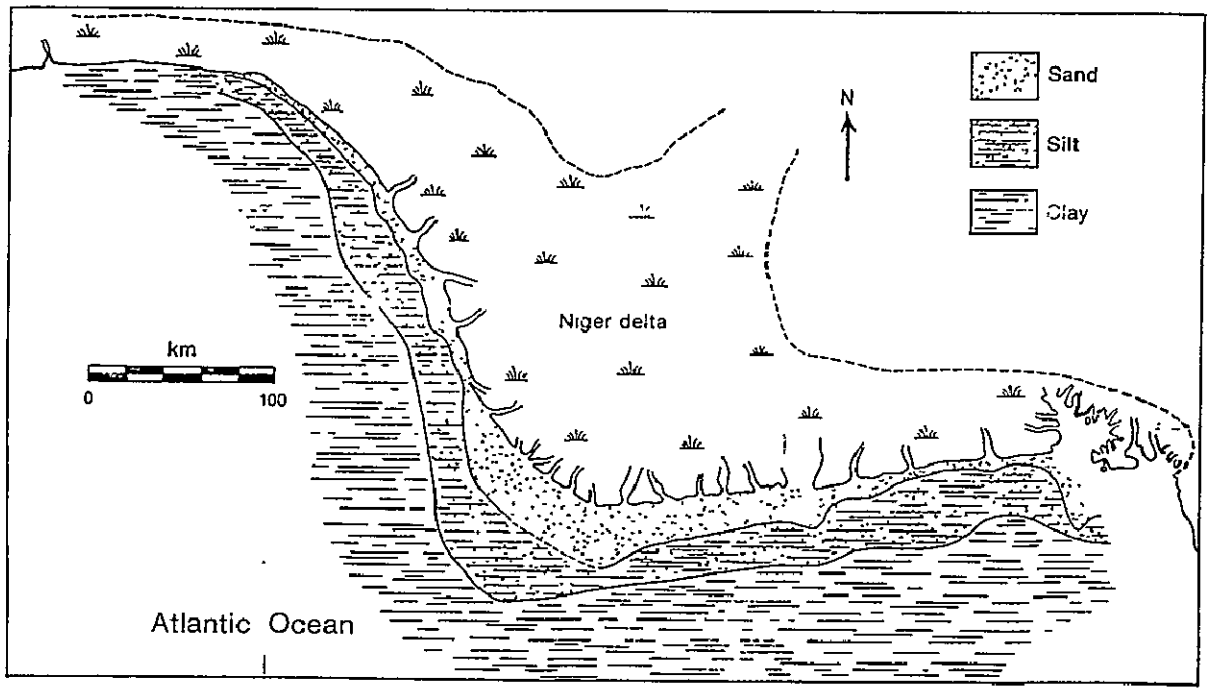


FIGURE J.8 SIMPLIFIED DIAGRAM OF ELONGATED EMBAYMENT
1-Sand; 2-Silt
(FM: ZENKOVICH, 8)

FIGURE J.9 BOTTOM SEDIMENT TYPE AND DISTRIBUTION, NIGERIAN COAST (FM. GARRELS AND MACKENZIE, 1)



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Appendix K

Water Resource Extractions and Returns

Water	Major Resource Uses and Environmental Manipulations	Directly Returned Resources and Resource Residuals	Approximate Amounts of Returns per Year (1970)
Agriculture/Farming	Consumption by Humans & Animals	Water-Diluted Wastes	500 Billion Gallons
	Irrigation		
	Waste Dilution		
Municipal/Residential	Consumption	Waste-Containing Water	7 Trillion Gallons
	Open Space		
	Waste Dilution		
Transportation/ Circulation	Right-of-Ways	Solid Wastes and Excrements	Not Well Established
	Watercraft Waste Disposal	Fuel Residuals and Spillage	Not Well Established
Industry/ Manufacturing	Processing	Heated Water	2.5 Trillion Gallons
	Cooling	Waste-Containing Water	20 Trillion Gallons
	Waste Dilution		
Resource Supply/ Mining	Consumption	Flushing and Process Water	7 Trillion Gallons
	Flushing and Mine Percolation	Gangue	Not Known
	Operations		
Energy Conversion/ Power Generation	Cooling	Heated Water	45 Trillion Gallons
	Hydropower	Hydropower Return	200 Trillion Gallons

Source: Dowdy, W.L., G. E. Clark, and R. G. Crum. 1970. Improved environmental management through advanced equipment and techniques. Technical Paper from the Space Division, North American Rockwell, Downey, California.

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APPENDIX L

WATER RESOURCE AGENCIES

1. DEPARTMENT OF AGRICULTURE AND COMMERCE

Service and regulatory

Purpose: to improve and expand the marketing of Virginia farm products and to protect the consumer.

Policies: Board comprised of 1 member from each congressional district appointed by the governor, plus the president of Virginia Polytechnic Institute (ex-officio) Executive officer—commissioner appointed by Governor

Enforces laws with respect to fertilizers, insecticides, sold in Virginia

Collects and disseminates information crops

Enforces laws relating to control of contagious and infectious diseases of plants and animals

2. DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT

Purpose: to preserve, develop, and advertise the resources of the Commonwealth

Policies: Executive office—director appointed by the governor, 12 members of board appointed by governor

DIVISIONS:

Forestry:

Enforces forest fire laws

Conducts reforestation programs

Conducts programs to control insects and diseases which attack forest

Mineral Resources:

Investigates geology, rock, mineral, and coal resources of state; maintains a cooperative topographic mapping program

Parks:

Operates and maintains state parks, recreational areas, and historical attractions and natural areas

Virginia State Travel Service:

Advertises Virginia's travel and vacation attractions

Water Resources:

Prepares comprehensive plans for water resources development; makes recommendations for river basin management Sections include: surface water investigation, quality geology and ground water, publishes information on streamflow and quality of surface waters.

Mined-Land Reclamation:

Regulates surface mining operations

Division of Salt Water Sport Fishing Promotion:

Publishes literature and answers requests pertaining to sport salt fishing

3. VIRGINIA SOIL AND WATER CONSERVATION COMMITTEE

Purpose: conserve soil and soil resources and control soil erosion, prevent flooding

Policy: 7 of 11 commissioners appointed by governor, 4 ex officio. Offer financial and technical assistance to supervisors of soil and water conservation districts, which in turn aid landholders in proper management of their land

4. MARINE RESOURCES COMMISSION (VMRC)

Policy: chairman appointed by governor (paid commissioner), 6 commission members appointed by governor

Purpose: enforce laws relative to fish and shellfish in Tidewater.

License commercial fisherman

Operate a patrol boat

Map and lease oyster grounds to citizens

5. VIRGINIA INSTITUTE OF MARINE SCIENCE (VIMS)

Policy: 8 citizens appointed by governor, Commission of Fisheries (VRMC) ex officio Conduct biological, chemical, and geological and physical studies of the marine environment; investigate problems of commercial and sport fishing industry; maintain a teaching program in oceanography; advise state Water Control Board.

Funded by appropriations from the General Fund of the Commonwealth.

Special research projects funded by grants and contracts from Federal, State, and private agencies

6. COMMISSION OF GAME AND INLAND FISHERIES

Purpose: Conserve and manage game and fish of fresh water and specified game preserves in salt water

Establish and enforce regulations under which game and fish are protected

Administer and enforce boating laws.

Manage public hunting and fishing areas

Acquire public access ways to shores for boat-landing facilities

Policy: 10 members appointed by governor Commission elects a chairman from these 10 and appoints a full-time executive director

Disseminate and publish educational material on outdoor resources

7. POTOMAC RIVER FISHERIES COMMISSION

Compact between Virginia and Maryland; 3 members from Virginia, 3 members from Maryland Virginia members from VMRC.

Purpose: survey, research, license, inspect, regulate fish and shellfish and seafood which is taken or may be taken from the waters of the Potomac River within its jurisdiction

8. ATLANTIC STATES MARINE FISHERIES COMMISSION

Compact with states of Atlantic Seaboard for the better utilization of fisheries 3 commissioners from each state Virginia commissioners appointed by governor—1 from General Assembly, 1 citizen knowledgeable in marine fisheries problems, 1 from VMRC

9. POTOMAC RIVER BASIN COMMISSION OF VIRGINIA

Compact between Maryland, West Virginia, Pennsylvania, Virginia and D.C. with consent of U S. Congress. Created conservancy district of Potomac River and its tributaries

Purpose: to encourage and promote abatement of existing pollution and prevention of future pollution in the streams of the conservancy district through research, public information, and cooperation with legislative and administrative agencies

Policy: 3 commissioners from each signatory body and 3 appointed by President of U S. The 3 appointees by governor to the Interstate Commission on the Potomac River Basin comprise the PRBC of Virginia

10. OHIO RIVER VALLEY WATER SANITATION COMMISSION

Compact between Illinois, Indiana, Kentucky, New York, Pennsylvania, Ohio, Virginia and West Virginia.

Purpose: control of future pollution and abatement of existing pollution of the waters of the Ohio River Basin Promulgates regulations, secures compliance by

municipalities and industries by pledged obligation of each state

Commission: 3 members from each compact state and 3 from U S appointed by governor or president respectfully In Virginia, the chairman and 2 other members of the State Water Control Board serve

11. STATE DEPARTMENT OF HEALTH

Policy: 9 members appointed by governor, state health commissioner ex officio; 1 member each from division of the state, 1 from Medical Society of Virginia, 1 each from Virginia State Dental Association and Virginia Pharmaecutical Association Commissioner, appointed by governor and must be a physician Includes division of Local Health Services and

Division of Engineering

Sanitary Engineering—supervises water supplies, inspects sewage treatment plants Advises State Water Control Board.

Shellfish Sanitation—inspects processing and packing of shellfish and crabmeat products, survey of growing areas and planting grounds made for signs of pollution and approved or disapproved for direct marketing of shellfish

Solid Waste and Vector Controlguides mosquito control districts and rodent control programs, executed in cooperation with local health services.

Industrial Hygiene—inspects industrial and commercial establishments

Radiological Health—radiation surveillance, assists AEC

12. VIRGINIA STATE PORTS AUTHORITY

Purpose: to promote the development of and solicit cargo through the ports of Virginia

Commission: 7 members, power of corporate body, businessmen appointed by governor, executive director appointed by board Construct and control port facilities

13. STATE CORPORATION COMMISSION

Issues all charters in the state to corporation and businesses Has authority paramount to Water Control Board in flow releases from dams for hydrelectric power

14. STATE WATER CONTROL BOARD

Purpose: to protect the quality of state waters.

Policy: 7 man board appointed by governor, board appoints executive secretary Established water quality standards, enforces standards through system of certification for discharges; can enforce orders through injunctive procedure in appropriate court. Investigates fish kills Does some regional water studies under special grants or fundings

ADDITIONAL AGENCIES

Hampton Roads Sanitation District Commission, Breaks Interstate Park Commission, Virginia Beach Erosion Commission, Chesapeake Bay Bridge and Tunnel Commission, Turnpike Authorities, Elizabeth River Tunnel Commission, Department of Highways, Division of State Planning and Community Affairs, Governors Council on the Environment (Executive), Industrial Development (Executive)

In an effort to provide some coordination with a focus upon environmental concerns among such a plethora of departments, agencies, commissions, boards, and authorities, the Governor in 1970 created a Council on the Environment whose precise impact is too current to be evaluated at this time. It is not entirely unlikely that, following the precedent of its analog on the federal level in 1970, it may recommend something similar to a state-level environmental protection agency

Appendix M

Tributaries of James River

Stream Name	Drainage Area (Sq. Mi.)	Length Miles	Elevation At Source	Elevation At Mouth	Mouth In County	Miles Above Mouth
James River	10,102.17	434.4	3,980	0	Norfolk-Hampton City Line	Chesapeake Bay
Jackson River	904.80	95.7	3,980	990	Botetourt	338.7
Cowpasture River	464.10	83.6	2,990	990	Botetourt	338.7
Sinking Creek	22.06	13.2	3,230	923	Botetourt	327.7
Mill Creek	22.53	10.9	2,870	922	Botetourt	327.5
Craig Creek	372.61	80.8	2,930	908	Botetourt	323.7
Lapsley Run	8.24	8.6	2,570	890	Botetourt	319.0
Catawba Creek	115.39	42.1	2,430	888	Botetourt	318.8
Hickory Hollow Branch	7.41	5.5	3,494	870	Botetourt	315.2
Mill Creek	62.51	15.3	1,504	819	Botetourt	303.6
Purgatory Creek	12.30	9.3	3,450	812	Botetourt	301.8
Jennings Creek	35.46	9.5	3,680	790	Botetourt	296.6
Cedar Creek	16.06	11.9	3,215	730	Rockbridge	287.3
Elk Creek	17.73	14.9	2,591	715	Rockbridge	283.8
Maury River	839.30	80.3	3,802	701	Rockbridge	280.8
Otter Creek	11.76	10.3	3,376	615	Amherst	272.9
Hunting Creek	8.67	8.3	3,550	602	Bedford	271.7
Reed Creek	22.12	11.5	4,010	590	Bedford	270.8
Pedlar River	107.00	30.9	2,970	555	Amherst	265.7
Judith Creek	13.03	9.9	980	540	Bedford Lynchburg City	257.7
Harris Creek	48.12	21.4	1,820	512	Amherst	254.8
Blackwater Creek	65.45	10.4	639	498	Lynchburg City	253.2
Williams Run	6.61	5.5	905	486	Amherst	249.8
Opossum Creek	14.54	9.3	1,130	481	Campbell	248.1
Beaver Creek	36.95	12.0	970	478	Campbell	247.5
Archer Creek	8.62	7.2	885	477	Campbell	247.3
Joshua Creek	3.68	2.8	825	452	Appomattox	241.2
Beck Creek	16.81	6.0	637	443	Amherst	239.8
Partridge Creek	14.80	9.0	940	433	Amherst	237.5
Stonewall Creek	13.99	9.5	858	432	Appomattox	237.1
Wreck Island Creek	58.86	17.9	840	409	Appomattox	230.0
Allen Creek	12.23	6.2	1,002	390	Amherst-Nelson Line	227.0
Bent Creek	30.93	13.2	1,022	382	Appomattox	224.7
David Creek	41.76	15.7	953	375	Buckingham-Appomattox Line	223.4
Owens Creek	10.70	6.5	920	355	Nelson	217.0
Tye River	417.61	41.7	3,000	350	Nelson	215.1
Mallorys Creek	7.62	7.4	1,602	344	Buckingham	212.8
Sycamore Creek	10.16	6.7	702	310	Buckingham	202.2
Rockfish River	247.18	40.0	3,810	290	Albemarle-Nelson Line	196.9
Ballinger Creek	17.37	9.4	645	271	Albemarle	191.3
Rock Island Run	20.41	8.9	593	270	Buckingham	190.5

(Continued)

Tributaries of James River (Continued)

Stream Name	Drainage Area (Sq. Mi.)	Length Miles	Elevation At Source	Elevation At Mouth	Mouth In County	Miles Above Mouth
Totier Creek	29.54	10.2	702	260	Albemarle	186.7
Hardware River	137.95	21.3	385	237	Fluvanna	179.1
Bremo Creek	9.18	6.5	505	215	Fluvanna	175.7
Slate River	244.91	47.6	1,080	208	Buckingham	174.4
Bear Garden Creek	14.36	9.1	505	198	Buckingham	172.7
South Creek	13.94	6.1	410	181	Fluvanna	164.9
Rivanna River	769.52	76.7	1,280	178	Fluvanna	163.2
Byrd Creek	112.44	18.8	266	170	Goochland	159.2
Willis River	278.27	56.1	690	165	Cumberland	155.8
Muddy Creek	40.57	13.6	410	160	Cumberland	152.7
Deep Creek	80.76	20.2	428	150	Powhatan	146.7
Gaddes Creek	2.07	3.0	330	149	Powhatan	145.9
Solomons Creek	4.90	4.3	370	149	Powhatan	145.5
Big Lickinghole Creek	70.74	14.9	415	143	Goochland	140.4
Little Creek	8.03	4.6	365	142	Goochland	139.5
Mohawk Creek to dam at Beaumont	5.74	4.4	345	160	Powhatan	137.5
Hughes Creek	4.07	3.7	345	135	Powhatan	135.4
Beaverdam Creek	40.13	8.6	322	130	Goochland	133.1
Fine Creek	23.16	10.4	370	126	Powhatan	130.9
Genito Creek	10.71	6.9	385	123	Goochland	129.0
Dover Crk. to Little River Mouth	8.44	7.2	375	120	Goochland	127.5
Norwood Creek	35.93	7.4	318	117	Powhatan	124.9
Tuckahoe Creek	63.34	17.4	382	117	Goochland-Henrico Line	120.7
Bernards Creek	21.12	7.8	325	113	Powhatan	120.6
Spring Creek	1.50	2.3	382	112	Chesterfield	118.3
Westham Creek to James River and Kanawha Canal	1.88	2.7	338	110	Henrico	115.3
Rattlesnake Creek	1.68	2.4	327	103	Chesterfield	114.1
Powhite Creek	12.82	8.5	370	82	Chesterfield	111.3
Reedy Creek	3.45	3.9	327	59	Richmond City	109.6
Gillies Creek	15.26	6.7	161	0	Richmond City	106.5
Almond Creek	5.44	3.3	155	0	Henrico	105.2
Mill Creek	0.98	1.7	165	0	Chesterfield	103.6
Falling Creek	60.66	23.0	365	0	Chesterfield	100.3
Cornelius Creek	10.61	8.1	165	0	Henrico	98.6
Coles-Run	1.78	2.8	135	0	Henrico	98.5
Kingsland Creek	13.40	8.5	220	0	Chesterfield	96.6
Proctors Creek	18.70	8.7	215	0	Chesterfield	95.2
Roundabout Creek	5.81	6.3	149	0	Henrico	88.4
Fourmile Creek	19.87	8.1	165	0	Henrico	88.1
Turkey Island Creek	19.29	10.9	145	0	Henrico-Charles City Line	79.8
Shand Creek	1.12	5.9	75	0	Chesterfield	75.6
Johnson Creek	9.82	16.0	142	0	Chesterfield	75.4
Appomattox River	1,599.54	152.2	846	0	Chesterfield-Pr. George Line	75.1

(Continued)

Tributaries of James River (Continued)

Stream Name	Drainage Area (Sq. Mi.)	Length Miles	Elevation At Source	Elevation At Mouth	Mouth In County	Miles Above Mouth
South Fork Appomattox River	8.64	5.7	865	527	Appomattox	144.3
Bailey Creek	20.70	8.8	143	0	Prince George	73.7
Kimages Creek to Charles Lake	5.52	3.8	90	8	Charles City	71.0
Chappell Creek	3.53	3.7	145	0	Prince George	69.9
Powell Creek	31.85	11.6	125	0	Prince George	67.8
Herring Creek	28.29	5.7	20	0	Charles City	66.9
Queens Creek	26.41	2.0	8	0	Charles City	64.2
Flowerdew Hundred Creek	7.95	6.6	110	0	Prince George	61.5
Wards Creek	25.65	11.7	121	0	Prince George	60.5
Mapsico Cr. to Kettewan Creek	5.61	5.6	85	0	Charles City	58.1
Kennon Creek	3.81	3.9	41	0	Charles City	55.8
Upper Chippokes Creek	43.92	12.4	130	0	Prince George-Surry Line	51.9
Sunken Meadow Creek	7.73	4.2	125	0	Surry	49.1
Chickahominy River	461.63	83.4	280	4	Charles City-James City Line	46.5
Powhatan Creek	22.06	8.9	31	0	James City	41.3
Grays Creek	21.73	10.6	110	0	Surry	40.4
College Run	8.22	6.6	125	0	Surry	36.9
Lower Chipokes Creek	9.86	8.4	95	0	Surry	36.6
Mill Creek to the Thorofare	5.58	16.1	110	0	James City	34.6
College Creek	14.25	7.7	110	0	James City	33.0
Grove Creek	1.77	2.3	81	0	James City	31.0
Skiffes Creek	11.51	7.6	85	0	James City	28.4
Hunnicut Creek	1.78	2.1	35	0	Surry	26.7
Lawnes Creek	18.74	9.8	88	0	Surry	26.3
Warwick River	40.09	18.1	90	0	City of Newport News	18.8
Deep Creek	5.63	4.2	30	0	City of Newport News	18.2
Pagan River	70.50	12.1	55	0	Isle of Wight	17.0
Waters Creek	4.97	3.9	35	0	City of Newport News	14.8
Chuckatuck Creek	28.66	12.7	82	0	Isle of Wight-Nansemond Line	8.7
Nansemond River	218.57	34.2	82	0	Nansemond	8.2

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APPENDIX N

A DAY ON THE JAMES, WITH SPECIAL REFERENCE TO PHOTOGRAPHIC AND VISUAL STUDIES OF OUTFALLS, COMMERCIAL TRAFFIC, AND RECREATIONAL ACTIVITY, WITH IMPACT ON SOCIOLOGICAL AND HISTORICAL FACTORS, AS CONDUCTED BY A SUBCOMMITTEE OF THE 1971 LANGLEY-NASA ALL-FELLOWS DESIGN TEAM

A Trip Report July 9, 1971

TRIP PARTICIPANTS

Dan Meena
Sportsman, Newport News, Virginia
Owner and skipper, 17'-85 hp research vessel "Zippy Ann"
Helmsman ("my name is on the building")

Albert Millar, Jr.
English, Jutish literature, Christopher Newport College
Purser, passenger agent, brother-in-law to the skipper
Relief helmsman and lorist !
("passing Westover, home of William Byrd")

John B. Woodward
Naval Architecture and Marine Engineering,
University of Michigan
Student of commercial and recreational watercraft
Pilot and relief lorist ("that's the Jamestown ferry")

J T. Wyatt
Biology, East Tennessee State
Chief scientific observer ("that might be a turtle")
and movable ballast

Richard Swope
Mechanical Engineering, PMC Colleges
Photographer and student of outfalls
("let me have a look at that gusher")

NARRATIVE

The research team having been taken aboard with lunches, cameras, charts, gasoline, lubricants, and other appurtenances of scientific riverine adventure, the sleek craft under the skilled hand of Capt Meena darted swiftly from its launching site in Deep Creek, home of numerous picturesque boats of the Virginia watermen, true yeoman of the twentieth century, not to mention several score modern yachts of all sizes, and onto the waiting bosom of the Majestic James The throttle having been pushed to the upmost notch, fog enveloped the boat as it climbed in speed to 10 knots, 20 knots, 30, upward . westward, then northwestward through the Rocklanding Shoal Channel Past the renowned seed oyster beds, then first on the right and then on the left loomed through the parting mists the ghostly shapes of the Idle Fleet, silent reminders of the intrepid James River shipbuilders who lofted, fitted, welded, piped, painted, and launched them four score and seven years ago and in other times of peril, and so brought forth upon these waters impressive masterpieces of maritime skills dedicated to the proposition that the ideals nutured along these banks now visible in the distance should ever flourish, but now lie quietly at anchor awaiting who knows what future call But the fog now clearing more, other reminders of the fertile heritage of the James arose on either hand From the north bank the stony gaze of John Smith, first Virginian and leader of that fragile colony over whose ruins his cold granite likeness now stands, watched with a knowing smile—so the adventurers could imagine—as the little craft roared upstream in a manner so different from that of the daring pioneer, laboriously pulling at the sweeps of a crude pinnace up this very stream, hoping all the while to behold the Orient around every bend On the south bank, Hog Island, site of the New World's first pig ranch where now rises the low but impressive shape of the peaceful atom's promise of bountiful power, where the outfall is said to be above the intake, all planned in the hope that this new blessing will not bring future curses in the form of thermal manifestations of yet unknown consequence. Speeding onward, crashing through the wakes of oil barges, passing Claremont, Brandon, Weyanoke . . names that conjure images of a long tapestry of human struggle, life, work, pleasure, and accomplishment along these shores; passing the Chickahominy, a tributary rich

in its own lore, as well as the present source of catfish, turtles, and eels for markets attuned to the taste of these gustatory oddities, under the impressive new Governor Harrison bridge, named for a president of the United States, but honored here for his associations with this storied stream, and built for ready passage of the modern automobile, a contrivance that would have been beyond the dreamings of the riparian gentry who first made the James an artery of intellect as well as commerce, for the trees parted to reveal Westover, home of William Byrd, noted horseman, explorer, planter, diarist, and progenitor of many distinguished Virginians even to this day. The bridge having been passed, the impressive sight of Hopewell burst upon the eyes of the approaching adventurers Multicolored smokes issued from many vents, pipes, and stacks. Hanging low over the water, they lent rich variety to the scene, blending with the brown-purple-green tones of the water itself. Outfalls in many aspects lining the banks, the craft slowed for the first time to allow photographic recording of this feature of the modern James as an industrial asset so essential to the well-being of the population swelling within its basin and contiguous territories Accelerating again to avoid the musketry of Pinkertons patrolling the industrial waterfront, the boat soon turned into the Appomattox, a broad tributary flowing from the village of the same name where Marse Robert and U.S Grant negotiated an end to a period of strife that once bloodied the banks of our river, as speculations were bruited among the scientific party over what BOD, DO, and SS must have been in the stream when two armies camped along its banks in an era when the modern sewage handling marvels of our age were unknown, when bond issues, matching funds, abatement grants were yet unheard of, for gas was running low, and charts showed a supply point at the first Appomattox bridge Gliding to a halt at the Hopewell Yacht Club, for such it proved to be, a native voice cried out "want gas?" to which Capt. Meena replied "yes" while the research crew trooped upshore in search of the head as voyagers aware of maritime tradition are wont to call the santiary facilities, although marked "members only" admittance was soon gained by showing of official NASA badges plus hints of "doing it right here on the porch." Meanwhile the thirsty tanks were topped up with the vital petroleum essence, and having gathered once more aboard, the waters parted again as the nimble craft, now sensing its objective not far away—17 miles a bank lounger saying—sped back into the James on the last lap to Richmond. The river having narrowed, careful steering kept the boat in the middle of the stream even as VEPCO loomed, its Chesterfield Plant venting smokes and liquid streams required a slackening to record these scenes before the Pinkertons could draw their revolvers Sand barges, oil barges, Deepwater Terminal, yachts of the Richmond sporting fraternity lined the banks as hints of growing urbanization increased. Rounding the last bend, Richmond suddenly spread its skyline before the eyes of the questing comrades The objective had been reached in the remarkable time of three hours Although no bands played on the banks, no throng cheered, no governor, mayor, senator, or congressman stepped forward bearing laurel wreaths, the group knew the thrill of accomplishment . . "one small step for the NASA summer design fellows . " Pictures having been snapped, effluents sniffed, dangling participles reeled in, the party turned slowly downstream and lifted off for Menchville. The waters oozed back into place, and all evidence of the visit soon faded, but the All-Fellows Design Team had BEEN THERE

Nothing much happened on the way back

APPENDIX O

MARCHING TO A DIFFERENT DRUMMER

(A Trip Report)

Being a TRUE ACCOUNT of the remarks by John B. Woodward, delivered August 5, 1971, at the Annapolis hearings of the Environmental Protection Agency, relative to proposed standards of performance for marine sanitation devices, and containing DISPARAGING COMMENTS on certain other testimony

READ how he

ABANDONED written text to deliver an EXTEMPORANEOUS SERMON!

GAVE the only speech to be interrupted by APPLAUSE!

CONFOUNDED and ABASHED his opponents!

HAD the LAST WORD, and escaped PROSECUTION for using it!

LEFT the scene hurriedly, but IMMENSELY PLEASED with himself!

The meeting was held in Francis Scott oh-say-can-you-see auditorium, St Johns College, Annapolis, Maryland It was attended in its morning session by about 150 people Afternoon and evening sessions were also promised, but are not reported here because of departure of your correspondent at lunchtime. Meeting was presided over by four members of EPA, namely

Kenneth Mackenthun
Louis DeCamp (titles not recorded)
Lloyd Gebhard
J. Gary Gardner

First speakers were two Maryland congressmen (Mills and Goode), who told of their love for Chesapeake Bay, and how they would dearly admire to see it cleaned up, but . . "my constituents, all of whom are passionately in favor of clean water, believe that it should be cleaned without inconveniencing them . . . must therefore regretfully oppose the standards* " They were followed by Maryland and Virginia state water control people, who played trombone solos in favor of state control over boat sewage discharge, having apparently missed the point that WHO'S IN CHARGE (Uncle Sam) is long settled, and the issue still in the oven is WHAT the standards will be Never mind They were followed by a toothsome female conservationists who put in a few words of praise for high standards. Until HIMSELF took the pulpit, hers were to be the only words of support for EPA.

Followed then testimony from the PEOPLE, the long silent, long suffering, long affluent mass of yachting humanity, now awakened from its slumber by realization that is is about to be INCONVENIENCED Marina owners, individual boaters, representatives of boating groups ("I speak for 250,000 of my fellow boatmen, who heartily agree . "). Their testimony followed a general theme of "we all love the Bay, and want to see it protected, but . . " Behind the but a reiteration of standard arguments that run about like so·

1. Proposed standards can be met only by HOLDING TANKS good grief!
2. Holding tanks are messy.
3. There are no holding tank pump-out facilities
4. Lousy municipal treatment plants put it right back in the water anyhow
5 Holding tanks generate noxious gases. Explosive, too.
6 We're going to sneaky-pump it overboard anyhow.
7. Holding tank chemicals will poison the water, once they find their way back via those lousy municipal plants
8. It ain't us, it's those BIG POLLUTERS.
9. Holding tanks are inconvenient, inconvenient, inconvenient (i e , save us from those gruesome standards). Solid applause after each speaker

Then the unsuspecting moderator, his eye glooming down his list of testifiers, picked out "Dr ** Woodward, please?"

Now this doctor answered the call with a prepared written statement in hand, which said that proposed standards should be replaced by a flat prohibition of discharge from pleasure boats, seeing as it is fatuous to expect small handy-dandy one-toilet treatment plants to meet any kind of effluent standards, and a futeless effort and waste of resources to attempt the development of such a device, and a further waste and lugubrious comedy to attempt enforcement, while his own research and personal experience show no-discharge operation to be feasible.

But, Lord Have Mercy, the temptation to lay a lecture on those protesting boaters! Looking at the sea of faces, each wondering what's this pointy-head pseudo-intellectual snob from Michigan (isn't that where the Weathermen went to learn bomb making?) going to say, how could a man of spirit resist unsheathing the sharp side of his tongue, even if he was supposed to be addressing EPA, and not scorching sinners? Yes, a temtation too great to resist Laying aside his notes, at arms length . First, though, he softly wooed their confidence, telling of his own boat, telling them of his work with the NASA-ASEE-Old Dominion University water quality team, and how its final report might criticize EPA, slug Virginia, and excoriate Richmond, but through HIS EFFORTS was going to give pleasure boats a Clean Bill APPLAUSE rocked the auditorium at this news ("hey, here's an egghead that's not so bad after all!") But wait, he says, hear me further, sinners, for I am here to urge **stronger standards**—TOTAL RETENTION, yet—for your boats, and I'm going to slap the fish across your face, meaning to show that you will really be getting what you said you wanted! We all know that our ancient method of overboard-it-goes is acceptable in open waters, in New York harbor, even, yes, in Chesapeake Bay, as long as it is banned from small harbors, from shellfish areas, from some areas of the Great Lakes, etc. But you begged for uniform standards Your spokesman, claiming your passionate support, orated upon the difficulties, the irrationality, the INCONVENIENCE, of having different rules in different places New York boating magazine editors, smuggly thinking that they could see all of the U.S. from their office windows, blew the editorial trumpet for UNIFORMITY. Naturally, they thought, nation-wide standards would be

*Standards are so strict on coliform, BOD, and suspended solids that available treatment devices can't comply

**No idea where he got the "doctor" idea, modest me not flaunting any Ph.D.s

tailored to protect the water that is still clean Now he tells them of his own boat, how his three summers of no-discharge show that people who want to obey a non-discharge rule (specifically, Michigan law) find it quite feasible. So, if your claim to love the Bay is to be taken at face value, stop asking to be allowed to do as little as possible for it, and bend yourselves to doing the most you can.

Enough, he sat down Aforementioned toothsome female and a few bearded individuals applauded. Boatmen glower. Whether any value in it for Bill Ruckelshaus to be questioned, but great sport for the speaker.

The next testifier went back to the main theme of the meeting holding tanks are the only present way of meeting the proposed standards, and they are dangerous, inconvenient, unrealistic, inconvenient, etc. But now he had his inspiration for flaying the enemy ("we have heard from the distinguished* professor; however, he fails to . ") His best shot was "If he really takes it home** to flush into the municipal sewer, I say he is an ecological hazard!***" At this, one of his supporters in the audience turned to the professor, now lurking in the back row, with "what do you think of that?" This professor, though he may have a certain taste for controversy, doesn't like to argue, much preferring simply to ATTACK the opposition The best way of doing this, if not carried to excess, is to declaim any handy Anglo-Saxon expletive that might remotely fit the opposing assertion or question. This he did in a stage whisper, hoping it might ricochet as far as the podium The questioner, apparently not prepared to converse in Exotic Language, was adequately squelched But a lady**** TURNED TO GLARE ("my soul, such language from one to whom is entrusted the education of our youth!"), causing the professor to remember that it is in some places a criminal act to say BAD WORDS in public And thinking also, that the lunch break now immediately at hand might give the irritated victims of his recent lecture a chance to practice their Anglo-Saxon on him, he slipped from his seat, flitted rapidly from shadow to shadow, bush to bush, and so safely regained his Detroit fume-belcher, and LEFT TOWN Back he fled to Langley Research Center, where he expects that his summer colleagues will support him for stomping on the polluters, and that his expense account will be quickly approved

Artfully prepared in the
third person, by

John B Woodward

John B. Woodward

---

* i e., municipal treatment no good

**Referring to my Porta-Potti

***Thank you, in spite of the sarcasm

****LADY—woman who is **not** toothsome

APPENDIX P

IMPROVEMENT OF WATER QUALITY THROUGH EFFLUENT CHARGES

This section contains a sketch of a system of effluent charges which would be suitable for use as the main moving force in a program to improve water quality In order to implement such a system for a particular river basin, several steps are necessary

The Basin Authority

First, it is necessary to have all of the dischargers who are to be included in a single effluent charges system under a single authority The Delaware River Basin Commission is an example of an authority which is generally suited to institute and supervise a system of charges It is not necessary for all parts of a river basin to be included in the same system of charges Thus, the same authority may or may not have jurisdiction over all parts of the basin However, it appears that, in most cases, it would be preferable for a single authority to have jurisdiction over all of a single basin.

Zoning the Basin

Second, it is necessary for the basin to be divided into zones in an appropriate manner In accomplishing this task it is highly desirable to have a suitable water quality model available

The Water Quality Profile

Third, it is necessary to establish in each zone a target level for each water quality parameter which is of interest. Each zone is a part of a longitudinal water quality profile to be attained for the basin The target levels of dissolved oxygen may be determined by the basin authority or by some higher authority such as the Environmental Protection Agency

The following discussion is based on the assumption that such a profile is specified only for the concentration of dissolved oxygen

The shape of the desired water quality profile for a given basin will depend on a number of factors The reason for dividing the basin into zones is to permit locational differences in benefits and costs of dissolved oxygen to be reflected in corresponding differences in the target concentrations of dissolved oxygen. For example, in a heavily populated industrial area, both the benefits and the costs of clean water are likely to be higher than in a thinly populated area The best level of water quality in the industrial area may be higher or lower than in another type of area, depending on whether the benefits or costs of clean water increase more as the river moves into an industrial area

If the entire river is considered as a single zone and a uniform effluent charge levied on all dischargers, the quality of the water may vary widely from point to point On the other hand, if the same water quality is desired in all zones, the effluent charges may vary widely from point to point.

From the target profile and the actual profile the dissolved oxygen deficit can be determined and translated into the amounts of oxygen demanding materials (BOD) which must be removed from each zone to attain the target profile.

In many cases attainment and maintenance of the target water quality profile will require control over the level of concentration of effluents as well as the total loadings An appropriate water quality model would be extremely useful if not essential in carrying out this step

Determining Abatement Costs

The next step in instituting a system of effluent charges is to derive, for each discharger, a function relating total abatement cost to the level of abatement of the various pollutants If only BOD is to be considered, this function will simply give the total cost of attaining each possible level of BOD removal in the most efficient way.

The next step is to derive from the total cost function, a marginal cost function whcih shows the increment to total cost which is necessary to step up the percentage BOD removal by a given amount, e g , from 85 to 90%. This marginal cost function is of critical importance since it serves as the basis for determining the level of the effluent charge to be levied

The costs should be based on the most economical abatement techniques which are known. Even so, they will, in some cases, be overestimates of the actual costs since the effluent charges will provide incentives for dischargers to try to develop cheaper abatement techniques. In some cases they will be successful; thus, the estimated costs will probably need to be revised from time to time It is highly desirable, for administrative reasons, to set the effluent charge as accurately as possible initially in order to minimize the number of times its level must be adjusted For this reason a high priority should be given to accuracy in the initial estimation of the abatement cost relations

The costs may be estimated in a number of ways. The cheapest, and least effective, method is to base the estimates on generalized cost data from secondary sources. These would need to be adjusted for the effect of location differentials and price level changes Such estimates might reflect the actual costs for some dischargers rather poorly.

Another method is to rely on cost data furnished by the dischargers Presumably they are in a better position to make such estimates than anyone else. The risk is that they may deliberately bias the estimates upward or downward, whichever they believe will minimize the ultimate abatement cost to them If the cooperation of the dischargers can be obtained, competent personnel of the basin authority can enter the discharger's premises, observe the production processes; determine the composition of the effluent and construct quite accurate estimates of abatement costs This may be especially desirable for small companies who may have no such personnel of their own. They may be glad to receive any information on costs, especially suggestions as to how they might be reduced

The cost data actually obtained for a given discharger is likely to consist of estimates of cost for a relatively few different levels of abatement In using the data it will be necessary for the basin authority to obtain cost estimates

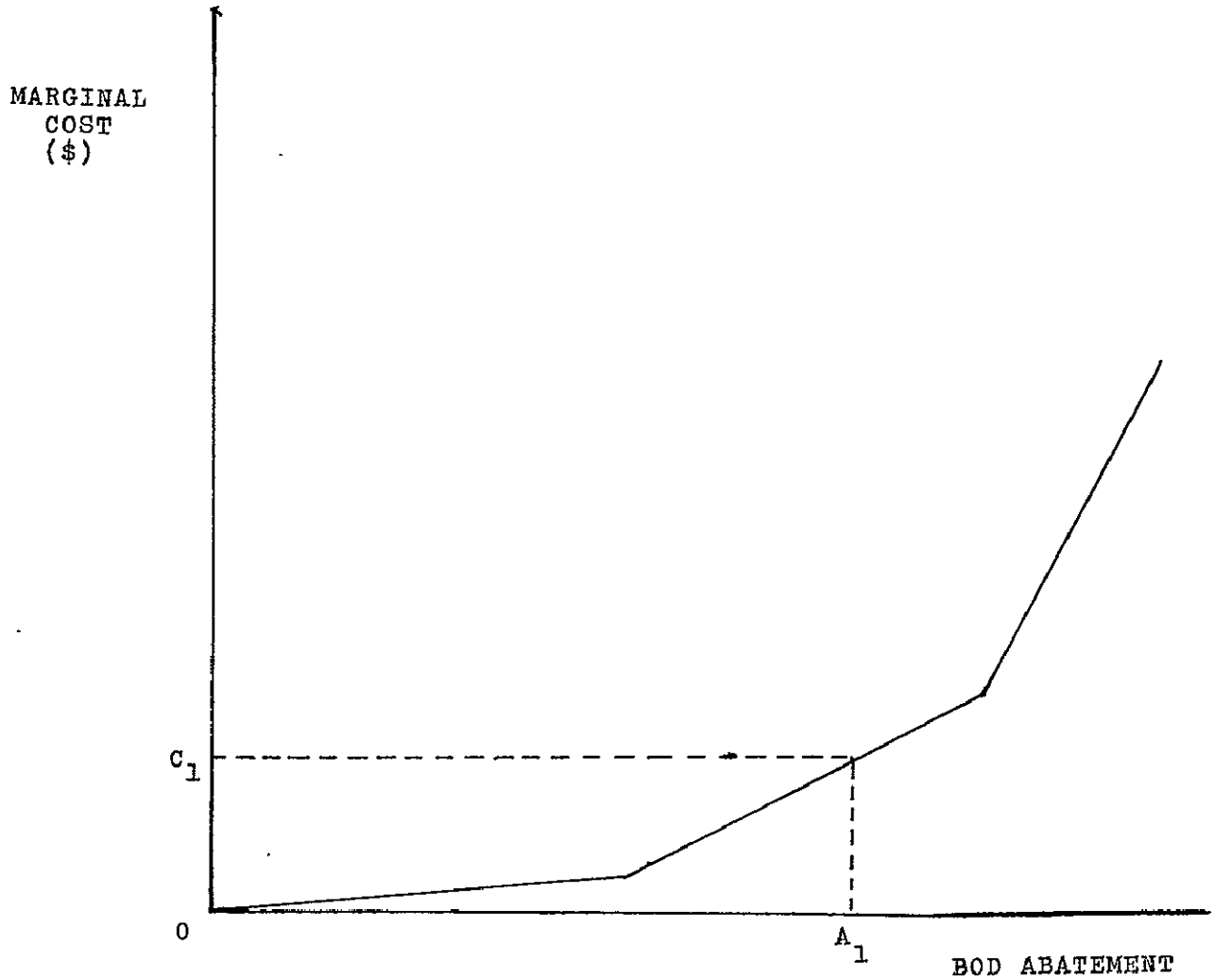

FIGURE P.1 HYPOTHETICAL MARGINAL COST CURVE FOR BOD ABATEMENT

for intermediate abatement levels by interpolation between the point estimates as illustrated in Figure P 1 This will necessarily introduce some imprecision into the estimation of the amount of abatement which would result from any given level of an effluent charge

The cost data available indicate that, for a given volume of effluent the marginal cost of abatement above the primary level rises as indicated by the above diagram. This fact is important. It means that, for a charge of a given amount, the level of abatement which a single discharger will find to be most profitable will be determined by his marginal cost relation The illustrative diagram above indicates that an effluent charge amount OC1 would induce that particular discharger to abate his BOD discharge by amount OA1. Lower charges will lead him to select lower abatement levels and higher charges will produce higher abatement levels for him The important fact is that, for any charge, the abatement forthcoming from this particular discharge can be read from his marginal cost curve.

Setting the Effluent Charge

The necessary cost data having been obtained, the basin authority faces the problem of determining a charge per unit of BOD discharged which is to be levied upon all dischargers of BOD

This step can be accomplished quite simply when the charges are based only on discharge of BOD or any other pollutant taken alone The procedure is to select a tentative value for the charge; determine, from the marginal cost curves of the various dischargers, the amount of abatement each will produce in response to this charge; total these abatement levels for all dischargers and compare the total with the target level of BOD removal for the entire zone If the actual level of abatement expected to result from that charge is less than the target level, the charge is revised upward This procedure is repeated until the total of expected removals from the revised charge is equal to the target level The change which accomplishes this is then levied upon all dischargers and each is left to make his own decisions as to level and method of abatement.

The problem of highly concentrated effluents in probably best handled by imposing a surcharge on discharges exceeding a specified maximum concentration The surcharge would serve the purpose of inducing dischargers of concentrated effluents to dilute them Such dilution would reduce the impact on water quality in the near vicinity of the point of discharge. Since

dilution can, in all or nearly all cases, be accomplished cheaply the surcharges required should be quite low

The procedure outlined above will result in an effluent charge of a size which will abate BOD by approximately the desired amount It is important, however, that the basin authority not be limited to the use of any particular method of setting the amount of the charge Rather, the authority should be required simply to set the effluent charge at a level such as will produce the desired amount of abatement This will premit the authority to adjust the charge to correct for the effect in inaccuracies in the cost data and in the translation of the target concentration of dissolved oxygen into target BOD abatements The latter type of inaccuracy may be a problem since any water quality model capable of furnishing the information necessary to make this translaion will yield results which are only approximately correct In some cases the errors of this type may be substantial, especially if a suitable water quality model is not available.

Since the estimated costs are likely to be higher than the actual costs in some cases, the effluent charge determined from the estimated costs may produce a level of abatement higher than the target level. In this case the charge may be reduced In any area in which growth is expected it may be better to hold the charge at the original level This will avoid the necessity of increasing it later when growth requires the percentage abatement levels to be raised in order to maintain the desired water quality profile.

The charge system described above may produce abatement levels which vary widely from one individual discharger to another Those dischargers with high abatement costs may find it profitable to keep abatement at a relatively low level and continue to discharge a large fraction of their BOD load, paying the effluent charges on that fraction On the other hand, dischargers having low abatement costs will find it profitable to carry abatement to high levels and pay the effluent charges on the small fraction of residual BOD discharged. From the standpoint of a society which desires cleaner water, it is the aggregate abatement level, not the individual levels, which is important.

Treatment of wastewater to remove BOD will also remove substantial amounts of suspended solids and plant nutrients It may be desirable to levy effluent charges on these pollutants as well as on BOD. If so, the abatement cost relations for them should be constructed on the assumption that the expected level of BOD abatement, with the incidental abatement of these related pollutants, has been carried out. If it is desired to further abate the discharge of these pollutants, the marginal costs of doing so can be estimated and used as bases for appropriate charges on them

Revenue from Effluent Charges

A system of effluent charges produces revenue which may be used in a variety of ways. The amount of such revenue will depend on the amounts of pollutants discharged after abatement as well as on the level of the charges Given the preabatement discharge levels for the various pollutants, the revenue forthcoming from the charges can be estimated. The target levels of abatement are subtracted from current discharge levels and the residuals are multiplied by the charges to be levied upon them The revenue can be appropriated for general uses; applied to further water treatment, e g , instream treatment or given to states and municipalities for use in improving water quality or other aspects of the environment

The payments which result from the effluent charges are costs from the point of view of the individual dischargers. In part, they are also costs to society, representing payment to society for the psychic or other costs of putting up with the unabated fraction of the pollution. The remaining part is not a true cost but merely a transfer of wealth from the individual discharger and, ultimately, his customers (citizens in the case of a municipality) to the public at large

Advantages and Disadvantages of Effluent Charges

One of the main advantages of the charges system outlines above is that it will produce the desired water quality profile at a lower cost than will any other arrangement. The bulk of the abatement will be done by those dischargers having the lowest abatement cost Moreover, the dischargers subjected to charges remain free to operate as they think best. This system will probably also yield lower administrative costs than any other, mainly because the amount of information required is also minimized To implement the program, the only information required about individual polluters is the abatement cost data Once the program is in operation, it is necessary to monitor the individual discharges in order to determine the amount of pollutants on which each is to be charged However, no historical data are needed.

Effluent charges do not give dischargers any incentive to merely install waste treatment facilities which may or may not be operated efficiently They focus directly on the objective, i e., abatement of the pollutants for which charges are made.

It has been said that the revenue produced by effluent charges might "give the U S Treasury and entrenched interest in the continuation of the pollution " It would be possible to set an effluent charge at a level which would maximize the resulting revenue rather than optimize the resulting water quality. However, the Treasury would not determine the charge levels. The basin authority, which would determine them would have instructions to set charges not to maximize revenue but to reach the target (optimal) water quality levels.

Another advantage of effluent charges is that they provide incentive for continuing abatement efforts since additional abatement is always compensated by reducing charge payments Most incentive systems provide dischargers an incentive first to use delaying tactics and, if required or induced to abate, to do so only to a certain level.

A system of effluent charges also probably provides fewer points at which dischargers can make use of political pressure or delaying tactics to avoid or delay the abatement effort. The administrative simplicity of effluent charges reduces the opportunity to use both political pressure and delaying tactics The incentive to delay is reduced by the necessity of paying effluent charges while abatement is being delayed

Perhaps not the least of the advantages of effluent charges is the fact that they reduce the necessary amount of direct regulation of firms and municipalities to an absolute minimum The basin authority is, instead, in much the same position as a business which sells to another business On behalf of society it "sells" the right to discharge one or more pollutants at stated prices and collects the resulting payments All decisions about abatement levels and methods are made by individual dischargers.

The charge system proposed here appears to have disadvantages also. The first is that it would be a quite drastic departure from past practice Sometimes a substantial period of time is required for the public to understand, become accustomed to and evaluate a proposal which is a substantial departure from the status quo For this reason any needed enabling legislation might not be

immediately forthcoming. However, effluent charges have been proposed by many people and the process of public evaluation is already well underway They have been in use for some years in the Ruhr area of Germany The state of Vermont is in process of implementing a system of charges but only as a temporary measure Waste treatment charges, fundamentally no different from effluent charges, are used in many places

Charges are sometimes opposed on the ground that they are in effect a "license to pollute" since individual dischargers are left to make their own abatement decisions While it is true that the basin authority has no control over individual abatement decisions, it does control the aggregate level of abatement through its authority to set the effluent charge.

Again, effluent charges are considered unfair by some who would prefer to see proportional abatement by all dischargers However, if differential abatement is unfair, there are substantial offsetting effects as well as rewards First, those who select a low level of abatement must pay corresponding higher effluent charges Second, Schaumburg's work in the Delaware estuary indicates that the cost, using effluent charges, of attaining the level of abatement selected as best by the Delaware River Basin Commission would be only about half as much as in the case of proportional abatement[1]

As with any other pollution abatement system, political pressure is likely to be exercised by firms and municipalities in an effort to reduce pollution abatement and its associated costs at the cost of imposing dirty water on the public These pressures would focus, in the case of effluent charges, on the target water quality profile for the basin and on the level of the effluent charge A significant reduction in either of these would lead to a saving by the dischargers As noted elsewhere in this report, it is important that the authority be able and willing to resist such pressures.

Other Impacts of Effluent Charges

Effluent charges would induce firms and municipalities to incur costs for abatement and would require them to pay effluent charges on the residual discharge The ultimate incidence of these costs and their impact on income, employment and the foreign trade balance can be discussed only in general terms until more data on abatement costs becomes available

In the case of municipalities, the additional costs will be borne by the community's taxpayers to the extent that they are not defrayed by federal subsidies or sewer service charges The distribution of the costs among income groups and between the business and nonbusiness sectors of the local economy will depend on the community's tax structure Communities vary widely in the proportion of their revenue derived from property taxes, gross receipts taxes, business license fees and other sources of revenue. The case of sewer service charges is discussed elsewhere in this report

A profit-maximizing firm will adjust its production operations and pricing policies in such a way as to maximize profit in the light of its changed cost structure The adjustments it will ultimately make may differ considerable from those it will make immediately To begin with, the firm will be willing to supply the market with any given quantity of its product only at a higher price In the short term, the extent to which the firm will find it profitable to raise prices will depend on the price elasticity of the demand for its product(s).[2] For a given structure, a firm producing products having high price elasticities, perhaps because good substitutes are available, will be able to make only small increases, if any, in its prices Large increases would lead to a rapid loss of sales. Such a firm would, of necessity, absorb most of the added costs by a reduction in profits Other firms, producing products having low price elasticities, would be able to pass most of the added cost to their customers through price increases.

As noted elsewhere in this report, some firms experiencing reductions in profits will find it not worthwhile to continue the affected operations and will close them down with consequent reductions in employment and income. However, in a nationwide water quality effort all of the firm's competitors are presumably also forced to bear the pollution costs which they formerly imposed on the public Thus, no artificial competitive handicap is imposed on any firm Under these circumstances the fact that a firm does not find it profitable to remain in business or to operate a particular plant indicates that society places a higher value on the resources thus consumed than on the products produced It is in the interest of society for this firm or plant to cease operations and for the resources thus freed to be put to other uses

Two qualifications need to be made to the above analysis First, while society as a whole benefits from more efficient use of the resources involved, the impact of the adjustment is concentrated in the immediate area of the defunct firm or plant and on relatively few people. Thus, real hardships may result. Second, if the adjustment takes place in a time of unemployment, it may be difficult to find alternative uses for some of the resources until full employment is again attained.

The developments discussed above will lead to a depressed rate of return in those industries most heavily affected by the added costs relative to returns in the least affected industries In the long-run, the latter will tend to expand relative to the former until the rates of return are again in equilibrium Thus, the mix of products produced by the economy will change The employment impact, over the long term, will be nil Income, as currently measured, is likely to be adversely affected, the reason being that resources currently used to produce goods and services which are counted as income would be diverted to the production of cleaner water. The clean water benefits are, for the most part, not captured by current income measurements Thus, the fall in income would be apparent rather than real.

Any pollution control system which affects the cost structure of manufacturing firms will also affect their competitive position in foreign trade. The extent of the impact on the country's balance of trade will depend on the amount by which costs are increased The trade impact would be dampened considerably by the existing trade barriers in the form of import quotas and protective tariffs, both internal and external Moreover, our main trading partners are having their own water pollution problems To the extent that these countries require their industry to bear the pollution costs which they now impose on the public, their costs will rise, tending to offset the trade impact of our pollution control efforts.

Other pollution abatement incentive systems which impose the abatement costs on the dischargers and,

[1]Graduate School of Business Administration, University of California at Los Angeles, 1970, Mathematical Programming for Regional Water Quality Management, Federal Water Quality Administration, U S Department of the Interior, Washington, D.C , p. 95.

[2]Price elasticity is a measure of the extent to which consumption of a product is responsive to changes in its price A low price elasticity indicates that consumption tends to be unresponsive to price, e g , cigarettes, and vice-versa

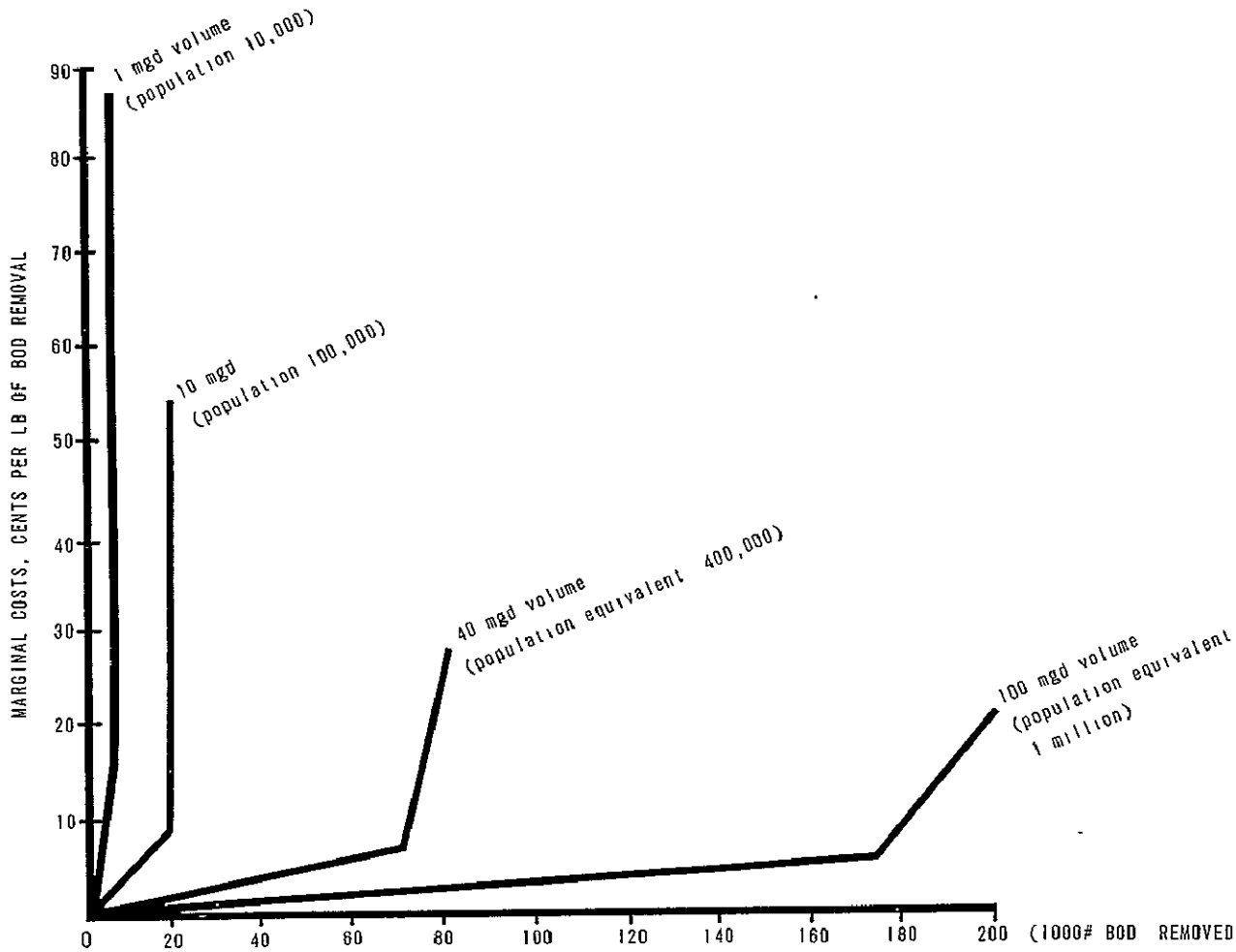

FIGURE P.2 ESTIMATED MARGINAL COSTS OF WASTEWATER TREATMENT FOR SELECTED CITY SIZES

ultimately, their citizens and customers would have the same effects in these areas as would effluent charges

The manner in which effluent charges would operate for BOD removal is illustrated here for an artificial situation involving a river basin with four cities generating a total of 302,000 pounds of BOD daily. Their populations, in thousands, are assumed to be 10, 100, 400, and 1,000 respectively. Each person is assumed to generate, daily, 100 gallons of wastewater containing one-fifth pound of BOD It is also assumed that no treatment is currently being done.

The marginal cost curves for BOD removal in the four cities (Figure P 2) are based only on secondary (activated sludge) and tertiary (granular carbon absorption) treatment. The available cost data indicate that no effluent charge would induce a city not presently treating its sewage to adopt primary treatment alone The reason is that the marginal cost of removing a pound of BOD by primary treatment is greater than by secondary treatment Thus, an effluent charge which would make it profitable for a city to adopt primary treatment would make it even more profitable for it to go ahead and adopt secondary treatment

The levels of BOD removal which would be forthcoming in response to various levels of effluent charges in these four cities are shown in Table P.1. The lowest charge which would evoke any response is six cents per pound of BOD discharged At this point the large city would adopt secondary treatment This would remove 170,000 pounds of BOD or 56 3% of the total The three smaller cities, in order of size, would adopt the same level of treatment at charge levels of seven, ten and sixteen cents respectively This would produce abatement of 84 4% percent of the total BOD. At this level, none of the cities would adopt tertiary treatment

Should the charge level be raised to 22 cents the large city would adopt tertiary treatment A charge of 30 cents would be necessary to induce the medium-large city to do the same. The marginal costs of tertiary treatment in small plants are so high that the two smaller cities would not install tertiary plants in response to any reasonable effluent charge They might, however, obtain additional

Table P.1

Level of BOD Removal In Response to Selected Effluent Charges

Charge (Cents per lb. BOD)	Volume of Effluent (mgd) 1	10	40	100	BOD Removal Pounds	Percent of Total
	(1,000 Lbs.)				(1,000 lbs.)	
6	0	0	0	170.0	170.0	56.3
7	0	0	68.0	170.0	238.0	78.8
10	0	17.0	68.0	170.0	255.0	84.4
16	1.7	17.0	68.0	170.0	256.7	85.0
22	1.7	17.0	68.0	196.0	282.7	93.6
30	1.7	17.0	78.4	196.0	293.1	97.1

BOD removal by hiring the larger cities to treat their sewage. They could afford to pay rather high transmission costs in order to escape the high marginal costs of tertiary and perhaps of secondary waste treatment

The Need For Supplemental Regulation

It seems likely that effluent charges would be inferior to direct regulation in abating some types of pollutants and, in some particular situations Efficient monitoring of discharges if necessary for an effluent charges system to function efficiently. This is technically infeasible for such pollutants as silt from construction projects, some industrial wastes which are present in trace amounts, and perhaps in other cases as well Regulations may also be needed to protect against accidental discharges or spills which would have disastrous effects

For BOD, a charge which is sufficient to limit discharge into a particular zone of the river to the target level may still result in a fish barrier or other intolerable conditions at a particular point In most cases this would probably indicate a need for rezoning the basin in such a way that charges alone would produce a acceptable level of water quality While direct regulation has proven to be a singularly inefficient means of obtaining clean water, it may not be possible to dispense with it entirely

APPENDIX Q

Research Needs

Research needs can be divided into various categories; physical, biological, operational, economic, and socio-political--all of which have been shown in this report to occupy significant positions in the machinery which must be constructed to manage water resources

I. Physical Research Needs

Comments

In as much as the sediments carried by a stream or estuary are an integral part of the entire system, the interaction of these particles with introduced pollutants, their settling behavior, their chemical properties, etc, must be understood before they can be managed. The research areas listed below indicate the direction such research should take.

A. Substrate Studies

1 Geochemical studies dealing with ionic reaction between fresh and salt waters (Concentration of nutrients, pollutants, particulate matter; chemical flocculation of clay particles; clay mineral diagensis).

2 Sediment/water interface problems (bed load transport, bottom stabilitization and slope stability)

3 Pollutant behavior (clay particle/pesticide interactions; isotope, herbicide, and pesticide residence times, degradation and recycling rates of various wastes)

II. Biological Research Needs

Comments

Water quality management requires acceptance of the fact that traditional ecosystems are changing and new ecosystems are continually emerging. Aut-and synecological research dedicated to understanding complex interactions between biological organisms and wastes introduced into the system is necessary for efficiency in management of present systems and to anticipate ecological succession in changing systems.

A. Long-term Food Web Studies

1 Primary productivity, algal response to turbidity fluctuations, nutrient additions, effect of algal blooms on water chemistry

2. Organic succession (effects of the loss of one or more trophic elements; effect of adaption to changing energy and nutrient conditions)

3 Biota/Pollutants (measurement of specific ion concentrations in burrowing and filter feeding organisms; effect of transfer through trophic structure; physiological effects of pollutant uptake; thermal effects)

III. Operational Research Needs

Comments

Modern technology has produced apparatus capable of being adapted for research in various areas of pollution abatement and water quality management Maximum efficiency in obtaining synoptic data, particularly for mathematical modelling of dynamic systems, must be achieved. The Research Needs listed below are necessary to achieve that efficiency

A. Pollution identification systems

1. Wide range surveillance (need to utilize remote sensing satellites more effectively; need to develop instrumentation for variable speed and hover craft vehicles)

2 Local surveillance (need for specific area survey devices; need to develop true synoptic sampling apparatus for real time studies)

B. Physical and biological monitoring systems

1. Specific ion (heavy metals) and particulate matter (size distributions; size and composition of organic mattersizes

2 Fish census techniques (fixed beam radar or electromagnetic wave stations); standing crop determination (productivity studies).

3 Viral technology (sampling design and rapid analysis capability for large water volumes)

IV. Economic Research Needs

Comments

Benefit- cost analysis has not been applied to pollution abatement and water management due to lack of quantitative data concerning the benefits of higher quality water. Research is needed to develop such data The following represents priority research goals for water quality management programs.

A. River basins

1 Economic models for specific abatement programs (ex. paper mill wastes vs petrochemicals, effect of harbor development).

2 Need for economic assessment of ecological damage by specific effluents. (Necessary for river basin zoning plans)

B. Specific streams

1 Development of effluent charge concept for variable flow rates (seasonal fluctuations)

2 In stream treatment cost data required for selection of most efficient and economic abatement program

3 Cost data for 100 million and sewage treatment plants

V. Social Research Needs

Comments

The process of institutionalization or change required for a successful water quality program can be divided into three stages 1) development of public awareness, 2) evaluation and policy formulation, and 3) implementation Certain social and cultural barriers to change occur in each phase, and special action is necessary to minimize their effects The research needs listed below are necessary for progress to be made in each of the listed areas

A. Public awareness

1 Survey of factors relating to awareness and interest in water quality problems in all socio-economic groups

2. Research to identify new and innovative ways to develop environmental awareness in groups already burdened by other problems

B. Evaluation and Policy Formulation

1 Studies of social structural conditions which impede awareness and concern for underlying environmental problems This would provide bases to develop a "readiness" index which will assure that allocations for the problems will be most effectively utilized

C. Implementation

1 Socio-political research toward developing.a group process methodology to assure positive public opinion at the grass roots level.

2. Research to identify agency forms and strategies that will most effectively obtain community acceptance.

3 Socio-psychological studies toward optimizing the effectiveness of water quality environmental education

4. Research to develop an institutional mechanism within the water management agency which will respond rapidly to changing social-technical environments

APPENDIX R
Glossary

ABSORPTION: The assimilating of one substance into the body of another.
ADSORPTION: The adherence of a gas, liquid, or dissolved material on the surface of a solid. Also the change in concentration of gas or solute at the interface of a two-phase system
ADVECTION: Transfer by horizontal motion and mixing of atmospheric properties.
AERATION: Creation of intimate contact between air and a liquid by spraying liquid in the air, bubbling air through a liquid, agitating the liquid to promote surface absorption of air, and other means.
AEROBIC: Requiring, or not destroyed by, the presence of free elemental oxygen
ANADROMOUS: Going up rivers to spawn
ASSIMILATION: The process of absorption, interalization, or incorporation.
BATHYMETRY: Measuring the contour of the bottom in a body of waters
BENTHOS: The aggregate of organisms living on or at the bottom of a body of water.
BIGHT: A slight bend in a coast forming an open bay, usually crescent-shaped
BIOTA: Animal and plant life (flora and fauna) of a stream or other water body.
CARBONACEOUS: Of, consisting of, or containing carbon.
CAVITATION: The formation of partial vacuums in a flowing liquid as a result of the separation of its parts commutation, sequential sampling method for identifying data on a time-study basis.
CRITERION: A standard of comparison or measurement
DATA: Units of sensory observation.
DEAERATION: The removal of oxygen from water to lessen its corroding power.
DYNAMIC HEAD: That head of fluid which would produce statically the pressure of a moving fluid
EPILIMNION: A zone in which water, being of substantially uniform temperature and density, is easily moved along horizontally by wind induced currents and vertically by convective currents
ESTUARY: Where the tide ebbs and flows and fresh waters of the land meet the salt waters of the sea; a tidal embayment.
EUTROPHICATION: An enrichment process involving an excess of nutrients in an aquatic system
FALL LINE: The geographical line indicating the beginning of a plateau, usually marked by many waterfalls and rapids
FLOCCULATION: In water and wastewater treatment, the agglomeration of colloidal and finely divided suspended matter after coagulation by gentle stirring by either mechanical or hydraulic means
FLUME: An open conduit constructed on a grade and sometimes elevated; aqueduct.
FLUVIATION: Collectively, all the numerous activities of streams
GEOSYNCLINE: A very large, troughlike depression in the earth's surface
HYPOLIMNION: A stagnation zone in water in which horizontal movements are very slight and vertical ones are almost absent
IN SITU: in position, in its original place.
INTERFACE: A plane of interaction between units
LIMNOLOGY: Scientific study of bodies of fresh water with reference to their physical, geographical, biological, and other features
NITROGENOUS: Of or containing nitrogen or nitrogen compounds.
OPTIMIZE: To select a superior strategy subject to a given set of constraints
OUTFALL: The point, location, or structure where wastewater or drainage discharges from a sewer, drain, or other conduit
OUTPUT: The product of a system.
PARAMETER: A variable or an arbitrary constant appearing in a mathematical expression
pH: (potential of hydrogen) The reciprocal of the logarithm of the hydrogen-ion concentration. Used to indicate acidity or alkalinity
PROCESS: A series fo actions or operations conductive to an end.
RIPARIAN: Of, pertaining to, or situated or dwelling on, the bank of a river or other body of water
SALINITY: The relative concentration of salts, usually sodium chloride, in a given water A measure of the concentration of dissolved mineral substances in water.
SALT-WATER WEDGE: A salinity intrusion that occurs in certain tidal waterways and has the distinguishing characteristic of a stratum of salt water underflowing a stratum of comparatively fresh water.
SEDIMENTATION: The process of subsidence and deposition of suspended matter carried by water, wastewater, or other liquids, by gravity, settling
SENSOR: That which selectively detects energy patterns.
SEWAGE: The spent water of a community. Term has generally been changed to wastewater
SEWERAGE: System of piping, with appurtenaces, for collecting and conveying wastewater from source to discharge.
STATE-OF-THE-ART: Current status of knowledge or technology in a given discipline.
SYNERGISM: The improvement in performance achieved becaused two agents are working together
SYNTHESIS: The systematic composition of elements to form a whole.
SYSTEM: An aggregate of interrelated components or elements comprising a unified whole
THERMOCLINE: The middle of three horizontal strata of water in a lake or impoundment in which the temperature exhibits a sharp gradient between the temperature of the top stratum and that of the bottom stratum.
TOXICITY: The state, quality, or degree of being toxic, or poisonous
TURBIDITY: A conditon in water or wastewater caused by the presence of suspended matter, resulting in the scattering and absorption of light rays
WATER COLUMN: The water above the valve in a set of pumps Also a measure of head or pressure in a closed pipe or conduit
WEIR: A diversion dam A device that has a crest and some side containment of known geometric shape and is used to measure flow of liquid

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