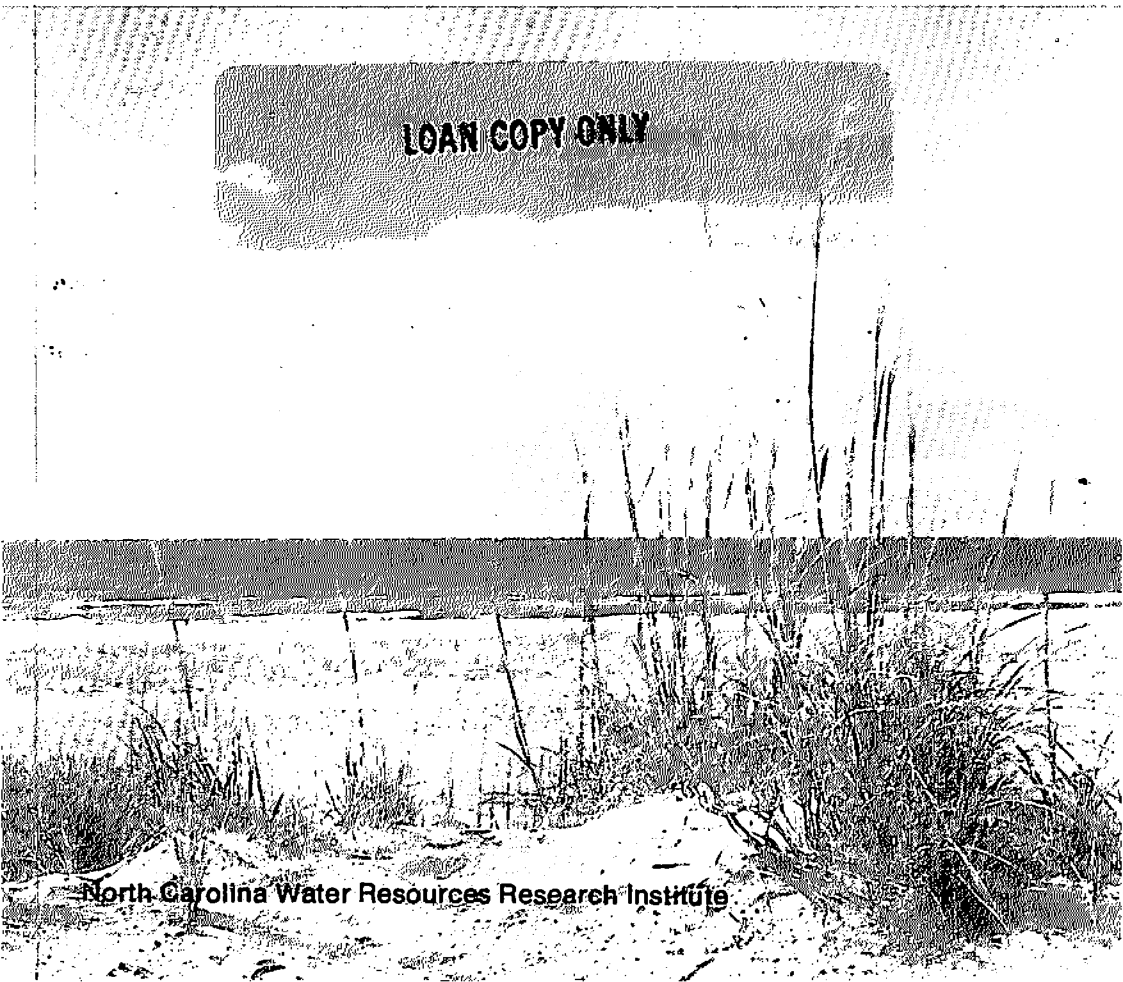
The proceedings of the southeastern conference on

Water Supply and Wastewater in Coastal Areas

Coastal Plains Center for Marine Development Services—Coastal Plains Regional Commission

Water Resources Research Institutes and Sea Grant Programs of the Carolinas and Georgia



North Carolina Water Resources Research Institute

These Proceedings may be ordered ($8.00 each per copy if prepaid or $10.00 each per copy if billed) from:

Water Resources Research Institute
124 Riddick Building
North Carolina State University
Raleigh, North Carolina 27607

WATER SUPPLY AND WASTEWATER IN COASTAL AREAS

Southeastern Conference

April 2-4, 1975

Sponsored by the

Coastal Plains Center for Marine Development Services, Coastal Plains Regional Commission
Water Resources Research Institute of The University of North Carolina
University of North Carolina Sea Grant Program

In cooperation with the

Sea Grant Program, University of Georgia
Environmental Resources Center
Georgia Institute of Technology
Sea Grant Program, South Carolina
Marine Resources Center
Water Resources Research Institute
Clemson University

Conference Host

University of North Carolina at Wilmington

Conference Secretariat

Water Resources Research Institute
124 Riddick Building
North Carolina State University
Raleigh, North Carolina 27607

Edited by James M. Stewart

PREFACE

Among the most valuable resources of the Southeastern United States are its coastal lands and waters. The coastal areas, and in particular their estuaries, are among the most biologically productive regions of the nation, spawning major sports and commercial fisheries. The extremely high recreational and esthetic values of coastal lands and waters carry the seeds of their own destruction through their attractiveness for economic development.

In recent years these areas and their fragile ecosystems have been threatened with increasing pressures for development. Unless these pressures are controlled and directed in a conscious way, the very features of the coast that make it economically, esthetically, and ecologically rich will be damaged, even destroyed. A major problem associated with increasing population growth and economic development in these areas is the provision of safe and adequate water supplies and management of wastewater discharges in a manner consistent with public health and welfare and environmental protection.

The Conference was conducted to review the *State of the Art* of proper planning and management of water supply and wastewater disposal in coastal areas. Special attention was paid to defining technological and institutional alternatives, their relation to land use planning and environmental protection, and to identifying those water and wastewater problems of significance in coastal areas.

Each session had two speakers followed by a discussion period. Excellent audience participation with lively discussions added considerably to an understanding of the topics covered. Both the presentations and discussion sessions are included in the *Proceedings*. Chairmen for the individual sessions were Col. Beverly Snow, Coastal Plains Center for Marine Development Services, Ralph Heath, U.S. Geological Survey, Marshall Staton, N.C. Department of Human Resources, F. Eugene McJunkin, University of North Carolina at Chapel Hill, and David H. Howells, Water Resources Research Institute.

The program planning committee included Professor F. Eugene McJunkin, Chairman; Col. Beverly Snow, Coastal Plains Center for Marine Development Services; Dr. B. J. Copeland, North Carolina Sea Grant Program; Dr. Edward Joseph, South Carolina Sea Grant Program; Dr. Edward Chin, Georgia Sea Grant Program; Dr. L. Douglas James, Georgia Environmental Resources Center; and Dr. A. W. Snell, South Carolina Water Resources Institute.

The Conference would not have been possible without the financial support provided by the Coastal Plains Center for Marine Development Services, Coastal Plains Regional Commission.

TABLE OF CONTENTS

CALL TO ORDER

Colonel Beverly C. Snow, Jr.
Executive Director
Coastal Plains Center for Marine Development Services
Wilmington, North Carolina

As Executive Director of the Coastal Plains Marine Center, one of the organizations sponsoring this meeting, I have been asked to open it and to chair the session this afternoon. The problems we will be discussing during the next two days and the purpose of the meeting are set forth in your program and need no further comment from me. I should mention, however, that we started planning this meeting nearly a year ago and well before the proposed Wrightsville Beach ocean outfall came to the forefront of public attention, which really has happened only during this past month. The relationship between this project and this meeting is coincidental. However, since the subject in general is on the program this afternoon, the local community as well as other interested communities throughout the Southeast are fortunate in that they will be able to take advantage of the expert knowledge available not only in this part of the country but in others which we have managed to assemble here at this meeting.

This brings me to the principal aspect of my own organization's involvement in this meeting. Our role in the Coastal Plains Marine Center is to improve the understanding, management, and use of the Region's coastal zone and Continental Shelf resources. We are supported by the Coastal Plains Regional Commission, and it is a real honor and pleasure for us to have with us today the Honorable Jack Hawke, Federal Co-chairman of the Commission. Jack will be talking to you very shortly.

One of a number of ways in which we carry out our role in the Center is through what we call Cooperative Projects. Projects in this particular part of our program are joint efforts by the Center and State agencies having marine and coastal interests, and benefit not only the States, but more importantly have potential impact on the orderly economic development of the Coastal Plains Region. You will note that both the speakers and the other participants in this meeting come from the member States of the Coastal Plains Regional Commission, and from areas outside the Region, thus permitting the sharing of available expertise and information across State lines. As far as we are concerned, this meeting is an outstanding example of the type of Regional cooperation in information exchange which we are constantly striving to promote.

Cooperating with us in this conference are the Water Resources Research Institutes and the Sea Grant Programs of North Carolina, South Carolina, and Georgia.

OPENING REMARKS

R. Jackson Hawke, Jr.
Federal Co-chairman
Coastal Plains Regional Commission
Washington, D. C.

I am extremely honored to be able to be with you today and address a group of experts in a field which I have very limited knowledge. You know, I tried to figure out what I was going to say to you folks when I got down here today. The only thing I could think of was a comment often attributed to W. C. Fields where he often said, "Water--I hardly touch the stuff."

I noticed in the pamphlet that you sent out announcing your meeting that you gave a summary of the background of the problems that you are going to be discussing during the conference. I would guess that this is the reason that you asked me to make a few remarks rather than for my technical expertise. The concern of the beauty and livability of our coastal areas of our three states was the very reason that the Coastal Plains Regional Commission was originally established. The Commission is composed, as Colonel Snow has already pointed out, of the three Governors of North Carolina, South Carolina, and Georgia--and just last week joined by the Governors of Virginia and Florida--and a federal member appointed by the President of the United States. It is meant to be a partnership to bring the full weight of the state governments and the federal government to bear upon the problems of the economic development within our region. In our original long-range plan, which was done by the Commission, we stated that our goal was to close the income gap between that existing in the region and the rest of the nation. That income gap today is approximately $1,000 per person and has created related problems within our region of poor housing, low educational attainment, poor transportation systems, poor health care delivery, and all the related problems that you can imagine, such as low per capita income areas might provide. We can only achieve this goal of closing the income gap by increasing our productivity and by attracting new commerce to settle in our region. At the same time, the Commission is keenly aware of the sensitive nature of the coastal environment and has established environmental concern as one of its major program areas. We limited our program areas to four in the last few years. One of the four program areas is environmental concern.

A second program area which we have is marine resources which is also closely tied with the conference that you are having today. In both cases, we have an advisory committee which is appointed by the Governors and the Federal Co-chairman and a committee of experts to help us relate our program to the actual needs of the region. We also helped create the Coastal Plains Center for Marine Development Services, and we are the sole funding agency for the Marine Resources Center. So you can see that through our programs and our involvement we are quite interested in the conference that you are having here. We are quite interested in the problems that you have, and we are quite interested in working with you to find the solutions.

Your pamphlet also states, and I quote from it: "The extremely high recreational and esthetic values of coastal lands and waters carry the seeds of their own destruction through their attractiveness for economic development." Quite frankly, I don't think that this really has to be true. We do have a serious need to balance the right of the people of this region to earn a sufficient livelihood with the concerns of saving the ecological balance that makes our region unique. We can never forget that we are talking about people with low per capita income and attempting to help them to earn a sufficient income to have a sufficient livelihood. I have faith that American technology such as that represented in this room can help us find a way to close the income gap and at the same time protect our environment for future generations.

You know, there's probably no more natural resource that any of us enjoy than that of water and none that we take more for granted. We have recently experienced some of the problems that have developed with the shortage of oil. Our country went through a very traumatic experience, and we didn't quite know how to react. Well, I can't personally imagine what the reaction would be if we were faced with the same critical shortage of water today. I can remember just a few summers ago in the neighborhood I live in in Raleigh the cries of anguish and the wringing of the hands that developed when we had a water shortage in our little neighborhood. You thought it was the worst thing that had ever happened. People had to stop watering their lawns every night; they had to stop washing their cars every other day; they had to stop using the dishwasher, the clothes washer, the garbage disposal; and you would have thought the world was coming to an end. But it didn't take long for as soon as that water shortage was over, we all forgot about it and went right back to the wasteful ways we had been involved in all along.

When you talk about the disposal of wastewater, this is, again, another problem that the average citizen doesn't concern himself with unless the septic tank backs up or the sewage system becomes blocked and stinks and bothers their neighborhood in one way or another or maybe there's a massive fish kill in one of the rivers; then, it comes to their attention. Otherwise, we just take it for granted. Water and wastewater disposal is so vital to our total existence. We are so dependent upon it that we just naturally take it for granted. This conference will review the state-of-the-art of proper planning and management of water supply and wastewater disposal in coastal areas. Our coastal areas have unique problems in this field, but our coastal lands and waters are one of our most valuable resources. We must face the problem as a region and find solutions as a region. We hear much these days about developing new energy supplies in our region. This could involve deep-water ports. We at the Commission have just completed a deep-water port study. It could involve the development of petro-chemical companies, new transportation systems, nuclear power plants, and on and on. Now I don't profess to be the expert, but I have to ask quite seriously: "Where is the water going to come from for all of this development and where are the wastes going to go?" I trust that you who are meeting here today have those answers because I, frankly, do not.

When I received the invitation to address the conference, I asked one of my staff members to gather some information together for me so that I might have some facts in speaking to you today. All of these facts are very familiar to you and will be discussed later during the conference so I won't bother to go over them now; but perhaps as a layman, I can share a few thoughts with you and emphasize some of the problems that you face and some of the difficulties that you face in trying to find solutions to our water problems.

Now, I really hate to pop anybody's balloon, but when I asked for a quote that I might use, here is the first one that was given to me: "One of the hottest issues today is ocean outfalls for wastewater." Well, it seems to me that the average person is much more concerned about inflation, recession, war, what's going on in Vietnam, skyrocketing utility costs, busing of students--you can name it; and if we took a poll today of the top fifty concerns of the people in the country, we'd probably find that ocean outfall wouldn't even make the list unless it was mentioned by someone in your profession. When I say this, I'm not trying to belittle the problem; what I'm trying to do is to bring into focus the real magnitude of the problem we have when it's not recognized by the average citizen. The problem must be addressed, and it must be addressed by people such as yourselves on a regional basis. Research must be conducted to establish whether an outfall can actually be used in our region and, if so, where it might be located. I am told that, unfortunately, the research in this field is simply too far behind the need.

A second fact presented to me was: "Presently, the greatest handicap to water resource planning is the lack of funds." To coin an old phrase, I don't want any of you to feel "rained upon." I can say without reservation that this is also the greatest handicap facing the Coastal Plains Regional Commission and the Jack Hawke family at the present time. Recognizing this, then, how do we proceed from this point? I recognize that the serious issues that you'll be discussing in this conference cannot be taken lightly, but I also realize as a layman you are discussing a problem which is beyond the comprehension and, therefore, the concern of most of our average citizens. I have been informed that our demands on water will be three times as great as they are today by the year 2000 for industrial and municipal uses alone. Now that's a fact and a figure that the average laymen can understand. That's also a fact and a figure to confront the average layman when you consider that this leaves very little water for agriculture and recreation. Therefore, we must proceed immediately to find ways and examine ways of meeting this problem such as one that I know is on your program, that of reusing our waters rather than just passing them on into the ocean. About 90 percent of water for industrial and municipal use in our region comes from the ground. Yet, little has been done to assess the potential hazards of misusing these groundwater supplies. We are already witnessing chloride intrusion in several areas. The proliferation of septic tanks is contaminating shallow wells; and worse yet, our current land uses may be destroying vital recharge areas. Our surface waters are being highly taken advantage of without adequate data and management. Over recent years, hundreds of thousands of shellfish areas have been closed in our region alone. Drainage practices and urbanization are sending too much water downstream carrying with it sediment and polluting nutrients.

This conference has been co-sponsored by the major state universities in our three states. I am sure that you recognize that, as did the original founders of the Coastal Plains Regional Commission, that our water supply and wastewater problems must be addressed by the entire region. I must keep reminding myself the entire region now includes Virginia and Florida. One of the reasons for establishing a Title 5 Commission is that we're an area closely related with the problems and, therefore, can find similar solutions to solve those problems. The portions of Virginia and Florida that have now joined our Commission can help to find the solutions that we are trying to find for our entire region.

There are dozens of agencies at the present time with interest each going their own way, each doing their own thing. Planning, research in ports, management, and jurisdictional responsibilities must be pooled. Otherwise, we will not only duplicate efforts and waste money, but we will run the risk of critical water shortages in the near future. Unless we collectively design the means to protect and manage our water supplies, we may soon find ourselves with a water supply that isn't worth protecting. I hope that we can find the means to pool our efforts, knowledge, and resources in the years ahead before we are confronted with the serious consequence of going our own way. Unless we do so, the water problems that we discuss today will be the hottest issues that we face tomorrow.

I am happy to offer our solutions as a body and a means to help in these efforts of coordination. The Coastal Plains Commission has a unique partnership between the federal and the state levels. We can serve as a vehicle to achieve the cooperation in water research, planning, and management that this region needs. We have been successful in the past in bringing government, business, citizens, and educational sectors to bear on a number of projects in our region, such as the deep-water port study which I just mentioned. We would very much like to apply our action planning approach to the water problem, but we need your advice, support, and commitment.

A member of our staff, Eric Slaughter, is here today. He has prepared a paper that proposes such coordination on a regional basis and proposes the establishment of a water resources compact within our region. Eric would like to meet with any of you who would be interested in offering advice or pursuing the subject tonight at seven o'clock and get your ideas and suggestions. I think you may have already received a copy of his paper. Hopefully, out of these discussions and out of this conference and future cooperation we will find a way to work hand-in-hand for progress.

You know, the original settlers that came to the United States and landed on our shores sent back the word to Europe that our land was the "goodliest land under the face of heaven." They looked at the abundance, the beauty, and the natural resources that we have in our region. They talked about it as the future leader of the world because of the beauty and the resources that we have. I think that's still true today. You know, with the income gap that we experience, we are still the "goodliest land under the face of heaven." But I'm not satisfied to say this is what our ancestors said and even this is what we can say today. I would like to be able to have my children and my grandchildren and my great-grandchildren to be able to stand up and say the same thing. Unless we have development in our region that goes hand-in-hand with solving the problems of our region, this won't be the case. So I take my hat off to you; I thank you for coming, and I hope that you will work together in a state of cooperative effort to help us solve these problems.

WATER SUPPLY AND WASTEWATER DISPOSAL—PLANNING AND PROBLEMS—IN COASTAL AREAS

Colonel Paul S. Denison, *P.E.*
Henry von Oesen and Associates, Inc.
Consulting Engineers & Planners
Wilmington, North Carolina

INTRODUCTION

I would like to begin my presentation today with a brief quote:

> "Among the most valuable resources of the Southeastern United States are its coastal lands and waters. The coastal area, and in particular - the estuaries - are among the most biologically productive regions of the nation, spawning major sports and commercial fisheries. The extremely high recreational and aesthetic values of coastal lands and waters carry the seeds of their own destruction through their attractiveness for economic development.
>
> "In recent years, these areas and their fragile ecosystems have been threatened with increasing pressures for development. Unless these pressures are controlled and directed in a conscientious way, the very features of the coast that make it economically, aesthetically, and ecologically rich will be damaged--even destroyed. A major problem associated with increase in population growth and economic development in these areas is the provision of safe and adequate water supplies and the management of wastewater discharges in a manner consistent with public health and welfare and environmental protection."

If those statements sound familiar, they should, because they're taken directly from the program brochure outlining the purpose of the conference that we're participating in today. You've heard these thoughts expressed before on numerous occasions in other published papers and discussions related to problems that we face in the coastal margin.

BACKGROUND

The topic that I'm supposed to discuss today--and again, I quote from the program--is *Water Supply and Wastewater Planning and Problems in Coastal Areas; An Overview*. I think that it may be an oversimplification to state that any problems that exist in our coastal areas are the direct result of man's attraction to the sea and his exploitation of the coastal region to accommodate his needs as he sees them. These problems are not limited to water supply and wastewater disposal needs by any means. We also have:

1. Coastal erosion problems (natural processes as they interface with man's development endeavors)

2. Navigation projects to support national and local economic interests and recreational use of coastal areas

3. Structural considerations as influenced by the coastal environment (i.e., both on- and offshore structures as they are affected by hurricanes and other major weather events, etc.)

But these are not the subject of this conference, so let's isolate and take a look at the water supply and wastewater problems that we are here to discuss.

WATER SUPPLY PROBLEMS

Historically, as man began to occupy the coastal margin, he simply drilled shallow wells in the surficial sands to supply water for drinking and other purposes. At the same time, he discharged his sewage wastes back into the same surficial sands or land areas, using conventional septic tanks or even more primitive disposal means. As long as development was limited, the demands on the productive and assimilative capacity of the lands he occupied were minimal--the process seemed to work. But as development intensified, the land's capacity to meet man's needs became more and more marginal.

As development intensified, water supply demands increased, and in many areas small municipal (or private) supply and distribution systems were established. In all cases, water supply for these systems was dependent upon shallow or deep-well systems installed in the barrier islands to produce water to meet these demands. As we know, the ability of surficial sands on our barrier beach islands to produce large quantities of water is extremely limited. Perched water or fresh-water ponds which are employed in some areas are entirely dependent upon rainfall and have an obviously limited productive capacity. Deeper well systems were more productive, but they also have a limited capacity due to the ever-present threat of saline intrusion. Some of the municipal water supply systems in beach communities have already experienced this phenomena. This, then, results in the necessity for these continuously growing communities to look elsewhere for water supplies to meet their continuously growing demand.

At the present time, the obvious solution is to augment local water supply capabilities with additional potable water transported from the more productive mainland areas. Two classic cases in point exist right here in Wrightsville Beach and in the Dare Beaches area in northeastern North Carolina. In both cases, the productive capacities of water supply sources on the beach property have reached their limit, and programs are underway to obtain increased supplies from areas that lie behind the beach margin itself. It appears that this trend will and must continue with the growing beach communities looking to the water-rich areas on the mainland for augmentation of their water supply. Obviously, the cost of transporting water from these mainland sources to the beach margin is a primary consideration. However, at the moment it appears to be the only viable solution to the problem. I should emphasize here that not all of our developing beach communities in North Carolina have reached this point. It will probably be a number of years before groundwater supplies in some of our developing beach areas experience this difficulty. In some cases, it may never occur. As the state-of-the-art in water quality management and recycling progresses, we may be able to resolve the problems of the future without resorting to obtaining additional water supplies from external sources. We hope this prospect is not too far down the pike.

WASTEWATER DISPOSAL PROBLEMS

Wastewater disposal in the coastal area represents a more difficult and challenging problem, in my opinion. Man's increased development and exploitation of the coastal regions results in higher wastewater discharge loadings, which begin to overtax the assimilative capacities of the lands and/or receiving waters into which they have historically been discharged. My remarks here are primarily directed to the problem of disposal of domestic sewage wastes in the developing beach areas and barrier beach islands that we mentioned relative to the water supply problem. This is not to say that industrial and commercial developments in the coastal region don't represent serious wastewater disposal problems--they do. However, these developments are generally confined to the mainland areas adjacent to navigable fresh-water streams or the larger tidal estuaries and, with the exception of some smaller commercial operations such as seafood processing facilities, these major commercial and industrial developments have been under close scrutiny during the past few years and are being required to meet continuously increasing controls of effluent discharges into these waters in order to sustain their operations. This is not to say that problems still don't exist, but sufficient attention has been focused on this area that I won't attempt to discuss it in the limited time that we have today except for cursory mention a little later in my talk.

The specific problem that we really haven't faced up to to date is the one of domestic wastewater treatment and disposal in the immediate beach and adjacent estuarine areas. As growth and development has continued in these regions, the result has been ever-increasing discharges into the surficial sands or soils that surround our coastal waters to a point where the assimilative capacities of these soils have been taxed beyond tolerable limits. This has resulted in serious potential health and sanitation problems in the beach areas themselves, and considerable evidence has been presented to demonstrate that the excessive discharges of sewerage wastes into the coastal soils are beginning to adversely affect the fragile estuarine waters that surround these land areas. Only one beach community, the Town of Wrightsville Beach, has constructed a municipal wastewater treatment facility as a step towards resolving the problem. However, even in this case, secondarily treated wastewater effluent is discharged into the estuarine system adjacent to the beach (Shell Island Sound). This area is presently closed to shellfish harvesting, and although the facility is being efficiently operated and maintained in consonance with State permits for its operation, the discharge of this treated wastewater effluent still represents a serious impact on the estuarine systems in the area and inhibits the recreational use of these waters. Obviously, a better solution to the problem has to be found.

The problems we're talking about are not new nor have they been "just discovered." A number of responsible people have pointed out this problem for the past decade or more. I personally was asked to speak to the North Carolina Board of Conservation and Development at their meeting in Nags Head in the fall of 1968. I stated at that time that the rapid growth phenomena being experienced in our coastal areas pointed up the urgent necessity to establish adequate land use plans and, specifically, that the problems of water supply and wastewater disposal in the coastal margin would have to be addressed and resolved to prevent the destruction of our valuable coastal resources as we had seen happen in so many coastal areas of our country. Some three years later, I was asked to speak to the North Carolina Board of Water and Air Resources at their fall meeting in Murfreesboro, North Carolina. In this case, I specifically addressed the growing wastewater disposal problems in the coastal margin and had the audacity to suggest that we needed to take a serious look at discontinuing wastewater disposal procedures that were having potentially serious pollution impacts on our fragile and productive estuarine systems in the coastal area. I went on to say that we needed to collect and treat domestic wastes in our beach areas and discharge them offshore into the Atlantic Ocean through ocean outfalls rather than to continue tolerating discharge practices that are polluting our estuarine waters.

STATUS OF WATER SUPPLY AND WASTEWATER PLANNING PROGRAMS

I think we are making progress in addressing these problems, but it is a slow and tedious process. This brings us to the specific point of planning and acting to resolve these problems. After considerable public involvement and a great deal of consternation, the North Carolina General Assembly passed a coastal area management act during its 1974 session. I won't comment on how successfully this act may help us to home in on the specific problems of water supply and wastewater disposal, but it does direct the local governing bodies of the coastal area to direct their attention to proper and adequate planning processes. More to the point, we find that the responsible governing officials in coastal areas have initiated planning actions to help resolve their water supply and wastewater disposal problems. For the past three or four years, our firm alone has been heavily engaged in studies and preparation of preliminary engineering reports to help solve these problems. To date, we have completed such studies in the Dare Beaches area of Dare County, in Carteret, Onslow, Pender, New Hanover, and Brunswick Counties, which pretty well covers most of coastal North Carolina. In some cases, these studies have resulted in the construction of new water supply distribution systems. Some examples are found in the Topsail Beach/Surf City area, and expansion or augmentation type projects are underway in Beaufort and Carteret County, Wrightsville Beach, and in Brunswick County. An ambitious regional water supply project that we have proposed for the Dare County complex (Dare Beaches area and Roanoke Island) goes to referendum for public approval on the 15th of this month. Similar projects are under consideration or underway in other coastal counties.

The wastewater collection, treatment, and disposal programs in these areas present a little different picture. The facility construction projects that were on the verge of being implemented two or three years ago were delayed by the passage of the 1972 Amendments to the Water Pollution Control Act which required that 201 Facilities Plans be prepared, reviewed, and approved before any State or Federal grant assistance could be obtained for the construction of these facilities. I'm not criticizing the 201 facilities planning concept when I say that its advent has caused delay in construction of facilities that would be operational today had the advent of this planning requirement not been levied upon the local units of government. On the plus side, the 201 planning requirement has accelerated action on the part of some coastal area governments where initiatives might not have been taken for some time to come without this stimulus. To date, 201 facilities plans have been completed for the Carteret County complex (heavily populated central part of the county, including East Bogue Banks) and for Wrightsville Beach. Preparation of plans are underway for the Dare County complex, West Carteret County and the Swansboro Area, the Onslow and Pender County beaches area, the Greater Wilmington area, South New Hanover County area, and portions of the Brunswick County beaches area. As you can see, this pretty well covers all of coastal North Carolina where development has caused easily identifiable wastewater disposal problems. The planning in each case is truly regional in scope; and in some cases, totally regional solutions will be presented. In other cases, it appears that the optimum solution to the problem will be to establish and operate sub-regional facilities within the total facilities complex area. I, again, may be oversimplifying a point to state that the planning process is working. Obviously, there are still numerous problems to be resolved between acceptance of the plan concept and implementation of the plan itself. This could be the topic of a whole new discussion, some of the points of which will be discussed by other speakers participating in the program.

I would like to close my remarks by pointing up one serious problem we have yet to face here in North Carolina. Our studies in Carteret County and Wrightsville Beach (which have been completed) indicate that the most viable solution to the problem of wastewater disposal in the beach communities is to collect and adequately treat the waste and dispose of the high-quality effluent residual into the Atlantic Ocean through ocean outfalls. This conclusion has been reached after detailed consideration of every conceivable alternative in complete consonance with the Environmental Protection Agency guidelines prescribing the planning process. Our preliminary conclusions in other areas we're studying, such as Dare County, the rest of Carteret County, Pender County, and even Brunswick County, indicate that this will be the most viable solution in these areas also. Our problem here is that the State has not promulgated rules and regulations concerning the question of such discharges by use of ocean outfalls; and consequently, the State is not in a position to certify nor approve what appears to be the most cost-effective and socially and environmentally acceptable solution to the problem. This concept is not new--it has been studied for a number of years and has been analyzed, approved, and is being employed in numerous coastal areas on both the East and West Coasts of the United States, and in other areas of the world. In my opinion, adequate and optimum protection of our environment in North Carolina is being delayed due to lack of guidelines and initiatives on the important question of ocean outfalls. I note that a number of other speakers will address this specific question later on in the program. I look forward with interest to hearing what they have to say.

OCEAN OUTFALL DISPOSAL SYSTEMS

Donald L. Feuerstein, *Ph.D.*
Associate
Engineering-Science, Inc.
600 Bancroft Way
Berkeley, California 94710

Submarine outfall disposal systems have been used in a number of areas of the world effectively, and successfully, to dissipate wastewater constituents in a receiving environment. Initial development and use of large submarine outfalls occurred on the West Coast of the United States, particularly in southern California, due probably to a combination of favorable or compelling conditions. Large human populations were concentrated on the coast, the ocean provided the only available receptor for wastewaters, and there was a need to maintain an acceptable bacterial quality of the beach areas.

Because the bathymetry of the West Coast allows attainment of substantial wastewater discharge depths reasonably close to shore (e.g., in Santa Monica Bay, 18 m [60 ft] of depth occurs about one statute mile from shore) that are not equalled on the East Coast (e.g., in Onslow Bay, 18 m of depth occurs more than 13 statute miles from shore), it has been assumed by many that major submarine outfall disposal systems would not be cost-effective on the East Coast; and as such, few exist. In view, however, of the increasing awareness of the necessity to provide for the most cost-effective and environmentally sound water quality control systems, the efficacy of submarine outfall disposal systems for East Coast conditions requires reexamination.

The objective of an ocean outfall, or for that matter any disposal system, is to reduce or eliminate any adverse effects of wastewater discharges on the receiving environment. This objective is accomplished with a submarine outfall system by effecting the necessary dilution in the immediate vicinity of the discharge with a diffuser section and by locating the diffuser section en appropriate distance from areas of special concern.

Of the various mechanisms which cause the diminution of discharged wastewater constituents in receiving waters, dilution and disappearance are the two most important ones. Dilution *per se* occurs as a result of two distinct mechanisms. The first is the so-called jet, or initial, dilution which occurs in the immediate vicinity of the diffuser section or point of discharge and which extends to some level in the receiving water above the discharge. The area extending upward to this level is referred to as the initial mixing zone. The second mechanism which causes a dilution of the waste in the receiving water is that which occurs as a result of lateral dispersion, or diffusion. This is a mechanism, very similar to molecular diffusion, which occurs as the wastes are transported away from the initial mixing zone by the receiving water currents.

The second mechanism for diminution of wastewater constituents, at least for the non-conservative wastewater constituents, is disappearance, or decay, whereby the particular non-conservative constituent disappears with time due to any number of factors, such as sedimentation, chemical conversion, or bacterial die-away. These, then, are the three principal mechanisms for diminution of the wastes in the environment which must be considered in the rational design of a submarine outfall disposal system.

Because most outfall disposal systems discharge predominantly municipal wastes into the marine environment, which is a salt-water environment, the discharged wastes are generally of lesser salt content than the waters into which they are being discharged. In addition, the municipal wastes are generally warmer than the receiving waters. These two factors cause the discharged waste, upon entering the receiving waters, to rise above the discharge point or diffuser and disperse in the initial mixing zone as a result of buoyant and momentum forces.

A schematic of a rising wastewater plume is shown in Figure 1. At some point in the water column over the port or diffuser, the wastewater-seawater mixture will achieve the same density as the receiving water and thereafter will have no further tendency to rise. Moreover, if the rising wastewater-seawater plume encounters a pycnocline which is a pronounced density gradient, it will generally rise no further because of insufficient energy in the rising plume to penetrate the pycnocline and because the rising plume would then be surrounded by water of much lesser density. Pycnoclines, generally about ten meters in depth, are quite common in coastal waters and result from a well-mixed upper layer caused by action of the wind and waves on the ocean surface. Figure 1 represents a situation in which the rising wastewater-seawater plume encounters a pycnocline resulting in a so-called submerged field. The submerged field is a desirable feature because not only will the discharged wastewater be invisible from a non-submerged vantage point but the floatables and other materials in the wastewater which have a tendency to concentrate at the interface, or at the top of this mixed wastewater-seawater zone, will have no tendency to surface and create nuisances. If there is no pronounced pycnocline or if the energy in the rising wastewater-seawater plume is such that the pycnocline is penetrated, the wastewater-seawater mixture will surface and may be apparent on the surface. In either case, the initial dilution, S_0, which occurs in the initial mixing zone, is the concentration of the wastewater divided by the concentration of the wastewater-seawater mixture. Because the ocean currents at any given time are highly variable with respect to speed and direction throughout the water column, it is important to predict at what level the wastewater-seawater mixture will have no further tendency to rise in the water column. It is at this level that the wastewater-seawater mixture will be transported away from the diffuser and will be attenuated subsequently by other mechanisms.

The relationships and calculations that will be presented are based on the dilution of soluble material and are not applicable to the dilution or dispersion of materials which are only slightly dispersed, such as floatable or particulate matter. It must be emphasized that these relationships do not apply if one is concerned about concentrations of floatable or particulate matter at the surface. Historically, the primary concern has been the resulting concentration of coliform bacteria or pathogens at some point in the receiving water. Because coliform organisms react as a soluble or dissolved substance in the immediate vicinity of the discharge, they can be treated as dissolved substances.

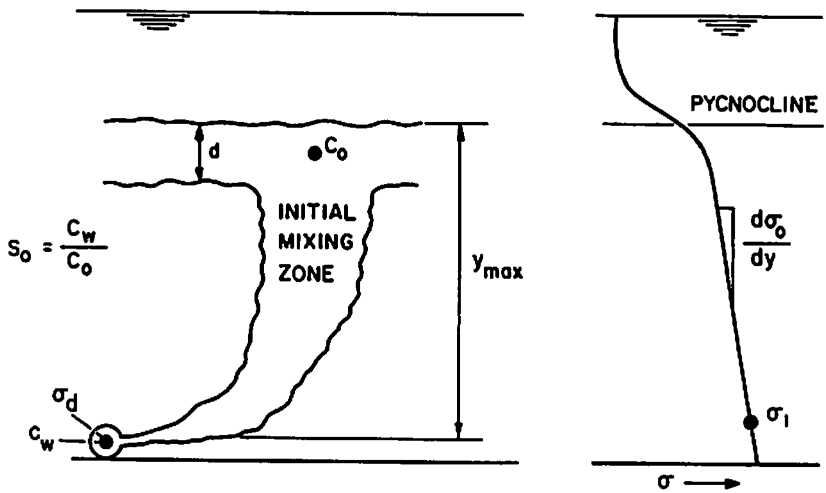


FIGURE 1
DEFINITION SKETCH OF RISING WASTEWATER - SEAWATER PLUME

The maximum height, y_{max}, achieved by the rising wastewater-seawater plume above the diffuser can be estimated using the following equation:

$$y_{max} = \left\{ \frac{610\ q_o\ (\sigma_1 - \sigma_d)}{\sqrt{g} \left[\frac{d\sigma_o}{dy}\right]^{3/2}} \right\}^{1/3} \tag{1}$$

y_{max} = maximum height of plume above diffuser, m

q_o = discharge per linear meter of diffuser, cu m/sec-m

σ_1 = density of ocean water at level of source

σ_d = density of wastewater

$\frac{d\sigma_o}{dy}$ = density gradient, 1/m

g = acceleration due to gravity, m/sq sec

The appropriate densities and density gradient for use in the expression are shown on Figure 1. Inspection of Equation 1 reveals that the only variable available to the designer of the ocean outfall which influences the maximum height of plume above the diffuser is the term q_o, which is the rate of wastewater discharge per length of diffuser. Thus, within any particular area of wastewater discharge (where seawater densities and density gradients are relatively constant with respect to specific location, and for a specified wastewater flow rate), the maximum height of plume rise is dependent only upon the length of the diffuser section.

The initial dilution, S_o, occurring near the top of the rising wastewater-seawater plume, can be estimated from the relationship shown in the following equation:

$$S_o = \frac{0.41\ g^{1/6} (\sigma_1 - \sigma_d)^{2/3}}{q_o^{1/3} \left[\frac{d\sigma_o}{dy}\right]^{1/2}} \tag{2}$$

It can be observed that again the only variable available to the designer is q_o, which is the wastewater discharge flow rate per length of diffuser. The other variable factors (density of wastewater, density of ocean water at the level of discharge, and the appropriate density gradient) are generally beyond the control of the designer.

The relationships shown by Equations 1 and 2 were developed for the case of a continuous discharge into a quiescent receiving body of water. As such, they are not exactly applicable to the very dynamic marine environment where there exists a continual mass transport of water past any particular location. On the basis of mass conservation considerations, the maximum initial dilution can be estimated using the following expression:

$$S_o = \frac{u\ b\ d}{Q} \qquad (3)$$

u = effective current speed, m/sec
b = diffuser length, m
d = mixing depth, m
Q = wastewater discharge rate, cu m/sec

This simple expression indicates that the maximum initial dilution occurring in the initial mixing zone is a function of the effective current speed perpendicular to the diffuser, the length of the diffuser, the mixing depth, and the wastewater discharge rate. Once again, this equation demonstrates that with the exception of relocating to a point of more favorable current speed or into an area of more favorable mixing depth the only variable available to the designer is the diffuser length.

Following the initial dilution that occurs in the immediate vicinity of the diffuser, the wastewater-seawater mixture will be transported away from the initial mixing zone by the ocean currents. This transport is accompanied by another dilution mechanism; namely, lateral dispersion. An idealized sketch of a laterally dispersing wastewater plume originating from the diffuser section is shown in Figure 2. As the wastewater of concentration C_o is transported away from the diffuser section, it decreases in concentration due to dilution effected by horizontal dispersion. For the idealized case, the maximum wastewater concentration at any distance from the diffuser will occur at the center line of the plume, as shown in Figure 2. C_o is the concentration of wastewater over the diffuser following initial dilution, and S_{dif} is the minimum dilution effected by horizontal dispersion at some specified point downstream.

The minimum dilution due to horizontal dispersion, S_{dif}, can be determined from the following expression:

$$S_{dif} = \left\{ \operatorname{erf} \sqrt{\frac{1.5}{\left[1 + \frac{8\ a\ t}{b^{2/3}}\right]^3 - 1}} \right\}^{-1} \qquad (4)$$

t = minimum travel time, hr

a = coefficient of diffusivity, $m^{2/3}/hr$

erf = standard error function

This expression is applicable to a line source discharge such as shown in Figure 2. It provides the dilution occurring along the center line of the plume. Inspection of this expression indicates that the only two variables subject to control by the designer are the travel time to the point of interest and the diffuser length. Because the travel time from the diffuser to some point of concern, such as the shoreline, is a function of current velocity and distance, the travel time can be changed by increasing or decreasing the length of the outfall.

The second type of diminution mechanism is that caused by the disappearance, or decay, of non-conservative constituents. For coliform bacteria, the appropriate expression for estimating the dilution effected by bacterial disappearance, S_{dis}, is the simple expression shown in the following equation:

$$S_{dis} = 10^{t/T_{90}} \qquad (5)$$

T_{90} = time required for 90 percent disappearance of coliform bacteria, hr

From this expression it can be seen that the only variable available to the designer of the disposal system is the minimum travel time, which is a function of the length of the outfall and the appropriate ocean current velocity.

The relative importance of the three diminution mechanisms for various outfall lengths, associated diffuser depths, and T_{90} values is shown in Table 1. These values have been calculated for a wastewater discharge rate of 0.33 m^3/sec (7.5 mgd); a horizontal diffusivity of 0.010 $cm^{2/3}$/sec (0.0010 $ft^{2/3}$/sec), which is a general oceanic average; a diffuser length of 100 m (328 ft); an effective current velocity over the diffuser of 3 cm/sec (0.058 knot); and a transport current velocity of 9 cm/sec (0.17 knot). Looking at the values listed in the column under T_{90} = 1 hour, a relatively small increase in distance results in a very large increase in total dilution. A T_{90} value of one hour is quite typical of values observed in warm waters around the world, such as the waters in the vicinity of Acapulco Bay, Mexico; Rio de Janerio, Brazil; Puerto Rico; and the Hawaiian Islands. As one proceeds northerly into colder waters, T_{90} values increase. Values along the California coast, for example, are observed to be nearer two to three hours. To consider the relative effect of T_{90} value at a fixed distance of two kilometers, for example, it is apparent from Table 1 that increasing the T_{90} value by a factor of four, from one to four hours, results in a reduction in total dilution of five orders of magnitude, or from a factor of 10^6 to only 10^1. Therefore, the T_{90} value employed in the design of submarine wastewater disposal systems is quite critical in determining the required length and location of the outfall.

It is apparent from Table 1 that the diminution resulting solely from horizontal dispersion is small in relation to other dispersing mechanisms. For example, increasing the distance from the diffuser or the length of outfall from 0.5 km to 10 km results in an increase in total dilution from two to 69. Dilutions on the order of 50 to 100 can be achieved in the initial mixing zone by proper diffuser design.

Although a high dilution of wastewater can be achieved with a submarine outfall disposal system, the other major functional component of the wastewater management system--namely, wastewater treatment--must not be overlooked in determining the most cost-effective system. For a given wastewater characteristic and receiving environment quality objective, there is usually a variety of wastewater treatment and disposal systems that can be integrated to provide comparable results.

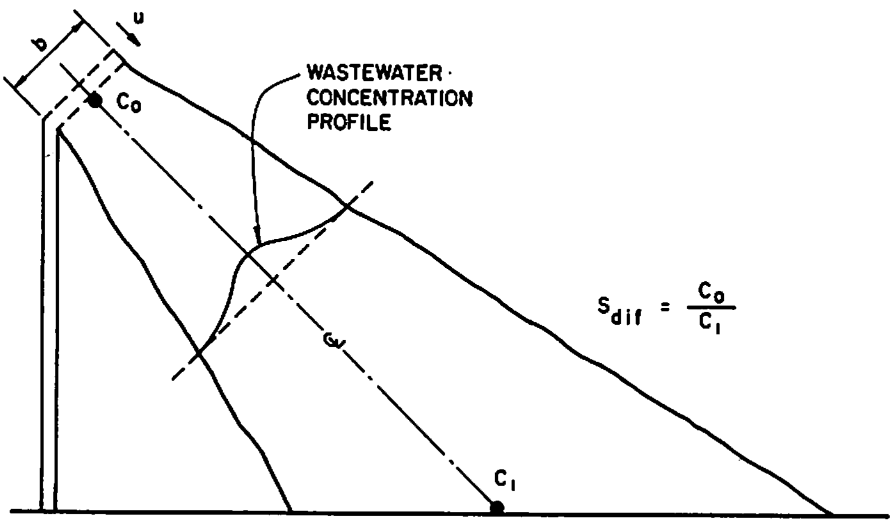


FIGURE 2
DEFINITION SKETCH OF HORIZONTALLY DISPERSING WASTEWATER - SEAWATER PLUME

Table 1

RELATIVE MAGNITUDES OF DIMINUTIONS EFFECTED BY SUBMARINE OUTFALL DIFFUSER SYSTEM[a]

Distance from Diffuser		Depth of Diffuser[b]		Dilution Factor			
				Initial Dilution[c]	Horizontal Dispersion[d]	Disappearance	
km	miles	m	ft			T_{90} = 1 hr	T_{90} = 4 hr
0.5	0.31	5.5	18.0	5.00×10^{1}	1.98	3.49×10^{1}	2.40
1.0	0.62	7.3	24.0	6.60×10^{1}	3.85	1.22×10^{3}	5.74
2.0	1.24	9.1	29.9	8.30×10^{1}	8.06	1.49×10^{6}	3.31×10^{1}
3.0	1.86	11.0	36.1	9.10×10^{1}	1.33×10^{1}	1.82×10^{9}	1.91×10^{2}
5.0	3.11	13.7	44.9	1.00×10^{2}	2.62×10^{1}	2.71×10^{15}	6.26×10^{3}
10.0	6.21	16.5	54.1	1.03×10^{2}	6.90×10^{1}	7.32×10^{30}	3.94×10^{7}

[a]Wastewater discharge rate = 0.33 m^3/sec (7.5 mgd); diffuser length = 100 m (328 ft).
[b]Onslow Bay, North Carolina.
[c]Effective current velocity = 3 cm/sec (0.058 knot).
[d]Horizontal current velocity = 9 cm/sec (0.17 knot); horizontal diffusivity = 0.010 $cm^{2/3}$/sec (0.0010 $ft^{2/3}$/sec).

In general, an increasing level of treatment or pollutant removal can be matched with a decreasing dilution capacity of the disposal facility to satisfy the same receiving water quality objectives. Because the costs, as well as the overall environmental effects, of the various candidate systems will differ, a careful consideration and evaluation of the overall wastewater management system must be undertaken if the most economical and environmentally acceptable treatment and disposal system is to be provided.

There is available a fairly large array of processes, representing a wide range of pollutant removal efficiencies, from which to select a treatment process train that can achieve a desired level of treatment or wastewater constituent removal. With respect to disposal of wastewaters into the marine environment, the wastewater parameters of potential concern can be grouped into several generic categories. These are settleable solids, suspended solids, floatables, oxygen-demanding substances, temperature, pH, nutrients, toxic metals, toxic organic compounds, and bacteria or other infectious agents. The magnitude of one or more of these groups of pollutants, depending upon the particular characteristics of the wastewater and the receiving environment, will usually define the necessary design criteria and configuration of the treatment and disposal system.

In addition, other existing and anticipated factors should be taken into account in the functional design of treatment and disposal systems. There appears to be a trend developing for more complete treatment of wastewaters, with little or no subsequent dilution required of the disposal system because of the increasing desirability and need in many parts of the world for wastewater reuse. Selection of more complete treatment has associated with it, however, several factors which require careful consideration.

One factor is an increase in waste solids requiring disposal due to the use of additive chemicals, such as alum or lime, and to the greater removals of both soluble and insoluble wastewater constituents. The costs of processing and disposing of these waste solids can be large, and the environmental effects of disposing of these materials on land can be quite adverse without proper precautions.

Other factors associated with more complete treatment are increased process unreliability, higher frequency of operational upset, and the need for greater knowledge and sophistication on the part of operating personnel. As the treatment process train becomes more extensive and complex, its reliability for providing the required level of treatment generally lessens due to a greater need for careful process control and an increase in the number of operations and equipment that can fail or malfunction. An adequate disposal system can provide the necessary immediate dilution to greatly reduce the environmental effects and risks of such occurrences.

Staged implementation is another important factor to be considered in the selection and design of a wastewater treatment and disposal system. Disposal systems, and particularly submarine outfalls, are usually sized for ultimate flow conditions at the end of useful life, which is normally 30 to 50 years. Therefore, the conduit is oversized for most of its useful life, resulting in necessarily high capitalization costs. Treatment plants, however, can be more readily staged to produce an overall higher use factor over the entire planning period, a more equitable distribution of capital costs, and a certain flexibility to respond to unforeseen future changes in wastewater characteristics, water quality objectives, and public attitudes. Disposal systems, on the other hand, have relatively low recurring costs, whereas treatment systems have relatively high recurring costs for labor, power, chemicals, maintenance, and replacement.

In general, treatment and disposal systems that rely primarily on the disposal system for effecting the major diminution or attenuation of controlling pollutants have the relative advantage of possessing high degrees of wastewater dilutions, low recurring costs, and great reliability. Treatment and disposal systems that rely primarily on the treatment system for reducing pollutant concentrations in the environment have the relative advantage of providing specificity of particular pollutant diminution, of reducing the pollutant emission rate, and of providing flexibility to respond to unforeseen future changes.

In conclusion, considerations of the phenomenological aspects of dilution effected by submarine outfall disposal systems, local oceanographic conditions, and an ever-increasing demand to lessen the environmental effects of wastewater discharges indicate that submarine outfall disposal systems on the East Coast could be cost-effective and should be given careful evaluation.

QUESTIONS AND DISCUSSION

QUESTION: (Professor Eugene McJunkin) Could you redefine T_{90} again?

DR. DONALD FEUERSTEIN: The T_{90} value is a convenient parameter which is the time it takes for 90 percent of a given number of organisms to disappear from the sample. A T_{90} of one hour indicates that if you have 100 organisms, at the end of one hour you would have 10 organisms. In other words, 90 would perish or disappear.

QUESTION: (Professor David H. Howells to Colonel Denison) In your comments you spoke on the one hand to the future problem of increasing the available water supply, perhaps having to recycle some water particularly in the coastal fringe; and on the other hand, you point to the efficacy of ocean outfalls and their lower costs or possible lower costs. It seems to me that once we make the decision to take a wastewater to sea, water incidentally which has a very low dissolved solids content relative to sea water, one that is really fairly ready for reclamation, and dispose of it in the ocean, it's gone--it's a resource gone. It would seem to me that we ought to explore whether to discharge to sea or to land and tie this decision back to the available water supply--whether we might not want to think more about, say, land disposal, recharging the groundwater and building this up for greater use. Would you care to comment?

COLONEL PAUL DENISON: I think this represents a very real question and one that I did allude to in my talk simply by stating that when we reach the stage that we can recycle in a true sense, obviously this is the route we have to go. I think that the profession recognizes this need and is dedicated to this objective; however, we feel that we're still some years away from the breakthrough, so to speak, that will actually let us recycle wastewater effluent discharges in a sense that they can resolve the water supply question.

You asked shouldn't we look at the possibility of recycling by land disposal in order to recharge our water supply short areas. The answer is: Yes, we should and we have. The basic problem, I think, stems from the fact that our present degrees of treatment and the problems of discharging quantities of waste that still have some undesirable residuals, limit this possibility in large degree when we are talking about the very narrow barrier beach islands that we are so much concerned with. We looked at the possibility of land disposal with treated wastewater effluent; but once again, with the cost of property and the very limited availability of land in the beach area, land disposal is not a cost-effective solution at the present time. When you talk about transporting effluent back to some larger land areas where land disposal can be effective, then it is not cost-effective because of the transport cost.

Now, other recycling concepts such as spray irrigation on golf courses and this sort of thing which are water-supply demanding are certainly a point of consideration. The State has established guidelines for this limited disposal use, which in a sense is recycling. We find once again that the restraints or restrictions placed on this method of disposal are extremely limiting as compared to the quantities of water that we are talking about discharging. So I think this simply boils down once again to the fact that with the treatment that we can afford to provide today plus the very limited discharge capability as far as recharging the aquifers in the beach systems are concerned, recharging appears to represent a very limited potential at this stage of the game.

In reference to a very important remark that you made, the suggestion for wastewater disposal by ocean outfalls at this time is not intended to be the end-all answer to this question. It's being considered on a nationwide basis and is being approved in many other areas at the present time as an interim solution to the problem until we achieve the breakthroughs that you are talking about and demonstrate that we can effectively recycle the discharges from our wastewater treatment facilities. Our problem now is that when you look at the alternatives, our options are limited. I would like to emphasize that one of the primary objectives would be to get these discharges out of our extremely fragile estuarine systems and into an environment that is so much more capable of assimilating them. The ocean is a much more hostile environment relative to the small amount of discharges that we intend to put out there than are our estuaries. It really boils down to the question of what other options do you have? Our analysis indicates that the most cost-effective, and we sincerely feel the most environmentally acceptable, solution to the problem during this interim period is ocean outfalls.

QUESTION: (Mr. John R. Bettis) Have either of you two gentlemen been able to get a permit from EPA in the last two or three years to build an ocean outfall? If so, how do you meet their monitoring requirements at the discharge point?

DR. DONALD FEUERSTEIN: The answer to the first question is definitely yes. There are a number of outfall systems that have been approved along the West Coast. One example is the system that we designed for the City of Santa Barbara. It went through the normal permit procedures for the State of California, which had in some instances a more stringent ocean discharge policy than does EPA; we see no problem in meeting the requirements.

We are also involved--it's not in design yet--with a system involving an ocean outfall in Monterey Bay in California which has the full blessing of EPA. There is also a system in Humboldt Bay in northern California where, surprisingly or not, many of the local people, and particularly the conservationists, felt that it was better to discharge the treated wastewaters into the very limited confines of Humboldt Bay; but the state and EPA said: "It shall be put in the ocean through an outfall." The West Coast does have a more favorable situation for submarine outfall systems in that it can reach reasonable depths within short distances of the shore. But a point perhaps that I did not emphasize in my paper was that nowhere in the equation is it obvious that depth is a critical parameter to effecting a major dilution in the ocean. Certainly, it is important but not directly. The problem of water reclamation and reuse versus sending it out to the ocean through an outfall disposal system has, of course, been under consideration for California for many years. California--particularly, southern California--is an area which is not blessed with much rainfall; and as such, is a very water-short area. They transport water from northern California, which means a conduit of about 400 to 500 miles, extensive pumping, and so forth, just to supply the water demands for southern California.

All the comments that Colonel Denison mentioned I agree with; I would like to emphasize two points that he did not mention, however. In California where crops are extensively irrigated and where wastewater could be used for this purpose, one is faced with the seasonal demand for this water and the fact that you cannot irrigate golf courses even during certain portions of the year because of the rainfall. The problem then becomes what to do with this reclaimed water during the period when it is not required. You either store it or dispose of it in some manner.

The other problem which I did allude to in my talk is that most reclaimed water demands require a high quality of water, even irrigation, and cannot tolerate major operational upsets in the treatment processes which in the case of reclamation and reuse facilities is fairly sophisticated. One is now faced with the problem of what to do with the wastewater when it does not meet the water quality specifications of the user. An outfall is probably the best way to dispose of those wastewaters during that period of time and with the least environmental effect. I think there is a strong case for considering ocean outfalls even though one anticipates substantial water reuse in the future.

Another problem that exists with respect to reuse of reclaimed water is the fact that although you may be in an area where everyone demands water, it is very difficult and it takes time to line up and get users under a long-term contract, which is required if you commit yourself to a wastewater reclamation and reuse project.

Finally, the reclamation of wastewater has been practiced in southern California probably more than anywhere else in the United States, and most of these successful operations, particularly those of which you may be aware in the Los Angeles County area, are online systems. In other words, they are systems set on a large sewer main and take off the water at a constant rate, remove the solids and provide the quality of reclaimed water desired and discharge all of the solids and residuals back into the sewer to be transported downstream to a conventional sewage treatment plant for ultimate disposal. I would say that at least in California where you have such a situation, wastewater reclamation does have very, very good cost benefits. But there are other areas where you don't have that ideal situation.

QUESTION: (Mr. Ted Mew) For what projected levels of population were you planning in the Dare Beach study?

COLONEL PAUL DENISON: The land use planning and demographic studies that were done in the Dare Beach area, or in Dare County, were done by two independent agencies--one by the State Planning Office (field office in Washington) and another by an independent planner in the Raleigh area. These two independent or separately done studies projected populations for the Dare Beach areas extending through the year 2020. We used these projections as a basis for our preliminary engineering reports indicating both what water supply demand needs and wastewater disposal requirements would be. Now without referring back to the report, I have difficulty giving you the exact numbers, but let me mention that the very specific problem in the Dare Beach areas (which is peculiar to almost all of the coastal areas) is one of a tremendous swing in water supply demands and wastewater loading during the peak summer season. In the Dare Beach areas, for example, there are 35 to 40 thousand people on the beach during the summer season whereas permanent population during the months of January and February will be as low as 3000 to 3500 people. Now in order to meet water supply demands and wastewater disposal requirements you've got to be able to handle these peak loadings. So the answer is that the initial or 1972-1975 projection is in the range of 3500 people permanent population and 35 or 40 thousand peak population during the summer--June through Labor Day. These projections then go on up the scale projecting the growth phenomena that has been experienced in that area in five-year increments, ultimately reaching by 1995 planning period some 10 million gallons a day water supply demand and, of course, relatively equal wastewater disposal projections.

QUESTION: (Mr. Ted Mew) Would you say that these levels are at least approaching the levels of a Virginia Beach or an Ocean City type of development or high-rise condominiums on the beach? Is this what's being planned for?

COLONEL PAUL DENISON: Well, we're not planning for anything except the projections we've been given. The growth planning is the responsibility of local units of government.

QUESTION: (Mr. Ted Mew) I understand that, but I mean are you planning or designing your facilities to meet the certain type of development?

COLONEL PAUL DENISON: Our preliminary engineering reports for that area are based on the planning projections made by the planners and the land use plan associated with that. If you are familiar with the plan, it simply states that there will be developments in certain areas with low densities, some medium densities, some high densities, some green space set aside and so on. And, of course, the implementation or scaling the size or rate of increase in any of these areas will relate directly to the control established by the local units of government and by the planning agency within the county. The situation and the problems I have talked about in my talk exist; today, they are there, they are very critical, so the problem is: resolve to it immediately in response to whatever the citizens of Dare County determine shall be their destiny for the future. I have publicly stated on numerous occasions before and don't hesitate to do it today. I hope Dare County has no illusions of becoming a Virginia Beach or an Ocean City, Maryland, or anything else. I think that this is a primary objective that we are seeking throughout coastal North Carolina.

QUESTION: (Professor Jake Wicker) I'm going to ask this question as sort of a devil's advocate. Is there any need to pretreat or to treat at all if you are going for an ocean discharge other than perhaps to remove floatables?

COLONEL PAUL DENISON: I think either Don or I could speak to this, and he's already alluded to the fact that historically ocean discharge meant the discharge of raw sewage into the ocean. This, of course, is no longer tolerable or acceptable although some very interesting studies that have been done in southeastern Florida on ocean outfalls over 40 years' old discharging raw sewage (and this is still being done in some areas, not only in this country but the world) indicated that it was extremely difficult to pinpoint any definitive long-term environmentally detrimental effect. There were some short-term effects around the area of the discharge pipe itself, but let me go specifically to your question. The answer is that we don't feel, under any stretch of the imagination, that this is a desirable means of disposal of sewage waste, domestic or otherwise. So we do propose that we provide adequate treatment. We're speaking specifically, and our recommendations are subject to all the reviews by the approving authorities that will ultimately have to do this. We are recommending a good degree of reliable secondary treatment which will give you a treated wastewater effluent at the end of pipe; that if caught in a glass looks very much like a glass of water with a pinch of pepper sprinkled in it, so we are talking about a relatively clear discharge. We strongly recommend, of course, that whatever degree of treatment is recommended by the reviewing authority be effective; but here again, you get to the cost-effective analysis of what you are trying to do. How much should the taxpayer be asked to pay to achieve certain objectives?

I will regress for a moment to say that as practicing engineers if somebody tells us that our recommendation for a $2 million solution to the problem is not acceptable and they want us to design and construct a $10 million solution to the problem, we really and truly have no objections to that--except that from a professional and an ethical point of view we cannot recommend that because we do not think it is a proper solution to the problem. Directing back a very good question asked a few moments ago about what are the chances of an approval, Dr. Feuerstein referred to his experience on the West Coast. EPA Region II has been approving ocean outfalls in the northern part of our country for some time. Within the last two years we understand five have been approved in New Jersey and some number in New York.

In New Jersey, for example, I remember that the last one subject to approval is in Atlantic City where they are talking about 40 million gallons a day discharged to an ocean outfall to service that particular community. We're not talking about 40 million gallons discharged into the Atlantic Ocean off the entire North Carolina coast between now and the year 2000. And my personal hope would be that the mechanisms that we were talking about in Dare County a moment ago will come to bear and that we will see prudent development in the coastal area and that there will be whatever restrictions are necessary to insure they get proper development. But man is still going to want to come to the beach and still going to want to use the area. While he's there, he's still going to demand water and generate waste; and our objectives would be to insure that the supplying of water, treatment of this waste, and disposal of the residuals uses the most cost-effective, social, and environmental solution that we can come up with.

ENVIRONMENTAL ASSESSMENT OF MARINE OUTFALLS

David R. Hopkins, *P. E.*
U. S. Environmental Protection Agency
Region IV
Atlanta, Georgia

I greatly appreciate the opportunity to appear before you today to talk about ocean outfalls. This method of wastewater disposal is receiving considerable interest--both pro and con--in our part of the country--especially in southeast Florida; and now, recently, it is being proposed for this area.

Two years ago, the Atlanta Regional Office of EPA prepared and released an environmental impact statement titled, *Ocean Outfalls and Other Methods of Treated Wastewater Disposal in Southeast Florida.* As the principal project officer for this project, let me say that we learned a great deal about the interim viability of ocean outfalls. But we also came to realize that there's still a lot more that we don't know. To fill in the blank spaces will require more studies.

Right now, plans are underway to launch the necessary studies of the long-term effects of ocean outfalls in southeast Florida and their relationship to the environment of southeast Florida. EPA is cooperating with other agencies and groups in setting up these studies. Other studies are underway in southern California and Washington.

But first, I think it proper to set the stage for these studies. To do this, let's take a look at some of the legal aspects. Two acts are involved with ocean disposal. Ocean dumping is regulated under the provisions of Section 102 of the Marine Protection, Research, and Sanctuaries Act of 1972, as amended. However, ocean outfalls are regulated under Section 402 of the FWPCA; that is, National Pollutant Discharge Elimination System. Section 403 of FWPCA requires EPA to establish discharge guidelines and further adds where insufficient information exists on any proposed discharge such as to make a reasonable judgement, no such permit for a discharge into ocean waters will be issued except in compliance with the criteria set forth in EPA's Ocean Disposal Regulations and Criteria.

The Federal Water Pollution Control Act Amendments of 1972, Section 403(c), establishes criteria for the issuance of permits for ocean discharges. FWPCA, as the legislation is hereafter referred to, directs the EPA Administrator to establish guidelines for determining the degradation of waters of territorial seas, of the contiguous zone, and the oceans. FWPCA further directs that the guidelines cover seven specific points. I will list these, and I quote the exact wording of the law:

1. The effect of disposal of pollutants on human health or welfare, including but not limited to plankton, fish, shellfish, wildlife, shorelines, and beaches.

2. The effect of disposal of pollutants on marine life, including the transfer, concentration, and disposal of pollutants on their by-products through biological,

physical, and chemical processes; changes in marine ecosystem diversity, productivity, and stability, and species and community population changes.

3. The effect of disposal of pollutants on aesthetic, recreation, and economic values.

4. The persistence and permanence of the effects of disposal of pollutants.

5. The effect of the disposal at varying rates, of particular volumes, and concentrations of pollutants.

6. Other possible locations and methods of disposal or recycling of pollutants, including land-based alternatives.

7. The effect on alternate uses of oceans, such as mineral exploitation and scientific study.

That's a big order, but EPA established the guidelines in 1973 in a document titled, *Ocean Disposal Regulations and Criteria*. At the present time, these regulations are being revised, and it is a revised draft upon which I base my comments today, although I must emphasize that the revised regulations are not final.

Let me interject here that any state may propose criteria for EPA to adopt--other than the criteria set forth by EPA--for application to the evaluation of permits for dumping material in ocean waters within the state's jurisdiction or in other ocean waters which the state demonstrates will affect the state ocean waters.

I also add that in the case of municipal outfalls, which in all probability will have a grant, the application must first be certified to us by the state which means state approval comes before EPA. We cannot act on the grant without the state approval nor could we approve a permit without state approval.

To continue, let's go into the details of the criteria. FWPCA requires that criteria for the issuance of ocean disposal permits be promulgated after several considerations. These are:

1. the environmental effect of the proposed waste disposal operation,

2. the need for ocean disposal,

3. alternatives to ocean disposal, and

4. the effect of the proposed action on aesthetic, recreational, and economic values and on other uses of the ocean.

The criteria deal with the evaluation of individual permit applications on a case-by-case basis from information supplied by the applicant. Such information includes the characteristics of the waste and the effect of the water on the receiving environment. Notwithstanding any other provisions of these criteria, no permit will be issued when the disposal will result in violation of applicable state water quality standards approved or adopted by the EPA Administrator.

What are the prohibitions, limits, and conditions for issuing a permit for ocean disposal? First, obviously, there must be a determination that the proposed waste disposal will not unreasonably degrade or endanger the marine environment. To be more specific, it must be shown that the disposal will present no unacceptable adverse effects on human health and no significant damage to the resources of the marine environment. It must also be shown that the disposal will present no unacceptable adverse effect on the marine ecosystem. Further, it must present no unacceptable adverse persistent or permanent effects due to the discharge of the particular volumes or concentration of these materials. And finally, there must be no unacceptable effect on the ocean for other uses as a result of direct environmental impact.

Under no circumstances will EPA approve the discharge from an ocean outfall of any of the following:

1. High-level radioactive wastes as defined in the regulations.

2. Materials in whatever form (including without limitation solids, liquids, semi-liquids, gases, or organisms) produced or used for radiological, chemical, or biological warfare.

3. Materials insufficiently described by the applicant in terms of their composition and properties to permit application of the environmental impact criteria established by EPA.

4. Persistent inert synthetic or natural materials which may float or remain in suspension in the ocean in such manner that they may interfere materially with fishing, navigation, or other legitimate uses of the ocean.

Furthermore, for the most part, EPA will not approve the discharge from ocean outfall the following waste constituents as other than trace contaminants:

1. organohalogen compounds and compounds which may form such substances in the marine environment,

2. mercury and mercury compounds,

3. cadmium and cadmium compounds,

4. oil of any kind, and in any form, including but not limited to petroleum, oil sludge, oil retuse, crude oil, fuel oil, heavy diesel oil, lubricating oils, hydraulic fluids, and any mixture containing these, and

5. known or suspected carcinogens, mutagens, and teratogens.

The prohibition and limitation of the last list, however, may not apply provided the applicant can demonstrate with veritable scientific data that such contaminants are present in the waters only as chemical compounds or forms non-toxic to marine life and non-bioaccumulative to the marine environment. Further, it may be demonstrated that such constituents are present only as chemical compounds or forms which, within four hours of disposal, will be rendered non-toxic to marine life and non-bioaccumulative in the marine environment by chemical or biological degradation in the sea.

Now, if the applicant satisfactorily demonstrates that waste proposed for discharge satisfies the criteria I've listed, a permit for ocean outfall discharge will be issued unless--and there are these three additional conditions:

1. There is no need for outfall discharge, or alternative means of disposal are available, as determined in accordance with the established EPA criteria, or

2. There are unacceptable adverse effects on aesthetic, recreational or economic values and determined in accordance with the established criteria, or

3. Unless there are unacceptable adverse effects on other uses of the ocean as determined in accordance with the established criteria.

Even if the waste proposed for ocean disposal satisfies the environmental impact criteria, the EPA Administrator or Regional Administrator, as the case may be, could determine that any of the foregoing conditions applies and deny the permit. In that case, he may issue an interim permit if certain conditions are met. For example:

1. that the material must not contain any of the prohibited material,

2. that there is a need to ocean discharge the waste and that no alternatives are available, and

3. that the need for discharge and the unavailability of alternatives are of greater significance to the public interest than the potential for adverse effects.

In addition, there are limitations on discharge of waste containing living organisms. Such wastes may not be discharged if the organisms would extend the range of biological pests, viruses, pathogenic microorganisms or other agents capable of infecting or altering the normal population of organisms. Neither may they be discharged if they degrade uninfected areas or introduce viable species not indigenous to an area. I might point out, however, that this prohibition does not include effluents or sludges from sewage treatment works provided they have been treated to the equivalent of secondary treatment.

The impact of ocean outfall disposal on aesthetic, recreation, and economic values will be evaluated on an individual basis. Consideration shall be given to the potential for the outfall disposal for affecting recreational use and values of ocean waters, inshore waters, beaches, and shorelines. Consideration shall also be given to the potential for affecting the recreational and commercial values of living marine resources.

For all proposed waste discharges, full consideration will also be given to such non-quantifiable aspects as aesthetics, recreational and economic impact. These include responsible public concern for the consequences of the proposed discharge. It also includes the consequence of a permit being denied, including, without limitation, the impact on aesthetic, recreational, and economic values with respect to the municipalities and industries involved.

So much for the fine print in the *Ocean Disposal Regulations and Criteria.* Let's go on to some of the other matters. Certain terms constantly pop up in connection with the ocean outfall disposal, which should be defined.

Release Zone. In the case of ocean outfall discharge, the release zone is the area swept out by the locus of points constantly 100 meters from the point at which the waste material enters the ocean if no diffuser is used, or from the length of the outfall along which diffuser ports are located.

Disposal site use will be regulated by setting limitations on times and rates of discharge, establishing a disposal site monitoring program, and modifying disposal site use based on annual evaluations of disposal impact.

Let's say a little more about the monitoring program. The primary purpose of such a program is to evaluate the impact of disposal on the marine environment. The Regulations say that each EPA management authority shall develop and maintain monitoring programs for continuing evaluation of all disposal sites assigned to it. When disposal sites are being used on a continuing basis, such programs may consist of several components. These include:

1. Trend assessment surveys conducted at intervals frequent enough to assess the extent and trends of environmental impact.

2. Special studies conducted by the permittee to identify immediate and short-term impacts of disposal operations.

The Regulations also call for an annual evaluation of the impact of the disposal at each site, and this evaluation shall be submitted as an appropriate part of the Annual Report to Congress due at the end of each fiscal year. Such reports will be prepared by or under the direction of the EPA management authority for a specific site. And it shall be based on an evaluation of all data available from baseline and trend assessment surveys, monitoring surveys, and other data pertinent to conditions at or near a site.

The purpose of a baseline or trend assessment survey is to determine the physical, chemical, geological, and biological structure of a proposed or existing disposal site at the time of the survey. A baseline or trend survey is to be regarded as a comprehensive synoptic and representative picture of existing conditions. Each such survey is to be planned as part of a continual monitoring program through which changes in conditions at a disposal site can be documented and assessed. Surveys will be planned in coordination with the ongoing programs of NOAA and other federal, state, local or private agencies with missions in the marine environment.

Relative emphasis on individual aspects of the environment at each site will depend on the type of waste disposed of at the site. It will also depend on the manner in which such wastes are likely to affect the local environment. But no major feature of the disposal site may be neglected. The observations made and the data obtained are to be based on the information necessary to evaluate the site for ocean disposal. Furthermore, the parameters measured will be those indicative, either directly or indirectly, of the immediate and long-term impact of pollutants on the environment at the disposal site and on adjacent land or water areas.

An initial disposal site evaluation or designation study should provide an immediate baseline appraisal of a particular site. But it should also be regarded as the first of a series of studies to be continued as long as the site is used for waste disposal.

Where the bottom is smooth or evenly sloping, stations for water column measurements and benthic sampling and collections, other than trawls, should be spaced throughout the survey areas. Spacing should also be in such a manner as to provide maximum coverage of both the disposal site and contiguous control areas, considering known water movement characteristics.

And there are other considerations, as follows:

...The number of samples collected from the water column should be sufficient to identify representative changes throughout the water column as to avoid short-term impact due to disposal activities.

...A minimum of five water chemistry stations should be occupied within the boundaries of a site.

...Sampling stations for the biota in the water column shall be as near as feasible to stations used for water quality; in addition, at least two night-time stations in the disposal site and contiguous areas are required.

...Samples at the bottom shall be taken for both sediment composition and structure, and to determine the nature and numbers of benthic biota. At each station, sampling may consist of core samples, grab samples, dredge samples, trawls, and bottom photography or television, where available and feasible, depending on the nature of the bottom and the type of disposal site.

...The size distribution of sediments, mineral character, and chemical quality of the bottom will be determined to a depth appropriate for the type of bottom. Parameters to be measured at all stations include particle size distribution, major mineral constituents, texture, settling rate, and organic carbon.

The direction and speed of water movement shall be characterized at levels appropriate for the site and type of waste to be discharged. Where depths and climatic conditions are great enough for a thermocline of halocline to exist, the relationship of water movement to such a feature shall be characterized.

FWPCA requires the uniform attainment of effluent limitations based on secondary treatment for all publicly owned treatment works. However, there have been expressions of reservation on the necessity of secondary treatment of ocean discharges. Responding to these reservations, the EPA Administrator authorized a Task Force to report its findings and recommendations.

The Task Force spent six months on the study, and in a draft report has concluded that there is some justification for modifying the secondary treatment requirements as they apply to ocean discharges. But it found further that technical information available is not substantial enough to support an amendment to Public Law 92-500.

Specifically, the study group draft report concluded that pollutants of general concern in all ocean waters are toxic and persistent metals and organics, settleable solids, floatables, and pathogens. However, at the present time it does not believe that enough is known to relate the environmental effects of these pollutants to effluent quality on a quantitative basis. It suggested that more research is needed in this area.

Oxygen-demanding substances are of concern in most shallow nearshore ocean waters such as estuaries, bays, and the like; however, because of the dilution and dispersion possibilities, these materials do not generally cause adverse effects at most open ocean discharges.

Of the technologies considered by the Task Force, secondary treatment generally achieves the best removal of pollutants. However, this is designed primarily to remove oxygen-demanding pollutants and suspended solids. The removal of toxic and persistent organics in secondary treatment is incidental and attendant to the removal of BOD and suspended solids. However, reduction of BOD and suspended solids contributes significantly to the success of highly disinfected effluent. The Task Force suggests that technologies not yet fully developed may be better suited to marine pollution control.

EPA's Region IV has made a thorough study of ocean outfalls in southeast Florida which has been widely read and discussed. In March of '73 we released this study--a generic environmental impact statement titled, *Ocean Outfalls and Other Methods of Treated Wastewater Disposal in Southeast Florida*. This document is an examination of the impact of treated wastewater disposal methods in southeast Florida. The specific study area included Palm Beach, Broward, and Dade Counties.

In addition to discharge to the ocean via ocean outfalls, the alternative wastewater disposal methods considered were: discharge to freshwater canals and to estuarine waters; injection into the shallow and deep groundwater aquifers; discharge into the Everglades, land disposal, and septic tanks.

I must point out here that this environmental impact statement does not dictate the ultimate solution to the wastewater disposal problems of southeast Florida since it was not the intent of this environmental impact statement to select one effluent disposal alternative over others. Rather, it is to explore and discuss the various effluent disposal options available in southeast Florida.

We found that the disposal of secondary treated wastewater to the ocean via outfalls is a viable method of disposal for southeast Florida. We believe that diversion of wastewater from inland surface waters to ocean outfalls will substantially and immediately improve the quality of those surface waters. And we believe it will contribute to the long-term enhancement of inland surface water quality.

However, we also set three conditions under which the ocean outfall method of disposal may be used.

1. Alignment of the outfalls will be established to minimize disturbance of the reefs. A physical and biological site survey will be required to establish that alignment.

2. The outfalls will end beyond the last reef such that, under maximum shoreward current conditions, the boil will not overshadow the reef.

3. A continuous monitoring program will be initiated to detect any unforeseen changes in the maritime environment and, should such changes occur, alternate disposal methods will be required.

It's EPA's policy, as reflected in the FWPCA, to eliminate discharge to the nation's navigable waters. Ocean outfalls are considered an interim solution to total wastewater disposal until reuse and reclamation methods are identified, developed, and reliably implemented.

Incomplete studies described in our impact statement suggest secondary treatment and discharge beyond the reef line is a prudent course of action. Our position, however, strongly recommends additional long-term studies to determine what, if any, the long-term subtle effects are of continuing the discharge. We further state that results of these studies would be the basis for initiating any changes in the proposed ocean outfall disposal practices.

In conclusion, then, I want to leave you with these thoughts. The ocean is both a huge sump into which all discharges ultimately end and also a fragile and in many cases, unknown environment. Before we introduce new perturbations in the environment, we need to know what is there to be disturbed so that we can hope to understand the changes so that we can make rational decisions about whether or not to reverse those decisions.

MANAGEMENT AND FINANCING ALTERNATIVES FOR WASTE DISPOSAL IN COASTAL AREAS

Warren Jake Wicker
Assistant Director
Institute of Government
University of North Carolina at Chapel Hill

INTRODUCTION

Waste disposal in coastal areas presents some special problems as the previous speakers on the program this afternoon have indicated. My assignment is to open our discussions on the financing and management questions that must also be addressed if we are to meet waste disposal needs adequately.

Perhaps I should start by listing an assumption and a general qualification to what I shall say. First, I assume that federal financial assistance will continue, but direct federal involvement in management is unlikely.[1] This means that for most of us at this conference the key financial and management questions involve state and local governmental actions. My remarks will be focused on state-local arrangements, although in your discussion you may not so limit yourselves if you prefer.

Second, I shall speak primarily from my knowledge and experience with the particular arrangements in North Carolina. This conference represents three southern states, and we shall draw from the experience of all, but my opening remarks will primarily reflect a single state's background. This will have the advantage of making my remarks concrete even if they are not equally specific for those of you from South Carolina, Georgia, and other states. The translations to arrangements in your respective states will, I think, not be difficult--North Carolina's arrangements are not that different.

The factors that affect financing and management decisions with respect to waste disposal in coastal areas are for the most part the same kind that affect decisions of this type in other areas. But there are some differences, and some of the factors appear in special forms in coastal areas.

Our previous speakers this afternoon have outlined most of them well. Those that specially affect financing and management should be listed again. I would cite seven:

1. The coastal region frequently contains areas of environmental concern--fragile environmental systems requiring special management approaches.

2. The preservation of natural and recreational resources in coastal areas is often a matter of statewide and national concern.

3. Waste disposal is often especially difficult in coastal areas and the necessary facilities especially complex compared with facilities that are adequate in other

regions. This usually means that costs are comparatively high.

4. The year-round population of the coastal areas in the three states is relatively low, and urban development is essentially small towns and communities despite the presence of Myrtle Beach in South Carolina and some modest-sized cities like Savannah, Charleston, and Wilmington just back of the beaches.

5. The peak populations--the summer populations for which adequate disposal systems must be designed--are relatively large. In some places, the July flows may be twenty or more times the December flows. This variation has implications for financing and management as well as for engineering.

6. Much of the property in beach communities is owned by people who live--and vote--elsewhere. These developments are resort communities with extensive absentee ownership.

7. The small communities that represent the typical beach development in this region are also frequently characterized by limited financial capacity.

Areas of environmental concern are found in places other than the coast. There are small communities, poor communities, absentee ownership, difficult waste-treatment problems, and resorts elsewhere. But rarely do they all come together to present the special problems for financing and management that we typically find on the coast. These factors condition the arrangements that must be developed to provide adequately for waste disposal.

FINANCING AND MANAGEMENT APPROACHES

The traditional approach to financing and managing waste disposal in the United States has been to rely primarily on local initiative and local financing and management. Significant levels of state and federal financial aid are fairly recent. And even today, if one considers the total cost of waste disposal--outfalls, treatment facilities, interceptors, collection sewers, operation and maintenance--most of the cost is met from local sources.

There is increasing thought being given, however, to the possibilities of further modifying the traditional approach--including more state and federal financing and state management or sharing of management.

For our discussions today, I will outline briefly three classes of approaches that deserve consideration:

A. Local management and financing

B. State management and financing

C. A combination of state and local management and financing

Because the local arrangements are traditional and because in many places they will meet the needs quite adequately, I will review the local approaches first.

A. *Local Management and Financing Arrangements*

As suggested before, arrangements in this class of approaches assume the continuation of the present levels of state and federal support for the construction of waste-treatment facilities. These arrangements are also based on the anticipation that there will be continued local support to some extent, that local responsibility for the sewer collection system will continue, and that management will be local under state and federal regulations as to the nature of treatment required and the character and places of discharges. Five organizational arrangements may be cited:

1. *Cities.* Individual cities were the first local units to provide waste disposal. Uniformly, they have adequate legal authority, they are on the scene, and are usually the first financing and management option considered. In some cases, an individual city is an adequate and appropriate vehicle for local waste disposal financing and management. But increasingly, as areawide and regional solutions become more desirable, it is not.

2. *Counties.* In North Carolina and a number of other states, the county government is increasingly viewed as the unit of local government with special advantages for areawide and regional waste disposal management. Where counties have been given adequate legal and financing authority, they often have the necessary jurisdiction and are more viable financing units because of their larger tax bases and borrowing capacity and have ability to draw upon extensive management resources. An EPA study published last year reported on an examination of regional governmental arrangements about the country to determine which was most effective in dealing with regional environmental management problems.[2] The urban county--a county with powers traditional to cities--was judged to be the most effective. Two-tier arrangements, city-county consolidation, annexation, special districts, and councils of governments were all examined in this study.

   The county exists, it is organized, and it often covers the necessary jurisdiction. Frequently, it is already a regional government. Its major drawback is not its structure but its image. Too often county government is viewed as *country* government--both by citizens and by county officials.

   Fifty years ago, Jefferson County, Alabama, became the unit responsible for waste disposal for Birmingham and surrounding cities. The county (through the health department) provided the sewage disposal facility and interceptors while each individual municipality provided its own collection system. In a parallel area--solid waste disposal--counties are increasingly using the same approach: the county operates the disposal facility while cities and private haulers provide collection services. Waste disposal by county governments appears to be a promising arrangement for the future.

In many states, counties have been authorized to create subordinate taxing and service districts that are not separate units of governments but are administratively and organizationally a part of the county government. The advantage of these districts is that they permit use of county borrowing power while taxing only the areas that receive the service--an important consideration in waste disposal since the service is typically provided on less than a countywide basis. North Carolina law provides for such an arrangement, and at least two counties are preparing to use it in connection with water supply.[3] I know of no use yet with waste disposal.

3. *City-county contracts.* Joint agreements between cities and counties have become widespread in recent years in the United States. Most states now have an interlocal agreement statute similar to the model recommended by the U. S. Advisory Commission on Intergovernmental Relations; under such a statute two or more local units may undertake jointly any function each is authorized to undertake alone.[4] Joint agreements are an effective means to share local financing, consolidate management (in either the city or the county), or share in particular ways. Examples abound over the nation as well as in North Carolina. The major defect in such an approach is usually in securing joint agreement--and in a timely manner.

4. *Local authority* Most states permit the creation of local water and sewer authorities.[5] Typically, the authorities are created by two or more units of local government and are authorized to operate water and sewerage services on a utility basis. Normally, an authority has no taxing power, and the members of its governing board are appointed rather than elected. It is an excellent device for bringing together a number of different units. Its flexibility in how financing and management decisions are shared often make an authority an attractive vehicle. Sometimes, it is used because politically no other solution--county action or a joint agreement--is possible.

5. *Metropolitan district.* The metropolitan or special district (names vary) that encompasses several units is authorized in many states. In some places its governing board is elected; in others, it is appointed by the participating units. As I refer to them here, I have in mind districts that have authority to levy property taxes and issue general obligation bonds--the chief powers that are missing from an authority organization. Otherwise, in terms of management, the metropolitan district has many of the same advantages and would be used for much the same reasons as would the authority.[6]

B. *State Financing and Management Arrangements*

Because of the special conditions present in coastal areas, and especially on the beaches, a strong argument can be made for the state's managing waste disposal facilities in coastal areas and providing the non-federal initial financing of disposal facilities.

Informal discussions about such a move in North Carolina have been underway for the past two years. Actions in Ohio, New York, and Maryland and arrangements for the North Carolina Ports Authority suggest models for the forms of state action.[7]

Five principal arguments for state management are usually advanced:

1. Qualified management is needed. Often, the local units of government are not large enough to command qualified personnel.

2. In many places, a single treatment facility and ocean outfall to serve several communities is indicated. Securing concurrent agreement on financing is often difficult. The state is in a much better position to act and to provide financing.

3. The special environmental concerns of the coastal areas and the financial impoverishment of the local units make state action necessary.

4. The recreational character of the beaches and the nature of the property ownership all argue for the use of initial state borrowing and recovery of costs from user charges.

5. The state's advantages in borrowing would be great, resulting in lower interest costs. Substantial borrowing may also be done within the two-thirds limitation in North Carolina and without a vote of the people. Different provisions, of course, may apply in other states and must be considered.

How would a state management arrangement work? There are many possibilities, but let me suggest one as illustrative.

1. The state agency should be a water and sewer authority, probably with some members appointed by the Governor and some by the General Assembly and with requirements for special classes of representation and competence.

2. In many areas, combined water and sewerage operations would be advantageous, and often some of the same factors suggesting state action in regard to waste disposal also apply to water supply. It, thus, seems desirable to authorize the agency to undertake both.

3. The authority should have statewide jurisdiction. While coastal concerns might be the impetus for creating the

authority, most states have other areas that need state management and financing, and the same management vehicle could serve these as well.

4. State financing should be provided for constructing interceptors, lift stations, pumping stations, treatment facilities, and outfalls. Part or all of these costs should be recovered from the communities served. In some cases service might be on a wholesale basis to communities; in others, charges might be levied directly on individual customers. The power of the agency to set rates, enter into contracts, issue revenue bonds, and otherwise operate as a local water and sewer authority should be provided.

5. Collection systems would be the responsibility of the local governments. The authority, however, might operate the systems under contract with local units in some cases.

6. Standards for involving state participation and operation should be provided. For example, standards of the following type might be used:

   (a) A community system is needed--individual disposal units not working.

   (b) The communities to be served include areas of environmental concern.

   (c) Single disposal facilities serving two or more units of local government are needed.

   (d) Anticipated use is great enough to meet operation and maintenance costs at reasonable rates.

C. *Combination of State and Local Responsibility*

Obviously, there could be a middle ground--one that could take a variety of forms. Systems with divided responsibility for financing and management are frequently found.

Our public school system operates principally with local management and state financial support, but also with some local financing and state management. Similarly, divided systems are used for highways and hospitals.

One mixed possibility would be state financing and local management, with the state prescribing the standards for the entire management structure of the waste disposal operations. Already, we have certification requirements for wastewater treatment-plant operators. With federal support for constructing the most cost-effective areawide disposal facilities and state requirements for management, together with the present level of federal aid and increased state financing support, such a divided system should work.

Area or regional supervisors employed by the state to monitor the operations might be needed in addition to the water-quality monitoring that is already required.

Another possibility would be to provide for state management under separate individual systems--similar to the community college arrangement. Separate boards representing local and state agencies could be organized to operate under general state supervision. This approach would mesh operations in defined areas--perhaps two or more 201 study areas or a single 208 study area--in order to secure an adequate jurisdiction and justify a complement of qualified personnel.

Other combinations are also possible; given the creativity of those present, I have no doubt that they will be offered.

SUMMARY

The traditional approach to the financing and management of waste disposal in coastal areas in which cities and towns have accepted the local responsibility appears unlikely to meet present and future needs in many cases. Increasingly, action by county governments and by cities and towns jointly is needed. And in some cases, direct state participation in management may be desirable. An examination of forms of state and local response to the financing and management of waste disposal in coastal areas would be especially appropriate at this time.

FOOTNOTES

1. Federal regulations are, of course, central to much financial and management planning, but these are covered by other speakers and will not be reviewed here.

2. *Regional Governmental Arrangements in Metropolitan Areas: Nine Case Studies*, Office of Research and Development, U. S. Environmental Protection Agency, Washington, D. C., January 1974 (EPA 600/5-74-024).

3. *The County Service District Act of 1973*, N. C. Gen. Stat. Ch. 153A, Art. 16.

4. *1970 Cumulative ACIR State Legislative Program*, Advisory Commission on Intergovernmental Relations, Washington, D. C., 1969. North Carolina's is found in G.S. Ch. 160A, Art. 20.

5. North Carolina's statute authorizing the creation of authorities is found in G.S. Ch. 162A, Art. 1.

6. In North Carolina, there are both a Metropolitan Water District statute (G.S. 162A, Art. 4) and a Metropolitan Sewerage District statute (G.S. 162A, Art. 5). The Water District statute permits both water and sewerage services and usually would be the recommended form. However, it currently has defects--service outside

the county and transfer of funds to organizing units are prohibited--that need correction before the statute may be used in many situations. Both of these defects appear to have been inadvertent errors in drafting and probably could be corrected without difficulty.

7. The Maryland Environmental Service is authorized to undertake water supply, wastewater treatment, and solid-waste disposal projects on a "wholesale" basis. Title 3, Subtitle 1, New Revised Code. It is located within the Department of Natural Resources, whose secretary appoints the director and the two other officers who make up its board of directors.

   The New York State Environmental Facilities Corporation (Title 12, Public Authorities Law) was first organized in 1967 as the New York Pure Waters Authority. The Corporation is headed by a board of seven persons: the Commissioner of Environmental Conservation (chairman); the Commissioner of Health, and the Commissioner of Local Government, who serve ex officio; and four persons appointed by the Governor with the advice of the Senate. The executive head is a president appointed by the Governor with the advice of the Senate. The corporation is authorized to construct and operate water supply, wastewater treatment, storm water, solid waste, and air pollution control.

   The Ohio Water Development Authority (Chs. 6121 and 6123, Revised Code) has powers that parallel those of the Maryland agency. It is headed by a board composed of the directors of Natural Resources and Environmental Protection, who serve ex officio, and five members appointed by the Governor with the advice of the Senate.

   North Carolina's State Ports Authority is effectively an independent agency under the direction of a board with nine members appointed by the Governor. G.S. Ch. 143, Art. 22.

QUESTIONS AND DISCUSSION

QUESTION: (William E. Brunett) Will federal funds be available to conduct necessary site surveys for ocean outfalls?

MR. DAVID R. HOPKINS: There is talk and discussion within the agency of making monies available for the site survey through the 201 program; but as yet, I don't see a firm decision on that. The kind of studies I was talking about here are probably a lot more expensive than a 201 program could support. It is going to require cooperative studies between other firms and other programs of EPA, NOAA, the Coastal Plains Commission and Coastal Zone Management people.

QUESTION: (William E. Burnett) What if you want to build an outfall today?

MR. DAVID R. HOPKINS: Do you want to build it without adequate information as to effects of that outfall? If so, then you don't want to build it now. The existing laws require you to have some knowledge before you build anymore outfalls.

QUESTION: (William E. Burnett) In what step of the three-step federal planning process will the site studies occur?

MR. DAVID R. HOPKINS: Step one is the process in which you do the planning and look at the alternatives for waste disposal. Obviously, if you do consider ocean outfalls as a disposal alternative, you have got to know the impact of all the disposal alternative areas. So you should have the site plan available at the time you are doing the 201 plan. If you've got step one done, you've already decided whether you've got the information or not. Therefore, you need the information to help you decide.

QUESTION: One of the color slides showed pieces of broken coral. Is that a result of ocean outfalls or a natural occurrence?

MR. DAVID R. HOPKINS: This may be a natural pruning process. It was the opinion of the biologist who looked at the corals, without any indepth studies, that it was just abnormal eroding. They were not able to define or say why it was abnormal.

QUESTION: Are you saying that these studies are required regardless of the number of gallons per day of effluent or the degree of treatment of that effluent?

MR. DAVID R. HOPKINS: We're going to have to look at those things on a case-by-case basis. The effects or the magnitude of one MGD effluent cannot justify a million-dollar study out there just to find out the effects. On the other hand, I think there is room for case-by-case evaluation. But I think we are going to look at them very closely because we want to satisfy ourselves that we are not in violation of the law and, two, that we do have reasonable basis to assess the impact of the discharge. EPA will take a hard look at the plan. The emphasis on regulation now is to require more baseline surveys. The surveys will indicate the criteria you then put on that disposal. Maybe you will find unique features or resources which must be protected, and you have to keep the outfall away from that area. The purpose of the annual surveys will be to identify anything you couldn't see when you issued the permit. There is some degree of risk that the laws tomorrow may change the rules by which you are doing it.

QUESTION: (Professor David H. Howells to Professor Wicker) It would seem to me that if I were a mayor of a community along the North Carolina coast and I had sat here and heard all this discussion about the studies that would be required for ocean outfalls, I would have a very cold feeling in the pit of my stomach and not know how we could meet all these requirements. It would seem that it would be a very attractive alternative to turn to a state or regional agency to which I could contract all this responsibility. If there is interest, what would be the next logical step--the legislative process or more studies?

PROFESSOR JAKE WICKER: I would think that somewhere in the official bodies of your local government and agencies it would be time to form a group to officially look at this. This group should involve people from state and local levels. To my personal knowledge the consideration so far has been limited to state agencies, and at this stage, informal rather than formal. We have all the relevant state agencies here, and to my knowledge neither South Carolina nor Georgia has a state agency comparable to that in Maryland. I think the states here are similar with respect to state agencies to manage and operate facilities.

QUESTION: What has been the treatment requirements for previous outfalls?

MR. DAVID R. HOPKINS: In southeast Florida there are nine outfalls in the Palm Beach and Miami area. At the present time, the City of Boca Raton has an outfall which is about 10,000 feet long; it has secondary treatment on it. The treatment plant went on line in January 1973. The outfall was in place for about two years before that discharging raw sewage. The City of Miami, the Virginia Key outfall which was one of the slides, has what they call intermediate treatment with about 50-70 percent removal, and it is discharging now about 5,000 feet from shore. We just recently approved plans so they let the bids open for extending that outfall another 14,000 feet where it will be a little over three miles offshore. They are also in the process of upgrading a treatment plant and expanding it so that it will meet secondary treatment levels. All of the other outfalls in that area are in some stage of planning secondary treatment for those outfalls.

QUESTION: Would you describe any specific studies on what the effects of outfalls might be for the Wrightsville Beach area?

MR. DAVID R. HOPKINS: I don't really know what information is available for this area or what the effect of an outfall might be at Wrightsville Beach. I'd want to see that information in a 201 plan.

QUESTION: (Dr. Jay Langfelder) In some instances, there will be a very low probability of environmental damage. Within what range of probability will EPA be willing to operate? Will they, for example, tolerate a 5 percent probability of environmental damage?

MR. DAVID R. HOPKINS: I don't have a feel for those kinds of numbers about what is an acceptable threshold level or an acceptable risk. If you've got the data to plug in those kinds of analyses, I would be interested in seeing it. I think that kind of analysis would be appropriate for all the alternatives you are going to be working with and should be part of your decision-making process.

QUESTION: (Dr. Donald E. Francisco) First, I'd like to say that I'm impressed and overwhelmed by the rigor by which you approve ocean outfalls. Are the same types of precautions for discharges being used for the discharges behind the barrier islands? Do you ask for the same amount of data in both areas?

MR. DAVID R. HOPKINS: I would like to think that we are.

QUESTION: (Dr. Donald Francisco) Colonel Denison, with regard to the 201 analysis, where did you obtain the effluent guidelines in order to determine what unit process and the degree of pretreatment would be required in order to compute the cost of the system?

COLONEL PAUL DENISON: We concur with the general feeling that secondary pretreatment is required although there is some question as to whether additional treatment is required.

QUESTION: Would you comment on what you really mean when you say that there will be no discharge of specific chemicals?

MR. DAVID R. HOPKINS: The regulations are written in a way that discharges containing any amount of some parameters shall be prohibited. It allows others in trace quantities. I agree that when the regulation specifies none, then it really becomes a chemical sensitivity question.

QUESTION: (Mr. Frank Reynolds) What is EPA's policy regarding environmental impact statements for projects stemming from 201 plans?

MR. DAVID R. HOPKINS: Our policy is to look at each project to determine whether or not we should write an EIS. We do have regulations which contain a section entitled, *Criteria for Preparation of Environmental Impact Statements*. One of the sections addresses the question of significant adverse secondary impacts from the project.

QUESTION: Who will decide what the impacts of the project are?

MR. DAVID R. HOPKINS: First, I don't think local people can decide what this impact will be. There is a chapter in the 201 planning guidance called the Environmental Assessment. This chapter indicates the complete 201 plan should include a discussion of primary and secondary impacts. We use the Environmental Assessment to help us decide whether or not there are significant impacts from the project and whether our decision to approve that project would require an environmental impact statement. The NEPA requirements are basically a procedural thing. You've got to discuss all of these things. Public disclosures are important so the public and other decision makers can make an informed decision. The public then has knowledge as background for making the decision so they can somehow understand the impact of that decision. If they want to provide for 100 percent financing or if they want to grow from 3,000 to 30,000 in the next two years, do they really understand what they are saying when they make that decision to commit to that growth at least in sewers? Are they also considering the secondary impact and the other things that have got to go along with the city sewer? And if they haven't considered those, the impact statements in reality were backing it up a little bit, forcing you to put it in the assessment statement so that the people can understand what's going on. If they want to do that, then that's fine.

QUESTION: Do you feel that the general approach for EIS in Florida could be used here?

MR. DAVID R. HOPKINS: I see no reason why the same approach cannot be used here. That may be an answer as much out of ignorance as anything else. We wrote several EIS's in south Florida. We wrote one which I'll call the generic EIS, which was the broad area approach. We intended it to just look at disposal alternatives in the southeast Florida area--the Palm Beach to Miami area. There, we looked at outfalls, deep wells, shallow wells, and septic tanks. We then wrote three individual impact statements in Dade County. We wrote three more individual impact statements in Broward County, which covered Hollywood, Ft. Lauderdale, and North Broward County, and we only did one in Palm Beach County. EPA did the impact statements in varying degrees, the applicants did assessment statements. But the impact statements we wrote on those individual projects referenced that big, thick, yellow generic impact statement, and each contained rather brief discussions of the disposal methods applying the general discussion to the specific situation at each one of those regional treatment plants. They did not all go to ocean outfalls. The one for south Dade County actually went to deep wells. There was a time when the one for north Dade County was vascillating between deep wells versus ocean outfalls. The one in Palm Beach went to deep wells. They actually had a piece of an ocean outfall constructed when they got involved with the whole environmental impact statement process. There was a citizen law suit which said: "EPA, you can't get away with a negative declaration in this case." We reconsidered our decision, stopped construction on the project, and went through the impact statement process and actually ended up reversing our decision.

QUESTION: Is it practical to repeat the same south Florida procedures in North Carolina and South Carolina areas?

MR. DAVID R. HOPKINS: It seems to me it could, but we had a lot more data to start with down there. We had outfalls in existence down there which had been studied. So we could talk about an effect, and we could look at them. I don't know what the effects would be up here. I don't know what there is out there for the outfalls to affect. This is where an assessment statement or studies should be done even if we didn't have the money to do what needs to be done.

QUESTION: (Mr. Everett Knight) You are aware, Dave, of the national goal of no discharge by 1985. How do you see ocean outfalls fitting into that objective or what purpose will they serve after that date?

MR. DAVID R. HOPKINS: I did try to throw some qualifying words in my paper about how we felt that outfalls were an interim solution.

QUESTION: (Mr. Everett Knight) In what way is EPA attempting to reconcile the problems of water reuse and ocean outfalls?

MR. DAVID R. HOPKINS: I think EPA is wrestling with that problem. We wrestled with it down in south Florida, too. One of the rationalizations we came up with would be first of all south Florida has a water management problem. To solve that problem, it appears that some time in the future we are going to have to go to some kind of reuse. We feel that at that time any of these treatment processes do have failings and at that time outfalls still would be available as a safety valve.

QUESTION: (Professor F. E. McJunkin) We are so enamored with sophisticated waste treatment techniques that perhaps we are overlooking the important management aspects and the need for possible regional management to operate these facilities to perform as designed.

PROFESSOR JAKE WICKER: I agree, and I should point out to some of you who might be interested that Colonel Denison and his group and Freeman Associates did recommend a local authority that would have management responsibility for all the facilities. I am reminded of an experience, and I don't know whether it has any bearing or not, but I've worked with some of the people in this room on berms and erosion control for a great many years and nothing has happened. So it may be that one of the things you don't need an environmental impact statement for is doing nothing.

MR. DAVID R. HOPKINS: Let me respond; one of the specific items in the National Environmental Quality Act is the alternative of doing nothing.

LAND DISPOSAL OF WASTEWATER

F. J. Humenik
Associate Department Head
Biological and Agricultural Engineering
North Carolina State University at Raleigh

Terminal land disposal is limited either by the hydraulic or process loading rate that a particular plant-soil receiver system can accommodate. Hydraulic loads may or may not be reasonably controlled depending upon the wastewater source and influence over dilutional inputs. Generally, dilute wastewaters from domestic or municipal sources are hydraulically limited whereas the more concentrated industrial and agricultural wastes are limited by the quantity of one or several controlling constituents that would severely restrict the capacity of the land receiver system and ultimately result in environmental degradation. Each wastewater must be evaluated to assess concentrations of potentially harmful or process-limiting constituents. Generally, nitrogen is the process constituent which limits wastewater application rates in the moisture-excess Southeast and not salts as in arid areas for wastewaters which do not contain high concentrations of materials that would cause an imbalance in the soil chemistry or be toxic to the vegetative cover. Regions with high water tables and very permeable soils such as the Coastal Plains necessitate special attention to assure preservation of groundwater quality.

Recognizing the commonality of problems inherent in wastewater management and exercising the conservation of design technique, it becomes obvious that similar systems can be developed for the treatment of domestic, industrial, and agricultural waste. Although the generation and characteristics of various wastewaters are somewhat different, many of the unit processes used for industrial or agricultural processing waste can also be employed for domestic waste; and in fact, most of these unit processes were originated for the treatment of this more dilute waste. Correspondingly, many of the simple techniques currently being developed for the pretreatment and terminal disposal of animal or agricultural waste on land can be applied to municipal waste and often represent a very feasible and economical alternative to stream discharge. Phosphorus and nitrogen can be removed more reliably and conveniently by land disposal systems than by many of the elaborate and expensive processes currently being employed to remove these constituents prior to stream discharge.

The classic sewage stabilization pond is one of the most simple units for waste pretreatment and final stabilization in areas where evaporation exceeds rainfall. Increased degrees of treatment can be obtained if aeration is employed to help satisfy the oxygen demand and control odor. Lagoons can be placed in series to allow alternative aerobic-anaerobic treatment strategies for biological denitrification and other cellularized pretreatment strategies.

The use of trade names in this publication does not imply endorsement by the North Carolina Agricultural Experiment Station of the products named, nor criticism of similar ones not mentioned.

Some of the most successful lagoons are in arid regions where evaporation exceeds rainfall. Therefore, these lagoons can act as total containment devices and thus provide for terminal waste disposal. In moisture excess regions such as the Southeast where rainfall exceeds evaporation, excess lagoon liquid must receive further treatment before stream discharge or be applied to land to meet regulatory criteria. Lagoons may not overflow because of bottom leakage and thus present a high potential for groundwater contamination. Although no regulatory criteria concerning lagoon sealing exist at present, caution should always be exercised when planning lagoons for areas with high water table and soil permeability conditions such as coastal areas.

Effluent characteristics for various types of stabilization ponds and pond systems are shown in Table 1. Tables 1 and 2 have been reproduced from material in the new book by Metcalf and Eddy entitled, *Wastewater Engineering*. This book has an excellent section on various simple and advanced wastewater treatment units. However, virtually no lagoon sampled in this area approaches the treatment performance and, thus, effluent characteristics presented in Table 1. In fact, effluent concentrations from many animal waste and agricultural processing lagoons are orders of magnitude stronger than those listed in Table 1. These data on effluent characteristics of various types of stabilization ponds and pond systems must be viewed carefully because if all lagoons performed as noted, the excess water or effluent could be discharged into surface streams because none of these have effluent parameter concentrations that exceed 1.5 mg/l. Ponds can provide significant waste degradation and act as a storage reservoir, but extreme caution must be taken before it is assumed that excess liquid can be discharged to receiving waters.

Design parameters for stabilization ponds are shown in Table 2. Loading intensity in terms of pounds of BOD_5/acre/day varies from about 50 to 500. The totally anaerobic pond receives the highest BOD loading rate. It is a well-established principle that anaerobic ponds can accommodate a much higher loading rate in terms of organic carbon and oxygen demand than aerobic units. So it is logical to use an anaerobic lagoon as the first treatment unit in a series system. Today's challenge is to load an anaerobic lagoon so that the optimum degradation rate is realized without the production of offensive odors.

Current SCS national engineering standards for disposal lagoons and agricultural waste storage facilities are specified state by state on the diagrams presented in Figures 1 and 2. North Carolina criteria are 50 lb BOD_5/acre/day for 30 days' detention time. Although loading rates on these diagrams are responsive to geoclimatic conditions, criteria for contiguous states still vary in an unexplainable manner, such as between North Carolina and Virginia. Also, several states do not yet have complete design criteria, indicating the tentative status of stabilization pond design. Loading rates of anaerobic lagoons by zone presented in Figure 2 are related to the daily mean temperature, and the 3 lb BOD_5/1000 ft^3/day for North Carolina is equivalent to about 785 lb BOD_5/acre/day for a 6-ft deep unit. Comparison of this value with the stabilization pond rate of 50 lb BOD_5/acre/day verifies that much higher loading rates are specified for anaerobic lagoons than stabilization ponds. However, the expected performance for these different type ponds remains elusive.

Table 1

APPLICATION AND EFFLUENT CHARACTERISTICS OF VARIOUS TYPES OF STABILIZATION PONDS AND POND SYSTEMS

		Effluent Characteristics				
		Suspended Solids, mg/liter*			BOD_5, mg/liter†	
Type of pond or pond system	Application	Algae (BOD_5)	Micro-organisms (BOD_5)	Other (SS)	Soluble (BOD_5)	Suspended (SS)
Aerobic (6-18 in. deep)	Nutrient removal, treatment of soluble organic wastes, production of algal cell tissue	0.5-1.2	0.2-0.5	Low	0.02-0.1	0.3-1.2
Aerobic (up to 60 in. deep)	Treatment of soluble organic wastes & secondary effluent	0.4-1.0	0.2-0.5	Low	0.02-0.1	0.3-1.0
Aerobic-anaerobic (oxygen source: algae)	Treatment of untreated screened or primary settled wastewater & industrial wastes	0.2-0.8	0.2-0.5	0.1-0.4	0.02-0.1	0.3-1.0
Aerobic-anaerobic with & without effluent recirculation (oxygen source: surface aerators)	Treatment of untreated screened or primary settled wastewater & industrial wastes	0.02-0.1	0.2-0.5	0.1-0.4	0.02-0.1	0.3-0.8
Anaerobic	Treatment of domestic & industrial wastes	...	0.1-0.3	0.3-0.5	0.05-0.2	0.3-0.8
Anaerobic + aerobic-anaerobic with recirculation from aerobic-anaerobic to anaerobic	Complete treatment of wastewater & industrial wastes	...	0.2-0.5	0.05-0.15	0.05-0.1	0.3-0.8
Anaerobic + aerobic-anaerobic + aerobic pond system with recirculation from aerobic to anaerobic	Complete treatment of wastewater & industrial wastes with high bacterial removals	0.05-0.1	0.02-0.05	0.03-0.1	0.02-0.1	0.3-1.0

* Effluent suspended solids are composed of algae and other microorganisms which are estimated in terms of influent $(BOD_5)_i$ and a fraction of the influent suspended solids $(SS)_e$.

† Effluent BOD_5 is composed of a fraction of the soluble influent BOD_5 $(BOD_5)_i$ plus a contribution from the effluent suspended solids $(SS)_e$.

Table 2

DESIGN PARAMETERS FOR STABILIZATION PONDS

Parameter	Type of Pond: Aerobic*	Aerobic-anaerobic	Aerobic-anaerobic	Anaerobic	Aerated lagoons
Flow regime	Intermittently mixed	....	Mixed surface layer	....	Completely mixed
Pond size, acres	<10 multiples	2-10 multiples	2-10 multiples	0.5-2.0 mult.	2-10 multiples
Operation†	Series or parallel	Series or parallel	Series or parallel	Series	Series or para.
Detention time, days†	10-40	7-30	7-20	20-50	3-10
Depth, ft	3-4	3-6	3-8	8-15	6-20
pH	6.5-10.5	6.5-9.0	6.5-8.5	6.8-7.2	6.5-8.0
Temperature range, °C	0-40	0-50	0-50	6-50	0-40
Optimum temperature, °C	20	20	20	30	20
BOD_5 loading, lb/acre/day**	60-120	15-50	30-100	200-500	
BOD_5 conversion	80-95	80-95	80-95	50-85	80-95
Principal conversion products	Algae, CO_2, bact. cell tissue	Algae, CO_2, CH_4, bacterial cell tissue	CO_2, CH_4, bacter. cell tissue	CO_2, CH_4, bacterial cell tissue	CO_2, bacterial cell tissue
Algal concentration, mg/liter	80-200	40-160	10-40		
Effluent suspended solids, mg/liter††	140-340	160-400	110-340	80-160	260-300

* Conventional aerobic ponds designed to maximize the amount of oxygen produced rather than the amount of algae produced.

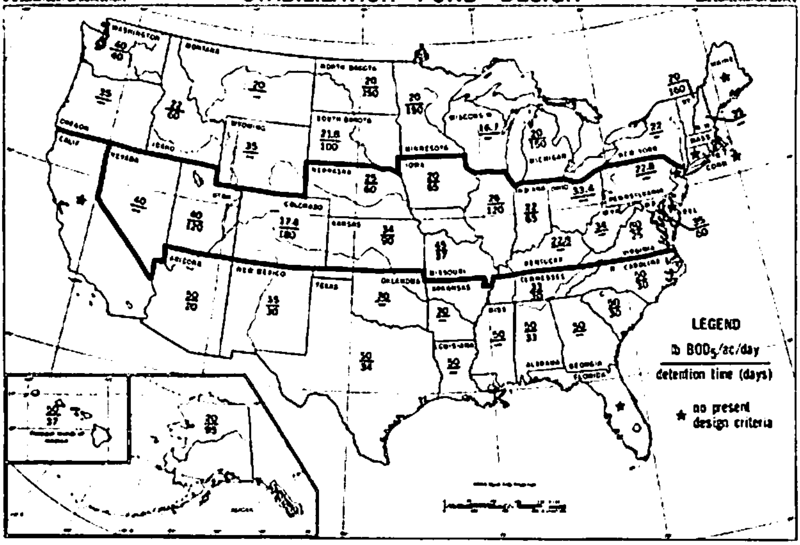
† Depends on climatic conditions.

** Typical values (much higher values have been applied at various locations). Loading values are often specified by state control agencies.

†† Includes algae, microorganisms, and residual influent suspended solids. Values are based on an influent soluble BOD_5 of 200 mg/liter and, with the exception of the aerobic ponds, an influent suspended-solids concentration of 200 mg/liter.

Figure 1

STABILIZATION POND DESIGN



Initially, animal waste lagoons were constructed on the basis of design criteria for sewage stabilization ponds. Existing information for sewage stabilization ponds based on BOD loadings/surface/acre, which are somewhat arbitrary, was extrapolated to develop sizing criteria for animal waste lagoons. However, it was not adequately appreciated that sewage is a very dilute waste compared to the agricultural and animal waste that would be imposed upon these lagoons. Therefore, it was not unusual that many animal waste lagoons failed in that they became filled with solids and were very odorous.

Design criteria recommended by different agencies for various types of animal waste lagoons presented in Table 3 still are not as uniform on the basis of BOD loading per acre as would be expected. Although this is in part due to the nature of the wastes, these data variances are currently being considered. However, it is obvious that a much larger surface area is required for aerobic, unaerated lagoons. This tremendous increase in size required for aerobic lagoons without mechanical aeration indicates that it is not generally economically feasible to consider an unaerated lagoon that would act as an aerobic unit.

Early research at the North Carolina Agricultural Experiment Station was directed at the pollutional potential of effluent from animal waste lagoons and runoff from agricultural land. Although about an 80 percent removal of COD occurred in the first lagoon and another 25 to 50 percent in the second lagoon of a two-unit series,

Figure 2

ANAEROBIC LAGOON LOADING RATES BY ZONES

DAILY MEAN TEMPERATURES OCCURRING ABOUT ONCE IN 13 YEARS
(FROM ASHRAE 1963 GUIDE)

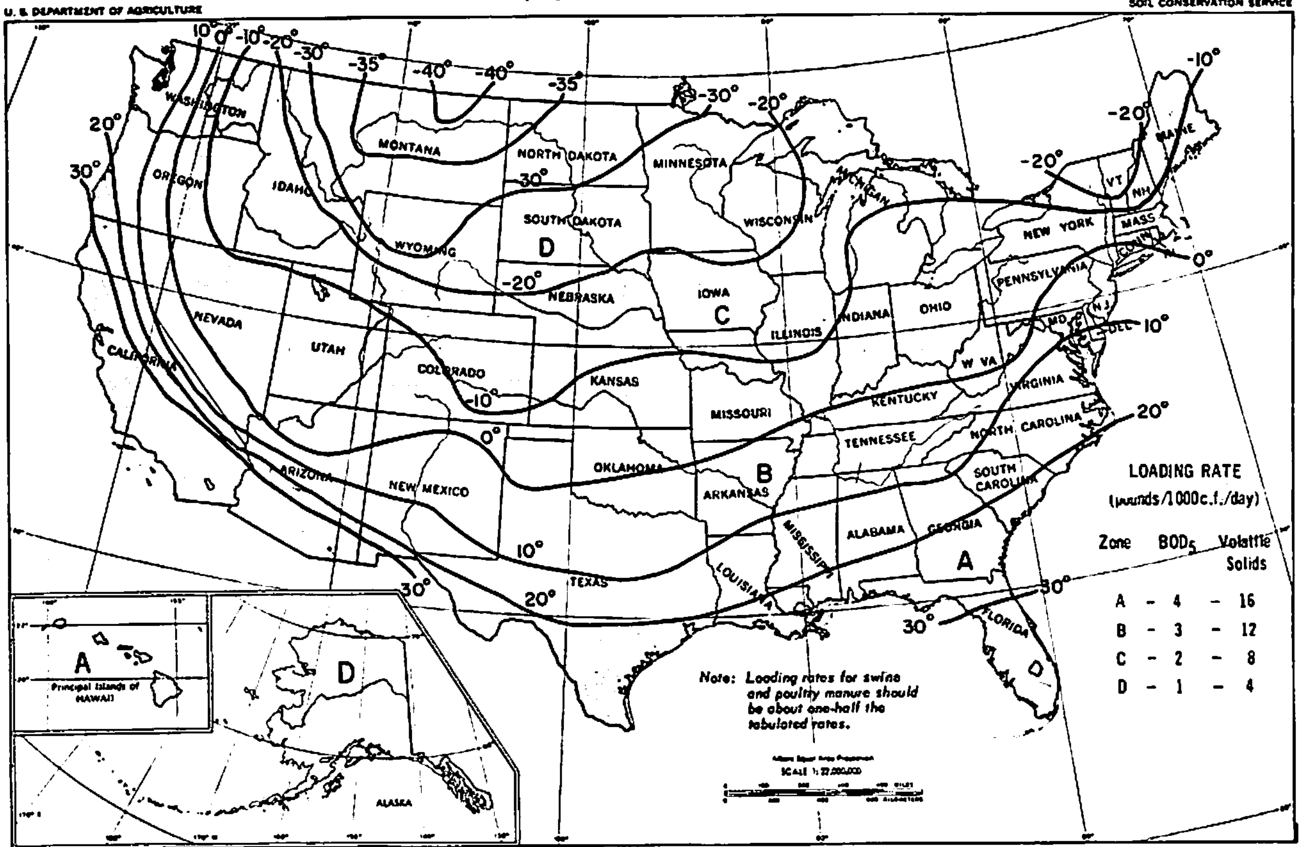


Table 3

DESIGN PARAMETERS FOR ANIMAL WASTE LAGOONS

	Dairy	Swine	Poultry
	Ft^2 surface area/animal		
a. Anaerobic lagoons six feet deep			
Midwest Plan Service	150	33	2.2
Soil Conservation Service	110	13	---
North Carolina	110	25	5
1. # BOD/acre (N. C.)	790	487	175
b. Aerobic lagoon without mechanical aeration	Ft^2 surface area/animal		
Soil Conservation Service	2420	290	21
North Carolina	2400	290	20

the quality of excess liquid or effluent was not suitable for stream discharge. However, runoff from watershed areas where swine were on pasture or animal waste was terminally disposed was very similar to runoff from a natural watershed devoid of farm animals. Therefore, it was concluded that land disposal of waste according to recommended practices was far superior to just lagoon pretreatment and total liquid treatment attendant to stream discharge. It was further shown that the water quality in receiving streams had a significant level of background pollution. This emphasizes the necessity to establish ambient conditions prior to the installation of any waste disposal system, especially one which exercises terminal land application.

Results from model field lagoons which are operated in a 3-unit series show that the liquid in the third or terminal series unit generally has an organic content very similar to the liquid in the secondary lagoon. Visual observations verify that the third unit acts as a biomass generator because algal blooms are very frequent. Based upon these data and other practical experience, three lagoons in a series are not recommended.

Aeration strategies employed for animal and agricultural waste lagoons are to provide minimum horsepower to achieve complete surface agitation for elimination of odor and floating scum. Aeration equipment that promotes surface pumpage instead of complete unit mixing is selected. Additionally, aerators can be equipped with anti-erosion shields to minimize bottom scour and resuspension of bottom sludge solids. Floating aerators are very desirable for lagoon installations because these units will easily fluctuate with liquid levels. The top agitated zone of this type pond may carry a bulk phase oxygen excess; but generally, the unagitated bottom area is anaerobic. Thus, a diphasic type of lagoon is established allowing anaerobic decomposition in the bottom sludge zone but yet providing an aerobic supernatant layer to minimize odor and nuisance problems.

Experience with an aerated lagoon at one of our swine research farms shows a 90 percent removal of oxygen demand and organic carbon with the maintenance of a dissolved oxygen concentration of about 10 mg/l in the surface liquid. However, the lagoon liquid still has a COD of 135 mg/l for this treatment strategy consisting of a series unaerated lagoon and aerated secondary pond. The excess liquid from this lagoon system is irrigated onto Coastal Plains-bermuda grass plots similar to typical land receiver areas that would be utilized in the coastal region.

Loading rates for stabilization ponds, animal waste lagoons, trickling filters, and activated sludge are summarized in Table 4. It is noteworthy that the loading rates for aerated lagoons are very similar to the loading rates for low-rate trickling filters and conventional activated sludge. If terminal land disposal is utilized, then aerated lagoons become very desirable on a cost-effectiveness basis.

Table 4

SUMMARY OF LOADING RATES

Unit	lb BOD_5/acre/day
Unaerated aerobic animal waste lagoon	30 - 50
Aerobic-anaerobic pond	15 - 100
Unaerated stabilization pond	
SCS criteria	20 - 80
Metcalf & Eddy	200 - 500
Unaerated anaerobic animal waste lagoons	130 - 1,000
Unaerated anaerobic lagoons (SCS)	250 - 1,000
Aerated lagoons (surface agitation)	3,500 - 10,000
Trickling filter	
Low-rate	1,800 - 10,000
High-rate	3,000 - 40,000
Activated sludge	
Conventional	8,500 - 50,000
High-rate aeration	45,000 - 450,000

Producer Scale Demonstration Site

Hatchery Waste. Chick Sales, Inc., Siler City, North Carolina, is a broiler-chick hatchery which has served as a demonstration site to evaluate pretreatment techniques prior to terminal land application. The waste management system now operational represents the culmination of cooperative activities by the North Carolina Agricultural Experiment Station and Extension Service, the Soil Conservation Service, and the hatchery management. This joint project has allowed assemblage of data required to routinely design a land-based treatment system for hatchery waste and has provided one of the first such producer-operated demonstration sites. A schematic of the total system for domestic and processed wastewater management at this hatchery is shown in Figure 3. This series separator-grinder, septic tank, aerated lagoon, and polishing pond-reservoir pretreatment prior to terminal land irrigation waste management system at Chick Sales Hatchery provides for no-discharge recycling of all wastewater components for pasture improvement.

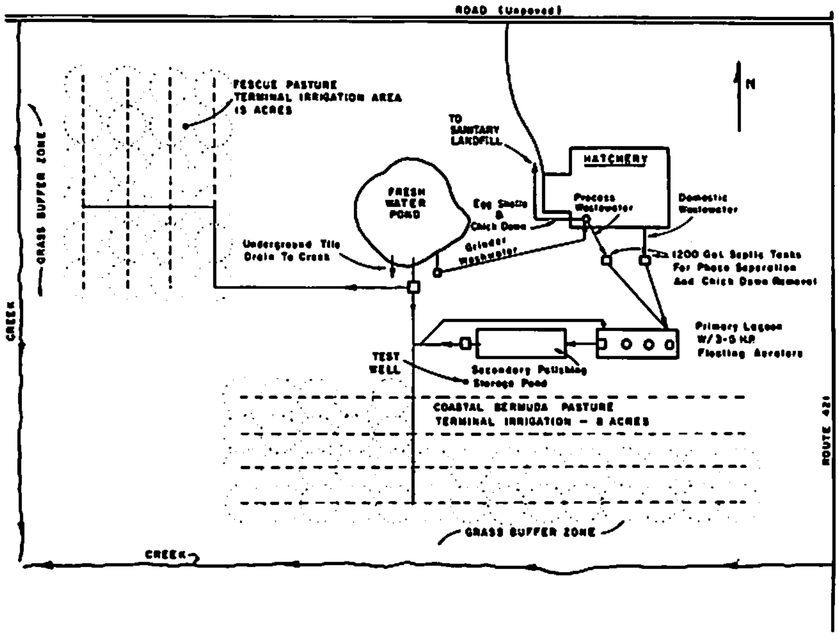


Figure 3

Schematic of system for domestic and processed wastewater management at Chick Sales Hatchery.

The two hatchery waste streams requiring management are the washwater clean-up and the effluent from the separator-grinder which receives hatching tray waste. Trays containing the no-hatches are washed into a separator-grinder which allows egg shells to be ground and separated for easy land disposal. Pond water or recycled secondary lagoon liquid can provide the 5-gal/min flushing water for the separator-grinder instead of well water utilized for the potable supply. Washwater is screened several times by floor traps to facilitate chickdown and solids removal. A vacuum system is used prior to any waterwashing to remove as much chickdown as possible. A central low-volume/high-pressure cleaning system has been adopted for more efficient washdown of walls, floors, and equipment. This system has proven extremely efficient in a clean-up as well as minimizing overall water usage. All detergents and disinfectants used in this high pressure system are biodegradable and have had no adverse effect on the total waste management system. Septic tanks were utilized to provide additional opportunity for phase separation of domestic and hatchery waste solids and, in particular, more complete removal of chickdown and egg shells before the lagoon system. Septic tank effluent is piped to the influent side of the primary aerated lagoon.

Aeration requirements were calculated on the basis of laboratory COD data for whole eggs and then extrapolated into the maximum waste load associated with the lowest expected hatchability rate of 80 percent. The projected double capacity load of about 150,000 no-hatches per week resulted in an oxygen demand of about 44 lb/hr which requires about 15 hp of aeration based upon a transfer of 3 lb of oxygen per horsepower hour. The domestic load oxygen demand was insignificant. Aeration horsepower required for odor control by complete surface agitation is generally defined to be about one-half the input BOD_5 or one-third of input COD. Generally, the treatment strategy employed is to utilize minimum horsepower required for complete surface agitating by floating aerators but not to employ the energy levels required for complete reactor mixing and achievement of high levels of dissolved oxygen. However, in this situation sufficient horsepower was provided to satisfy the total input COD because of the desirability to establish an exemplary site with high management flexibility. Therefore, three 5-hp aerators with anti-erosion shields designed to promote surface pumpage were purchased to provide sufficient oxygenation for the total COD input associated with the poorest expected hatchability.

This 6-ft deep aerated lagoon had water surface dimensions of 51 ft by 130 ft with a total capacity of 33,750 ft^3 for a volumetric rating of 2250 ft^3/hp or a surface rating of 445 ft^2 of horsepower. Thus, this lagoon was sized between the equipment manufacturer's recommendation of 1333 ft^3 or 167 ft^2/hp for complete mix, and 4000 ft^3 of 766 ft^2/hp for complete surface agitation. This aerated unit which provides a 63-day mean resonance time has excellent total surface agitation with all three 5-hp units operating and good surface agitation with just the outside two aerators running. Characteristic aerated lagoon levels are about 1500 mg/l COD and 300 mg/l TKN, with secondary unaerated lagoon values being 500 mg/l COD and 150 mg/l TKN.

Odor control was achieved after initial start-up with just the center aerator operating until the total present production capacity was recently achieved. Thereafter, the outside two 5-hp aerators have been required for odor control, and in addition have provided total surface agitation. Foaming has been an intermittent problem, especially on overcast days. The response most generally effective is reduced aeration by shutdown of the oxygenator at the input side. Thus, this unit documents minimum surface area required for complete surface mixing and helps set our recommendation range for achieving complete surface agitation at about 700 to 1000 ft^2/hp for these floating aerators.*

---

*Aerators used for all full-scale lagoon studies were manufactured by Sydnor Hydradynamics, Inc., Richmond, Virginia.

The plant-soil receiver system is divided into 8 acres of coastal bermuda grass and 15 acres of Kentucky 31 fescue grass to allow year-round application to an active vegetative cover. Application rates for a total nitrogen content of about 300 mg/l at a sprinkler rate of .26 in/hr would be 5.58 in. requiring 22.5 hr for the 400 lb N/acre/year for fescue and 8.8 in. requiring 34 hr for 600 lb N/acre/year for coastal bermuda. Irrigation application intensities are 7059 gal/acre/hr, and for nitrogen 17.7 lb/acre/hr.

The permanent set irrigation system has manual angle valves on each lateral for operating irrigation headers. Sprinklers are both part circle and full circle spaced on an 80 ft by 80 ft interval. The sprinklers have a 140 ft diameter throw with a maximum horizontal trajectory of 10 ft. Operating pressure is 55 lb/in^2 to minimize aerosol production. Sprinklers are placed 18 in. above ground surface. Following a wastewater application, the system is flushed with fresh water for cleaning and maintenance purposes. Effluent is applied to the coastal bermuda grass during the warm months and to the fescue during cool months. No application is planned during the months of December, January, and February. No effluent is applied within 100 ft of receiving streams, and maximum application during any one irrigation event is specified as .5 in. to preclude runoff as a result of wastewater irrigation. Irrigation is prohibited when high wind velocities or saturated soil conditions exist. Judgments are also made to avoid irrigation prior to anticipated rainfall.

A sampling program has been established to routinely monitor receiving streams above and below the terminal irrigation plots. Groundwater is also routinely sampled in test wells. Such monitoring strategies are most important for environmentally sensitive areas as exist in the coastal regions.

Swine Wastes. A similar system installed at Lexington Swine Breeders, Lexington, North Carolina, has demonstrated the impact that surface aeration for odor control can have on nitrogen reduction. A new aerated pond has been installed prior to an existing 1.5-acre lagoon. Sludge zone nitrogen removal for aeration units designed according to this strategy has been recorded to be about 25 percent of the total input. A high degree of additional nitrogen reduction has been achieved at this demonstration unit because the total Kjeldahl nitrogen supernatant concentrations in the secondary lagoon are only about 15 percent of the values recorded for the primary aerated unit. Since construction of the aerated lagoon, the nitrogen content in the original unaerated lagoon supernatant has been reduced by 50 percent, and a 75 percent reduction in oxygen demand has been realized. Originally, unaerated lagoon levels of 4500 mg/l COD and 450 mg/l TKN dropped to about 800 mg/l COD and 175 mg/l TKN. Thus, odor control and nitrogen removal of up to 85 percent on a concentration basis have been achieved at this demonstration unit which has the surface aeration rating of 1000 ft^2/hp.

Conclusions

Analysis of contemporary waste treatment systems show that unaerated ponds can provide significant pretreatment at a very low cost. The treatment efficiency of ponds can be increased by using series systems and providing aeration in the first unit. Pond systems can also be managed to facilitate nitrification-denitrification when aeration is employed in the first unit and the second unit is maintained anaerobic by direct raw waste inputs. Up to 85 percent removal of nitrogen has been recorded on a concentration basis when minimum horsepower required for complete surface agitation by floating aerators rather than complete reactor mixing and achievement of high levels of dissolved oxygen are the operational strategy for wastes with a high TKN content. The primary removal mechanism for such large nitrogen reductions is ammonia volatilization because of the increased surface area and surface renewal provided by these floating aerators which augment volatilization of the high levels of ammonia nitrogen.

Pond systems can also be very effective in removing heavy metals if the organic waste input is high and the organic metal complex remains in the bottom sludge. However, pond systems should not be considered as terminal treatment devices in which excess water can be discharged to surface streams. Pond systems must be considered as pretreatment devices prior to terminal land irrigation of excess liquid. In areas with high water tables, caution must be exercised to avoid groundwater contamination. Ponds can be sealed or built above ground to minimize impact on groundwater. Obviously, land values and area usage have a great impact on cost benefits of pond systems prior to terminal land irrigation.

Land irrigation is limited either by the hydraulic or process load. The higher degree of pretreatment provided or the lower concentration of nitrogen, the less value the excess water has for fertilization and the more hydraulic loading controls. Conversely, the hydraulic load becomes insignificant when dealing with wastewaters that have a high concentration of any constituent that would affect the plant-soil receiver system. Generally, nitrogen limits in the Southeast and current recommendations are to apply no more nitrogen than fertilizer requirements for a particular vegetative cover. Therefore, the most economic approach is to balance the process load with the hydraulic input by degradatory pretreatment if possible so that the application limit for both closely interrelate attendant to minimum acreage requirements.

It is not always best to treat wastewater to as high degree as possible before discharge to streams because land-based systems can provide a more economical alternative. The use of land application as a substitute for tertiary treatment of nitrogen, phosphorus, color, metals, and solids to meet current regulatory criteria can be much less expensive in most areas, including coastal regions beyond the high-intensity recreational areas. Land application systems can have very little impact on ambient environmental quality and thus pose minimal health or pollutional hazards when proper precautionary measures are taken, good agronomic conservation techniques followed, and recycling for utilization practices. Therefore, many of the systems currently being developed for agricultural waste management may have great applicability for the treatment of municipal, processing, and industrial waste as emphasis on waste utilization and achievement of non-point source discharges becomes more directive. Correspondingly, Section 201 of the 1972 amendment to the Water Pollution Control Act stipulates that alternative methods of discharging wastewater to land areas instead of the nation's water resources be evaluated henceforth in an effort to abate pollution and realize national water quality goals.

SHALLOW SUBSURFACE DISPOSAL OF WASTEWATER

A. C. Turnage, Jr.
Regional Engineer
Division of Environmental Management
North Carolina Department of Natural and Economic Resources

Our concern is with the disposal of wastewater in the coastal areas. For purposes of regulating wastewater treatment and disposal, the North Carolina Board of Water and Air Resources--now the Environmental Management Commission--has defined the coastal areas. It might be well to consider this definition. Coastal areas are defined as: (1) the Outer Banks, (2) those land areas bordering the coastal waters, including all waters assigned a salt-water classification and all tributaries that experience excessive growths of microscopic or macroscopic vegetation or that, because of their relative size and lack of water exchange, are found by the Board to be subject to such excessive growths, and (3) land areas bordering all natural impoundments situated east of a line previously established to designate coastal waters. This line follows the approximate route Calabash, Cape Fear River Lock No. 1, Jacksonville, New Bern, Washington, Edenton, Hertford, Elizabeth City, Moyock. An exact description can be found in the Board's Regulation 79. The important point is that, for purposes of this regulation, coastal areas are land areas in close proximity to certain specified water bodies.

We are concerned, then, with the shallow subsurface disposal of wastewaters in areas so defined. I think the key word here is disposal. The surface waters adjoining these land areas have been assigned classifications that require the maintenance of very high water quality. Most of the waters are classified either "SA" or "SB" for shellfish harvesting and bathing, respectively. Many of these water bodies also are experiencing or are subject to severe vegetative growths, either microscopic or macroscopic or both. For these reasons, the discharge of even a well-treated sewage effluent is not desirable. Therefore, the really limiting factor in these areas is disposal.

There are two possible methods of shallow subsurface disposal that will be discussed.

The first of these, the septic tank-nitrification line system, is in a sense a combined treatment and disposal system. However, while the system does provide some treatment, it is basically a disposal system. Such systems are logical and acceptable methods of disposal for small quantities of wastewater in isolated or sparsely developed areas. In such cases, their primary purpose is the disposal of the liquid waste.

This is evidenced by the fact that the major basis of design is the ability of the soil to absorb water. The septic tank serves the purpose of removing gross solids that, if not removed, would fill the soil interstices and destroy the soil's absorption capability.

Unfortunately, the removal of gross solids leaves a wastewater that is still far from clean. It contains many pollutants--dissolved solids, both organic and inorganic; various nitrogen components; and pathogenic viruses and bacteria, to name a few. These materials, discharged through the nitrification lines, are introduced to the pore-water and eventually to the groundwater.

The success or failure of a septic tank system has historically been measured by one factor only, rather than by the several factors that should be considered. The one factor normally noted is whether or not the soil does, in fact, absorb the water. Measured by this standard, a *successful* septic tank installation is one that does not result in sewage coming to the surface of the ground.

There are, however, other considerations. A septic tank system that is operating properly as measured by this criteria may, in fact, be significantly degrading water quality in the nearby surface water body or in the underlying groundwater reservoir. These potentialities for polluting are especially critical in the coastal areas. Soil can be too pervious, and many of the coastal soils are. Septic tank effluent introduced into loamy soil is not only disposed of but receives additional biological treatment due to the adsorptive properties of the soil and the biological activity of soil bacteria. Significant reductions in coliform bacteria and viruses are known to occur in such systems. On the other hand, septic tank effluent introduced into coarse sand apparently does not receive comparable treatment during its movement through the soil.

The open, highly porous soil structure allows high loading rates and thus invites high-density development. In addition, the rapid movement of effluent through the soil, together with the reduced effectiveness of treatment during this movement, results in a high potential for degradation of quality of both surface and groundwater.

Indiscriminate and unwise development where septic tank systems are used poses a potentially serious danger of contaminating the adjacent waters with fecal coliform and viruses. Even in less densely developed areas the installation of septic tanks in sand fill placed over existing organic muck or marsh-type vegetation can result in rapid horizontal movement of septic tank effluent along the sand-muck interface into the surrounding surface waters.

Unwise use of septic tank systems appears to be a major cause of large areas of our coastal waters being closed for shellfish harvesting. While this cause-and-effect relationship has not been positively documented, there is tentative documentation of such a relationship in several areas.

In those parts of the coastal area where shallow groundwater is used for water supplies, the contamination of the groundwater is of even greater concern. As an example, the Dare County Outer Banks depends entirely on a thin lens of shallow fresh water, trapped on top of the underlying salt water, for the total water supply needs of its inhabitants. While existing evidence indicates that the water systems being used, both public and private, are generally not contaminated, the continued use of septic tank systems in this area will eventually result in contamination of this fresh-water lens.

Studies presently underway have yielded some interesting--and frightening--preliminary results. Dye studies in one beach community have indicated a travel time, from bathroom through septic tank to adjacent surface water of four hours. The implications are obvious. Samples taken from test wells near high-density septic tank installations in another beach community contained up to 50 mg/l of ammonia. Let me repeat that these are preliminary findings only, and that studies in both areas are incomplete. However, the potential for serious degradation of both ground and surface waters is apparent.

There is a place for septic tank systems in the coastal areas, but extreme care must be exercised in their approval and installation. In low-density areas where soil structure is suitable and where adequate separation from surface waters and groundwaters can be maintained, such systems should be acceptable. Particular attention should be paid to the possible presence of a compacted muck or vegetative layer underlying sand fills because of the likelihood of an impervious interface resulting in horizontal movement of effluent.

As density of development increases or in areas that do not meet the necessary standards, some other means of waste disposal must be found.

This brings us to the other method of shallow subsurface disposal--the introduction to the subsurface soil of properly treated wastewater. This pre-supposes the collection of wastes at a central location for treatment. Consideration of such a system should be tempered by two restrictions of paramount importance. First, these systems are not a panacea. They can serve a useful purpose in some instances, but there are many locations where such systems cannot be used. Second, these systems should be considered in most cases as interim solutions only. The ultimate solution to the handling of wastewater from rapidly developing beach areas is the provision of regional sewage collection and treatment systems with disposal of the treated effluent by ocean outfalls or some other satisfactory method. However, the subsurface disposal of adequately treated wastewater from individual developments does constitute an acceptable interim step in the development of such regional systems. Obviously, these systems should be designed so that they can be integrated into the regional system as it becomes available.

The Board of Water and Air Resources, now the Environmental Management Commission, in July 1973 adopted a regulation containing criteria for the design of shallow subsurface systems in the coastal areas.

This criteria applies to both types of systems I have been discussing. It specifies that septic tank systems will not be approved in high-density areas, defined as areas containing more than three residential units per acre or areas producing more than 1200 gallons of wastes per acre per day. The latter restriction is designed to apply to commercial development.

With respect to disposal of treated effluent, the regulation in general requires the following: (1) wastes must receive tertiary treatment (biological treatment followed by solids removal) and bactericidal treatment; (2) treatment plants must be enclosed in solid or semi-solid enclosures, must have noise and odor control devices and automatic standby power sources, and must contain duplicate units for all essential operating units; (3) subsurface disposal facilities must be located at least 1500 feet from impounded public water supplies or public shallow wells, 500 feet from private shallow wells, and 100 feet from surface water bodies; (4) subsurface disposal areas must be loaded at a rate not exceeding 1 1/2 gallons per square foot of trench bottom per day, and must contain at least 1000 square feet of open "green area" for each residential unit served with not more than twenty-five (25) percent of the required area covered with non-traffic bearing paved surfaces such as tennis courts, patios, or walkways.

These requirements are given here in very general form and are not to be considered complete. The complete regulation, No. 79, is available from the Division of Environmental Management.

Systems designed as required by this criteria, if properly installed and operated, should provide adequate protection for the water resources of the State for the time required to provide regional systems for collection, treatment, and disposal of wastewater.

QUESTIONS AND DISCUSSION

QUESTION: (Professor James C. Brown) Dr. Humenik, would you review the process of pond mixing to increase ammonia removal?

DR. FRANK HUMENIK: The treatment strategy under investigation is to employ the minimum horsepower needed for complete surface agitation by floating aerators but not to employ the energy levels required for complete reactor mixing and achievement of high levels of dissolved oxygen. The top agitated zone of this type pond may carry a bulk phase oxygen excess; but generally, the bottom unagitated area is anaerobic. Up to 85 percent removal of nitrogen has been recorded for pilot scale and also producer sized units employing this aeration strategy. We think the primary removal mechanization is ammonia volatilization because the increased surface area and surface renewal provided by these floating aerators augment volatilization of the high levels of ammonia nitrogen characteristically around 500 to 1500 mg/l.

The opportunity for denitrification also exists because nitrates are generated in the upper areas which are aerobic. Denitrification then could occur in the lower anaerobic levels or even on a molecular basis in regions which have some dissolved oxygen. A large number of minute bubbles have been observed to be liberated when the surface aerators were stopped. These bubbles were much smaller than normally observed in lagoons as characteristic of gas released from bottom sludge. Concentrations of gas components for samples collected at the surface were highly variable; but generally, products of anaerobic fermentation such as methane and carbon dioxide and a high nitrogen content were present. The explanation for these recorded gaseous quality and quantity data and corresponding mechanisms is not yet fully developed. Either surface level nitrification followed by bulk phase liquid denitrification or entrained air bubbles which are stripped of oxygen present potential origins of these bubbles with a high nitrogen content.

Recorded nitrate levels of 10 to 15 mg/l are low but do not rule out significant nitrogen generation or either premise for the high nitrogen content of generated bubbles. Unfortunately, a nitrogen mass balance will not indicate denitrification losses because of the compounding effect of ammonia volatilization. We commonly realize about 25 percent nitrogen removal due to settling in the primary lagoon. The increased removal of nitrogen on a concentration basis is attributed to ammonia volatilization. This high level of nitrogen reduction on a concentration basis has been very surprising. Results for both model field reactors and full-scale lagoons corroborate about a 50 to 85 percent removal of nitrogen on a concentration basis. We feel that this is one of the significant results associated with our studies on minimum surface aeration for odor control and scum elimination. We currently recommend surface aeration of ponds for two primary functions--nuisance or odor control and nitrogen removal. Complete organic stabilization is not important because these lagoons are used in conjunction with terminal land application, and in our area application intensities are limited either by the hydraulic loading or nitrogen application rates. Nitrogen application should not exceed crop uptake capabilities or recommended fertilization schedules, and for waste with a high nitrogen content this amount of nitrogen is supplied in a small amount of liquid that can be easily accommodated by the soil-plant receiver system.

QUESTION: (Professor James C. Brown) Do you think this phenomenon has any application in domestic waste treatment?

DR. FRANK HUMENIK: Ammonia levels in domestic waste are not nearly as high as those in animal waste or industrial waste. If aerobic pretreatment is applied, the low ammonia and organic nitrogen content of 10 to 75 mg/l would generally be completely converted to nitrate. Ammonia volatilization without pH control will work best for waste with a high ammonia content because the driving force for volatilization is so much greater.

QUESTION: (Mr. Paul L. Anthony) I have questions. First, what are the relative merits of the percolation tests only versus soil tests for septic tank design? My second question refers to a law which came out in January stating that the field of a septic tank must have 100 foot separations between nitrification lines and SA waters. This law has been held to be not valid by the Attorney General. When will it be re-established?

MR. A. C. TURNAGE: To answer your second question, this was not a law; it was a regulation adopted by the Environmental Management Commission and Department of Human Resources. It was held to be invalid by the Attorney General because of some procedural difficulties in its adoption. It is my understanding that this will be readopted in the reasonably near future and presumably will become effective at that time. After spending several years in municipal work with city engineers, city managers, and town boards, I learned a long time ago not to predict what a public body will do. I assume that both of these regulations will be adopted, but I don't know that they will.

In response to your first question, percolation rate determination is a part of soil testing. But there are a lot of other factors involved in soil testing besides percolation. This is what I referred to briefly before; the structure of the soil and the type of soil are important. Yes, these things should be considered in septic tank design. In fact, the mechanism for using these tests is being developed by the two agencies involved. It's going to be kind of an academic question at least in the beach areas because the soil structure in the beach areas is well known. It is nothing but coarse sand so perhaps what we're looking at here is not relying on soil testing so much as using the percolation test and building in a safety factor to the loading rate. Mike Bell, representing the Department of Human Resources, and Everett Knight from the Division of Environmental Management are here. Perhaps they would like to address this point.

QUESTION: (Mr. Mark Stephens) Could the systems discussed here be applied to domestic waste needs--realizing a great fluctuation in the Coastal Plains region?

DR. FRANK HUMENIK: Yes, but one must recognize that domestic waste is rather dilute, and thus in evaluating the overall system possibly a different pretreatment strategy would be employed and terminal land application would be limited by the hydraulic load and not the nitrogen as with stronger agricultural and industrial waste. Other limiting constituents for plant-soil systems such as heavy metals, salts, high amounts of sodium and potassium, and other exotic materials must also be considered because excessive application intensities can result in soil sealing or destruction of vegetative cover crop. The management of the soil-plant receiver system is very important for either situation that may limit the process or hydraulic load. If the hydraulic load governs, then the soil-water characteristics are very important in determining maximum liquid loading based upon infiltration characteristics and storage capabilities of the soil. Internal soil drainage is also important in determining the maximum rate of liquid application.

COMMENT BY MR. A. C. TURNAGE: There is also a problem here with respect to the pretreatment units. There's the highly varying hydraulic waste. Of course, this is a problem no matter what your ultimate method of disposal is. This is always a problem in the treatment process itself, and we have found that this can be handled quite well by our engineering process, either by putting in a process that can adapt to this changing hydraulic load or by putting parallel plains in this process so that you can operate the number of plains that are required for the situation. At least from the treatment standpoint, it can be engineered out.

COMMENT BY DR. FRANK HUMENIK: Capacity to handle variable wastewater flows represents a significant advantage inherent in ponds that have high detention times and thus dilution or stabilization capacity. The primary aerated unit is generally not based on detention time or operated as a plugged flow reactor but is sized according to horsepower per surface area or volume recommendations. These aerated units overflow by gravity into a reservoir polishing pond which generally provides up to 13 weeks' storage. Thus, these systems can accommodate changes in hydraulic load with time and season easily.

QUESTION: (Mr. Marshall Staton) With reference to the dye studies where you found very rapid movement to the surface waters, how far were the denitrification lines from the water in question?

MR. A. C. TURNAGE: They were quite close and were deliberately chosen to be quite close. However, they did meet the requirements in the particular county. They were at least as far from the water as the requirements of that particular county. I want to point out that these were finger canals which had been constructed similar to many projects in the coastal areas. They were finger canals going up into subdivisions or, in this case, trailer parks. There was an interface of much sand that created a lateral movement that was more rapid than would be expected.

QUESTION: (Mr. Marshall Staton) Do you think a 100-foot separation from denitrification lines to separate waters was adequate if there had not been an interface to create this horizontal movement?

MR. A. C. TURNAGE: I don't think there is anything magic about the 100 feet. Obviously, it would seem to be a logical distance. Perhaps we need to do some studies to find out. At this point, I wouldn't want to be committed to it, and I think some testing and some researching in the area is definitely in order.

QUESTION: (Mr. Mike Bell) Would you give us some additional details on the test wells you described?

MR. A. C. TURNAGE: I did not intend to imply that the water supply in this area was not being protected. If I did leave this impression, I apologize. I'm aware that deep water supplies are being developed for this Dare County area. We did not find any significant coliform numbers in these shallow wells.

QUESTION: (Mr. Mike Bell) What other tests were run on these samples?

MR. A. C. TURNAGE: The only two that I have any numbers in mind are coliform and ammonia. We did not find any significant coliform; however, these tests were done in February when usage there was very low. In fact, the ammonia we found was probably residual from the latter part of the previous season. These are preliminary findings. We've got a number of test wells; and of course, this is the worst. We didn't find this everywhere we looked. This study will be continuing in the next few months, and we will have more data which will be available to you as it is developed.

DEEP WELL DISPOSAL OF WASTEWATER

James W. Crooks*
Chief
Hydrogeology Section
Office of Water Programs
EPA - Region IV
Atlanta, Georgia

and

Charles W. Sever
Hydrologist
Office of Water Programs
EPA - Region IV
Atlanta, Georgia

In relation to other forms of wastewater management, deep-well waste disposal and storage have received only minimal support or attention. As controls over the disposal of wastewaters to surface streams become more stringent and more vigorously enforced, there has resulted an increased interest by wastewater producers to evaluate deep wells as an alternate mode for discharge of their wastes. Injection of liquid wastes into the subsurface has proved to be both safe and economical and is gaining wide acceptance. It is expected to grow in popularity, particularly as a means of disposal to avoid prosecution under federal and state enforcement programs and among water management agencies in areas of water deficiency.

If the purpose of an injection well system is to dispose of 50 gallons per day of toxic wastewaters that contain non-degradable pesticides, heavy metals, radioactive minerals, or other hazardous materials by storing them underground in a confined system where they cannot accidentally re-enter man's habitat, then the criteria for a disposal well system would be quite different than if the purpose is to dispose of 30,000,000 gallons per day of highly treated municipal wastewater of a quality suitable for indirect reuse as artificial recharge.

Underground space, which consists of the area available between sand grains in some rock strata and of cavities or fractures in other rock strata, is recognized as a natural resource of considerable value. Virtually all this subsurface pore space is already occupied by natural water, either fresh or mineralized to some extent. Thus, injection does not usually involve the filling of unoccupied space but, rather, consists of the compression or displacement of existing fluids.

For certain municipalities and in certain locations, the underground injection of wastes may be the most environmentally acceptable practice available. In many areas across the nation where water deficiencies or management problems are forecast for the foreseeable future, the Environmental Protection Agency has recognized the need

---

* Oral presentation by Mr. Crooks.

to start conserving wastewater that has a potential for reuse by future generations whenever practical to do so. Storage of treated wastewaters for reuse is destined to become a major element for consideration in water resource management of water deficient areas.

Several deep injection wells have been constructed in Florida, Hawaii, Louisiana, Illinois, and Texas for storage of secondary treated sewage effluent into salt water aquifers. Secondary and tertiary treated municipal wastewater is of such good quality and in such large volumes that it is much too valuable to waste in areas where water shortages are forecast for the foreseeable future. Under certain conditions a double benefit can be realized by injecting a good quality sewage effluent into a saline aquifer; potentially harmful viruses and bacteria that might survive the secondary treatment process are removed from man's environment; and the injected fresh wastewater displaces a poorer quality (salty) groundwater thus creating a new reserve of useable water in underground storage. Expansion of this method of reuse as a tool of long-range water quality and water resource management is being encouraged by EPA[1] and many state regulatory agencies *as long as measures are taken to protect the public health.* The method is particularly adaptable and acceptable when the planned reuse is for agricultural or other non-potable demands.

Along many coastal areas, the heavy withdrawal of potable groundwater for municipal, industrial, and other uses from fresh-water aquifers has caused salt water encroachment inland into the aquifer systems. In such areas, treated wastewaters may be injected into the aquifer system to create a hydraulic barrier and hold back the encroaching salt water.

Since 1965, tertiary-treated sewage has been injected at Bay Park, New York, into a shallow artesian sand aquifer used for public water supply to create a hydraulic barrier against salt water encroachment.[2] Bacteria were apparently filtered out after about 20 feet (6 meters) of travel through the sand while iron, chloride, and other dissolved elements (minerals) were detected in significantly higher concentrations at distances of up to 100 feet (30 meters).

Similar experiments were conducted in Orange County, California. Fresh-water aquifers were recharged with effluent from a trickling filter sewage plant after the tertiary treatment. The wastes were injected into unconsolidated aquifers at depths of about 30 to 100 meters (100-350 feet). The tests indicated that after about 150 meters (500 feet) of travel, the injected water was free of bacteria and toxic substances, and the ammonia content was substantially reduced.

Since the early 1930's, the State of New York has required that water pumped from wells on Long Island at rates of 2.81 ps (45 gpm) or more must be returned, through injection wells, into the same aquifer from which the water was pumped. This requirement was imposed because heavy pumping has caused a sharp decline in groundwater levels in Western Long Island, with concurrent coastal encroachment of sea water.

Drainage wells are used extensively in certain areas of the country to control and store excess surface runoff after rains. Generally, these wells are shallow and inject into the uppermost aquifer zone (usually a drinking water source). An estimated 20,000 of this type injection wells have been drilled in Florida alone.

[1]Some problems that developed from this practice have added considerably to our understanding of underground hydrology. A common practice in the early days of the rapidly developing citrus processing industry in Florida was the disposal of citrus pulp and related wastes into the shallow groundwater systems. When, during the 1954 to 1956 drought of Florida, the water tables lowered drastically, water lines in private homes began discharging methane instead of water. Some enterprising individuals converted their water lines with methane burners to free heating and cooking facilities. Admittedly, this was, at least at the time, somewhat unusual; but it did point up the need for better understanding and knowledge before wastes are arbitrarily discharged underground as a matter of simple expediency.

Everyone recognizes that the underground emplacement of fluids by well injection will cause changes in the environment and to some extent may preempt other uses. However, the improper injection of municipal or industrial wastes or injection of urban runoff of other fluids for storage or disposal to the subsurface environment could result in serious pollution of water supplies or other environmental hazards. Therefore, each and all proposals for subsurface injection should be critically evaluated to determine that the subsurface storage capacity is conserved and used for its maximal benefit.

[2]The Environmental Protection Agency has recognized underground storage of wastes as a usable resource but also has taken steps to identify the need to protect the underground water resources and related environment. Specifically, the EPA has stated its position on underground disposal of wastes under the Administrator's Policy Statement No. 5 and the EPA Policy Statement on Water Reuse. Further, the EPA is now in the process of developing regulations to comply with the new Safe Drinking Water Act.

The Administrator's statement recognizes that to ensure protection of the underground drinking water sources[3] "it is the policy of the Environmental Protection Agency that:

1. The EPA will oppose emplacement of materials by subsurface injection without strict controls and a clear demonstration that such emplacement will not interfere with present or potential use of the subsurface environment, contaminate groundwater resources or otherwise damage the environment.

2. All proposals for subsurface injection should be critically evaluated to determine that:

    a. All reasonable alternative measures have been explored and found less satisfactory in terms of environmental protection;

    b. Adequate preinjection tests have been made for predicting the fate of materials injected;

c. There is conclusive technical evidence to demonstrate that such injection will not interfere with present or potential use of water resources nor result in other environmental hazards;

d. The subsurface injection system has been designed and constructed to provide maximal environmental protection;

e. Provisions have been made for monitoring both the injection operation and the resulting effects on the environment;

f. Contingency plans that will obviate any environmental degradation have been prepared to cope with all well shut-ins or any well failures;

g. Provision will be made for supervised plugging of injection wells when abandoned and for monitoring to ensure continuing environmental protection.

3. Where subsurface injection is practiced for waste disposal, it will be recognized as a temporary means of disposal until new technology becomes available enabling more assured environmental protection.

4. Where subsurface injection is practiced for underground storage or for recycling of natural fluids, it will be recognized that such practice will cease or be modified when a hazard to natural resources or the environment appears imminent.

5. The EPA will apply this policy to the extent of its authorities in conducting all program activities, including regulatory activities, research and development, technical assistance to the states, and the administration of the construction grants, state program grants, and basin planning grants programs and control of pollution at federal facilities in accordance with Executive Order 11752.

Briefly, the EPA policy on water reuse is:

1. EPA supports and encourages the continued development and practice of successive wastewater reclamation, reuse, recycling and recharge as a major element in water resource management, providing the reclamation systems are designed and operated so as to avoid health hazards to the people or damage to the environment.

2. In particular, EPA recognizes and supports the potential for wastewater reuse in agriculture, industrial, municipal, recreational, and groundwater recharge applications.

3. EPA does not currently support the direct interconnection of wastewater reclamation plants with municipal water treatment plants. The potable use of renovated wastewaters blended with other acceptable supplies in reservoirs may be employed once research and demonstration have shown that it can be done without hazard to health. EPA believes that other factors must also receive consideration, such as the ecological impact of various alternatives, quality of available sources, and economics.

4. EPA will continue to support reuse research and demonstration projects including procedures for the rapid identification and removal of viruses and organics, epidemiological and toxicological analyses of effects, advanced waste and drinking water treatment process design and operation, development of water quality requirements for various reuse opportunities, and cost-effectiveness studies.

The new Safe Drinking Water Act has for the first time established a sincere, detailed, technical approach to protection of groundwater by the Federal Government. Parts of this Act are specific in respect to actions that must be taken to protect groundwater from unrestricted injection of wastes into the ground. Mr. Sever, who was to present the speech today, now is in Washington working with others in EPA in developing regulations covering this aspect of groundwater protection.

I would like to provide a few excerpts from the Act to show the significance of this very new effort to protect groundwater resources:

> "Sec. 1421. (a) (1) The Administrator shall publish proposed regulations for State underground injection control programs within 180 days after the date of enactment of this title. Within 180 days after publication of such proposed regulations, he shall promulgate such regulations with such modifications as he deems appropriate.
>
> "(b) (1) Regulations for State underground injection programs shall contain minimum requirements for effective programs to prevent underground injection which endangers drinking water sources within the meaning of subsection (d) (2). Such regulations shall require that a State program, in order to be approved under Section 1422 -
>
> > "(A) shall prohibit, effective three years after the date of the enactment of this title, any underground injection in such State which is not authorized by a permit issued by the State (except that the regulations may permit a State to authorize underground injection by rule);
> >
> > "(B) shall require that the applicant for the permit to inject must satisfy the State that the underground injection will not endanger drinking water sources, that no rule may be promulgated which authorizes any underground injection which endangers drinking water sources;

"(C) shall include inspection, monitoring, recordkeeping and reporting requirements; and

"(D) shall apply to underground injections by Federal agencies, and any other person whether or not occurring on property owned or leased by the United States."

"(2) Regulations may not prescribe requirements which interfere with or impede -

"(A) the underground injection of brine or other fluids which are brought to the surface in connection with oil or natural gas production, or

"(B) any underground injection for the secondary or tertiary recovery of oil or natural gas, unless such requirements are essential to assure that underground sources of drinking water will not be endangered by such injection.

"(2) The Administrator may, upon application of the Governor of a State which authorizes underground injection by means of permits, authorize such State to issue one or more temporary permits each of which is applicable to a particular injection well and to the underground injection of a particular fluid and which may be effective until the expiration of four years after the date of enactment of this title, if the State finds, on the record of such hearing -

"(A) that technology to permit safe injection is not generally available.

"(B) that injection of the fluid would be less harmful to health than the use of other available means of disposing of waste or producing the desired product; and

"(C) that available technology has been employed (and will be employed) to reduce the volume and toxicity of the fluid and to minimize the potentially adverse effect of the injection on the public health. Further, and for brevity this must be out of context - I would like to emphasize the following:

"(c) any person who operates a new underground injection well in violation of subsection (b), (1) shall be subject to a civil penalty of not more than $5,000 for each day in which such violation occurs, or (2) if such violation is willful, such person may, in lieu of the civil penalty authorized by clause (1), be fined not more than $10,000 for each day in which such violation occurs.

"(e) If the Administrator determines that an area has an aquifer which is the sole or principal drinking water source for the area and which, if contaminated, would create a significant hazard to public health, he shall publish notice of that determination in the *Federal Register*. After the publication of any such notice, no commitment for Federal financial assistance (through a grant, contract, loan guarantee, or otherwise) may be entered into for any project which the Administrator determines may contaminate such aquifer through a recharge zone as to create a significant hazard to public health, but a commitment for Federal financial assistance may, if authorized under another provision of law, be entered into to plan or design the project to assure that it will not so contaminate the aquifer.

Finally, I would like to restate--waste disposal by deep-well injection can be used beneficially to preserve usable water and wastes--but--the proper controls mustbe recognized and used if we are to prevent irreparable damage to resources we will have even greater demands on in the future.

FOOTNOTES

1. The Environmental Protection Agency, *Policy Statement on Water Reuse*, July 7, 1972.

2. J. Vecchioli, *Experimental Injection of Tertiary Treated Sewage in a Deep Well at Bay Park, Long Island, New York; A Summary of Early Results*, 1972, Journal, New England Water Work's Association, Volume 136, Number 2, Pages 87-103.

3. The Environmental Protection Agency, *Subsurface Emplacement of Fluids*, Administrator's Decision Statement Number 5, *Federal Register*, Volume 39, Number 69, Tuesday, April 9, 1974, Pages 12922-3.

THE ROLE OF CONVENTIONAL WASTEWATER TREATMENT IN COASTAL AREAS

James C. Brown
Associate Professor of Environmental Engineering
and
Director
UNC Wastewater Research Center
Department of Environmental Sciences and Engineering
School of Public Health
University of North Carolina at Chapel Hill

INTRODUCTION

Should conventional treatment of wastewater and disposal of treated effluents to coastal waters be considered as a reasonable alternative in coastal areas? To establish a basis for consideration of this question, the meaning of *conventional treatment* and *coastal waters* should be defined. In this regard, the following definitions will be adopted:

> *Conventional treatment* - Treatment of wastewater in such engineered facilities as primary treatment plants, secondary treatment plants, oxidation ponds, and advanced treatment in physical-chemical plants or in conjunction with any type of primary or secondary treatment.

> *Coastal waters* - Waters of the nearshore ocean, sounds, estuaries or estuarine rivers. Waters of free-flowing streams which discharge into sounds, estuaries or estuarine rivers can have a very important effect on the quality of coastal waters, but for the purpose of this paper are not considered to be coastal waters.

Considering the geographical characteristics of the coastal areas in North Carolina, coastal communities and industries have three reasonable alternatives for disposal of treated wastewater. These are:

1. discharge to sounds or estuarine rivers,
2. discharge on land, and
3. discharge to the ocean.

DISCHARGE TO SOUNDS OR ESTUARINE RIVERS

Many areas of the sounds and estuarine rivers in the coastal regions of North Carolina are classified as SA (for shell fish culture) or SB (contact water sports). Those waters classified as SC (fish propagation) are, in general, so classified because of existing pollutional discharges, not because the lower classification results in the most beneficial use of the receiving waters. Under present regulations, discharge of effluents into SB and SC waters may be continued if the required criteria are maintained and nearby SA waters are not downgraded. However, it is likely that future state and federal requirements will prohibit new discharges and require the elimination of existing discharges.

A number of important environmental and ecological considerations argue against the discharge of wastewater effluents into sounds or estuaries. These types of coastal waters have long been recognized as some of the most valuable and productive of our water resources. Such waters are critically important to the growth of harvestable living organisms. They serve as nurturing areas for young organisms. Some species of high commercial value, such as oysters, spend their entire life cycle in these waters. In fact, it has been estimated that over half of the 4.5 billion pounds of fishery products harvested annually by U. S. fishermen are derived from species whose existence depends on clean estuarine waters during some or all of their life cycle. Water quality requirements for shell fish culture are quite critical. These and other bivalve marine organisms, because of the nature of their feeding mechanism, tend to concentrate and accumulate viruses and bacteria, including pathogenic types, from the surrounding water. Some species--e.g., oysters--are frequently eaten raw.

Sound and estuarine waters are also subject to excessive algae growth, particularly if the natural nutrient balance is upset. Wastewater plant effluents, even after secondary treatment and chlorination, contain much larger concentrations of phosphorus and nitrogen than occur naturally and can upset the natural balance with consequent nuisance growths. Such growths will reduce the natural diversity of marine organisms and reduce the production of undesirable species. In addition, such nuisance growths will affect the esthetic quality of the water and seriously inhibit its use for recreational purposes.

Although some areas of North Carolina's coastal waters are classified SC, large areas remain in the SA and SB classification. Waters in these latter classifications are relatively unpolluted. This absence of pollution contributes to the esthetic attractiveness of these waters, enhancing their value for recreation and tourism. To discharge inadequately treated wastewater effluents into these waters would seem counter to the long-term interests of the local communities.

LAND DISPOSAL

The discharge of treated wastewater effluents on soils has been considered more frequently in recent years (1,2); and as higher water quality criteria are required, this method of ultimate disposal will become more prevalent. In general, this method involves two steps: (1) secondary treatment is provided, and (2) the secondary effluent is discharged to the soil usually by methods of spray irrigation or overland flow. The soil is considered to act as a *living filter*, bacteria and virus are removed by filtration, residual organics are absorbed or filtered out and utilized in plant growth, phosphorus is either precipitated or absorbed by soil particles and is partially utilized in plant growth. On the other hand, some materials--e.g., nitrates and heavy metals--are not completely removed and can result in contamination of groundwater.

Another factor which should be considered is the possible failure of the soils to assimilate all the effluent. If surface soil layers become saturated with water, additional application of effluent results in runoff with consequent pollution of the surface waters. Such a condition might occur during wet periods of the year. To guard against this possibility, holding ponds are usually constructed to permit storage of effluent during periods when the soil is not in condition to accept additional water.

Much of the soil in the coastal regions of North Carolina is loose sand with some clay to a depth of twenty to twenty-five feet, and is suitable for the application of secondary effluent. On the other hand, the groundwater table is close to the surface and, hence, vulnerable to contamination. Because almost all small community and individual water supplies are drawn from relatively shallow wells, groundwater contamination by surface disposal could be a serious problem.

DISCHARGE TO THE OCEAN

Discharge of wastewater to the sea through ocean outfalls has been practiced for a number of years in some coastal regions of the United States. On the lower east coast of Florida from Palm Beach to the Florida Keys, there are ten ocean outfalls ranging in design capacity from 8 to 40 mgd with ocean lengths of from 4,500 to 10,000 feet. No treatment except comminution is provided for five of these outfalls. The EPA conducted an extensive study (3) of these outfalls and concluded as follows:

> "Secondary sewage treatment followed by adequate disinfection provides substantial reduction of disease-causing organisms and additional inactivation is obtained by exposure of organisms to ocean waters. Dilution of residual pollutional matter, including pathogenic organisms, and the separation of effluent from the general population provided by ocean outfalls, will protect the public health. Ocean outfalls have been used to dispose of untreated and partially treated sanitary sewage from the populated areas of southeast Florida for over 30 years. Based on recent studies, it was found that there are no detectable adverse effects beyond the small zone at the end of the outfall pipe. Neither is there any evidence of cumulative adverse effects resulting from the long-term discharges of untreated wastes. This, however, does not eliminate the possibility that changes are occurring which may be so subtle as to be undetectable by short-term observation."

In California, 125 coastal communities, including eleven of the thirteen largest cities, dispose of raw or primary treated wastewater through ocean outfalls. Concerning the effect of some of these outfalls on the marine environment, a recent article (4) based on the results of an extensive study of ocean outfalls conducted by the Southern California Coastal Water Research Project reported as follows:

1. There is no evidence that present ocean disposal practice has had any substantial adverse effects on the general ecological characteristics of the Southern California Bight.

2. Sea organisms exist in great variety and show great versatility and tolerance because of the wide range of conditions and natural fluctuation under which they evolved. There is little evidence that the open sea contains the delicately balanced communities which exist in marsh and estuarine waters.

3. The gross organic materials in normal domestic wastewater differs in no fundamental way from natural detrital material which serves as food for major members of the marine ecosystem.

4. Ocean discharge should be preceded by effective removal of floatable solids which may tend to accumulate in nearshore areas.

Considerations of environmental protection of land and freshwater resources along with the protection of productive estuarine waters and public health all seem to favor ocean disposal of wastewater effluents generated in coastal regions. However, in North Carolina there are institutional constraints which inhibit the implementation of this method. The most important of these are:

1. Ocean waters are classified SB to a point three miles offshore and current regulatory interpretation of Rule VI of *Rules, Regulations, Classifications and Water Quality Standards Applicable to the Surface Waters of North Carolina* as adopted by the North Carolina Commission of Environmental Management effectively prohibit new discharge to these waters.

2. Regulatory authorities do not consider that studies of ocean outfalls conducted elsewhere--e.g., Florida and California--provide reliable data for conditions off the coast of North Carolina. Studies in local offshore waters are just now in the formative stage and may require as much as five years to provide results. The effects of ocean outfalls are difficult to evaluate when no actual outfall exists.

Under these circumstances, it appears that conventional methods of wastewater treatment along with direct discharge to surface waters or in more critical situations discharge on land, will be called on to meet coastal area wastewater disposal needs in the near term future.

EXISTING CONVENTIONAL SYSTEMS

Most coastal towns and communities with permanent populations of less than 1000 are served by individual septic tank systems. Given suitable soils for drainage fields, along with adequate design, inspection during construction and a system to provide competent technical assistance to owners when problems occur, septic tank systems can and have provided adequate service without polluting surface waters. However, ideal conditions in regard both to soils and institutional arrangements are not always found. As a result, septic tank systems have failed in some cases and have fallen into general disrepute. This is unfortunate as in many instances they can provide an economical and environmentally satisfactory solution. Although septic tank systems are unsuitable for some high-density beach resort communities where the summer population may be 10 to 20 times the number of year-round residents, they may be an excellent solution for small coastal towns with a more stable population.

Most of the incorporated coastal area towns and cities with populations over 2000 have some type of conventional wastewater treatment plant. The table below represents some data relative to the types of conventional treatment provided at North Carolina communities located in the immediate vicinity of coastal waters.

MUNICIPAL TREATMENT PLANTS*

Population Group	No. of Communities	Population	No. of Trt. Plants	Type of Trt. Plant	Total Design Flow (mgd)	Present Flow (mgd)
14.000 -47.000	5	120,100	7	all T.F.[1]	30.1	17.1
4000 -13,999	5	29,100	5	3 T.F. 2 A.S.[2]	5.9	3.4
400 3999	9	14,500	9	7 A.S. 1 Oxi. Pond 1 Imhoff Tk.	3.3	2.1
TOTALS	19	163,700	21		39.3	22.6

*Not including military bases

[1] T.F. - trickling filter

[2] A.S. - activated sludge

As can be seen, the larger communities are served by trickling filter type plants. These are all of the high-rate type designed to remove about 85 percent of the BOD_5 and suspended solids in the influent wastewater. With two exceptions, the smaller communities are served by *package* type activated sludge plants.

Almost all of these treatment plants have been built during the last 15 years, and many of the package plants are of quite recent origin. With one or two exceptions, they are operating at well below their design flow. The summary table shows that the average flow at all the plants is only 57 percent of the design capacity. The water quality management plans prepared by the State under the requirements of Section 303 of PL 92-500 report few contraventions of receiving water quality standards attributable to discharges from these plants. It would appear, on the basis of the water quality parameters reported in the management plans, that these conventional treatment plants are doing an acceptable job. But is this actually the case?

ROLE OF CONVENTIONAL WASTEWATER TREATMENT

In general, low levels of dissolved oxygen have not been a serious problem in coastal waters. Where low D.O.'s have been observed near treatment plant discharges, the condition has been highly localized. This problem can often be remedied by providing facilities to promote the adequate diffusion and mixing of wastewater effluent with the receiving waters.

Bacterial concentrations in effluents can be controlled by adequate disinfection prior to discharge. With regard to harmful virus, not enough is known about their survival in salt waters. Disinfection, however, is known to aid in their control. On the other hand, serious questions have been raised concerning the overall ecological and environmental effects of universal chlorination of wastewater effluents. In any case, in regard to D.O. levels and bacterial concentrations, conventional treatment plants can perform an acceptable job in North Carolina coastal areas.

On the other hand, problems of coastal water quality are far more complex than indicated by D.O. and bacteria. For example, major sections of Albemarle Sound are considered to be eutrophic and portions of Pamlico Sound are borderline eutrophic. In the long run, such conditions can seriously affect the beneficial productivity of these waters and lessen their value as recreational resources. But discharges from conventional treatment facilities in coastal areas contributed only marginally to eutrophication. Eutrophic conditions develop when excessive quantities of nutrients, principally nitrogen and phosphorus, are available. These nutrients are contributed to the sounds and estuarine rivers by the entire tributary drainage areas, which extend far inland. Treated and untreated domestic and industrial wastewaters along with land runoff, especially that from agricultural lands, are the major sources of excess nutrient concentration in tributary waters.

The first step in controlling this problem should be to determine an acceptable level of primary or algal productivity for the waters to be protected. The second step should be the determination of the limiting nutrients and the allowable nutrient concentration such that the acceptable level of primary productivity will not be exceeded. Finally, a technically and economically feasible plan must be developed to control point and non-point sources of nutrients. This is a large order, but until it has been accomplished, little can be expected in the control of eutrophication in coastal waters.

If it is found desirable to control eutrophication, conventional treatment can play an important role. With modifications and additions both phosphorus and nitrogen can be removed at treatment plants. The technical literature is ample on this subject (5,6,7,8). Phosphorus may be removed by chemical precipitation using salts of aluminum or iron. The application of these methods also improves the overall performance of typical secondary treatment plants.

Phosphorus may also be precipitated by treatment with lime. This method raises the pH of the wastewater resulting in the conversion of ammonia-nitrogen to the gaseous phase, and it may be stripped from the wastewater by physical methods. Nitrogen removal is likely to be more important than phosphorus removal in most coastal waters as research has shown that the productivity of saline waters is frequently nitrogen limited. Nitrogen can also be removed by biological methods using a combination of aerobic and anaerobic processes. This system has been demonstrated at the pilot-plant scale. It is, however, a complicated and expensive procedure and probably not suitable for use at medium and small-sized plants.

If nutrient control, particularly nitrogen removal, is eventually found necessary for wastewaters discharged to the sounds and estuaries, the most feasible solution for small and medium-sized treatment plants in the coastal area will be that of land or ocean disposal of normal secondary effluents.

One of the most serious impediments to the effectiveness of conventional treatment plants results from inadequate operation. As plants are required to produce higher quality effluent, they become increasingly complex, and operating problems multiply. One of the greatest deficiencies in the present water pollution control law is its lack of provision for financial assistance for plant operation. At the regional level, joint management of several small treatment plants located in the same region could provide operations expertise otherwise unavailable. We have not done enough to provide the legal and institutional framework to encourage this practice.

SUMMARY

It appears that conventional wastewater treatment is and will continue to be an important factor in any water quality management plans for our coastal waters. It is reasonable to conclude that:

1. Under the present regulatory guidelines, secondary treatment is usually sufficient to maintain the legally required water quality standards.

2. In the future, as nutrient discharge limitations are developed, additional processes can be added to conventional treatment plants for the removal of nitrogen or phosphorus.

3. When removal of nutrients is not technically or economically feasible at a plant, conventional secondary treatment can serve as pretreatment for ultimate disposal by land-spreading methods.

4. Ocean outfalls offer the most environmentally and ecologically attractive solution for permanent and resort communities located reasonably close to the ocean. Therefore, when regulatory problems are resolved, conventional treatment methods can serve as pretreatment for ultimate disposal in the ocean.

REFERENCES

1. Environmental Protection Agency, "Wastewater Treatment and Reuse by Land Application - Volume II," Environmental Protection Series, EPA 660/2-73-006b (August 1973).

2. Environmental Protection Agency, "Land Application of Sewage Effluents and Sludges," Environmental Protection Series, EPA 660/2-74-042.

3. Anon., "Final Environmental Impact Statement -- Ocean Outfalls and Other Methods of Treated Wastewater Disposal in Southeast Florida," EPA Region IV, Atlanta, Georgia, March 19, 1973.

4. Hederoth, Charles W., Special Report: "Ocean Disposal - Good or Bad?", *Water and Wastes Engineering 10*, 10, pp. 32-38 (October 1973).

5. Brown, James C., "Alum Treatment of High-Rate Trickling Filter Effluent at Chapel Hill, N. C.," Proceedings of National Symposium on Ultimate Disposal of Wastewater and Their Residuals," Water Resources Research Institute of The University of North Carolina (1973).

6. Black and Veatch, "Process Design Manual for Phosphorus Removal," EPA Technology Transfer Publication (October 1971).

7. Downing, A. L., H. H. Painter, and G. Knowles, "Nitrification in the Activated Sludge Process," *Jour. Inst. of Sewage Purification* (Brit.) 2: 130 (1964).

8. McCarty, P. L., L. Beck, and P. St. Amant, "Biological Denitrification of Wastewater by Addition of Organic Materials," Proceedings of 24th Purdue Industrial Waste Conference, Lafayette, Ind. (1969).

QUESTIONS AND DISCUSSION

QUESTION: (Professor David H. Howells) What do you mean by existing flows? Is it the peak summer flow or the average flow or winter flow or what?

PROFESSOR JAMES C. BROWN: The data came from the state summaries which were usually based on yearly averages. Most of the towns with treatment plants are not resort communities. They are generally the more permanent types of communities which are subject to excessive summer growth such as occurs at the resort communities on Bodie Island, Nags Head, Kill Devil Hills, or Bogue Bank community. Most communities on the banks do not have treatment plants. We're talking about towns like Edenton and Elizabeth City. Swansboro is one that might have some substantial summer growth as well as Southport. Most of them don't have that degree of summer growth, but I would expect during the summer that all of them would have somewhat higher flows.

QUESTION: (Professor David H. Howells) Could average flows for these communities be giving a false impression of what actually exists?

PROFESSOR JAMES C. BROWN: Yes. It could perhaps make a false impression.

QUESTION: (Mr. Harry LeGrand) I have a question relating to deep-well disposal of toxic wastes in salt water below the fresh water aquifer. Each state has different attitudes on deep-well injection, and I wonder what the rationale is in North Carolina for complete injection of deep-well injection.

COMMENT BY MR. EVERETT KNIGHT: We had an experimental project in North Carolina involving the deep-well disposal of industrial effluent. This was discharged into an aquifer which was primarily salt water. The data available from intensive monitoring in this study indicated that these wastes posed a hazard to the fresh water strata. It was on the basis of this information that the regulations were developed.

QUESTION: Do current regulations cover the injection of heated water?

MR. JAMES CROOKS: Heat is considered a pollutant. If you have hot water, then you are going to have to cool it by cooling towers or whatever. When all other available disposal sites have been found deficient and the best technology has been used, then the solution will be to use the system least dangerous to human health. In this instance, it may cause less damage to human health to inject heated water into the groundwater which would be more acceptable than to put it into the stream where it may cause proliferation of viruses and pathogenic organisms, kill fish, or whatever. In that case, it may be permissible to inject the heated wastes for a short period of time, while technology was being developed to improve treatment necessary to allow that heated water to be disposed of in some other manner.

QUESTION: (Mr. Ralph Heath) Jim, do you mean that we are going to replace all those recharge wells on Long Island with cooling towers?

MR. JAMES CROOKS: No, I'm not saying what you are going to do. I'm saying that there is a policy statement on deep-well injection. There is a policy on water reuse, and there are other provisions in the Safe Drinking Water Act concerning groundwater protection. Right now, for example, in Florida they are injecting hot acidic wastes in some of those limestone areas. You can imagine what they do. They're dissolving part of Florida away. This is going on right now under some sort of grandfather clause, and I don't really know how this can be continued. This is going to be stopped eventually. In other words, treatment will be required to upgrade the water to the point where it will no longer be hot and acidic. It will have to be more compatible with the environment into which it is discharged. The same thing applies to the discharge wells of Long Island. There are existing conditions which can't be automatically stopped. We are working in a progressive fashion to cause a turn-around. Some of the material I read to you stated that a period of four years may be permitted to develop the kind of technology needed. There are a lot of things involved, more than just pure technology.

QUESTION: Will the Drinking Water Act contain any provisions for controlling groundwater withdrawals from interstate aquifers?

MR. JAMES CROOKS: I don't think we are going to have any control along interstate lines for groundwater. We realize this is a physical thing--aquifers--rather than political. Everybody has talked about it for some time and have tried the best approach. Now we're going to have to live with the fact that we do have interstate groundwater aquifer systems but that controls will have to be at the state level.

QUESTION: Could you give us the current status of groundwater research relating to underground disposal in deep wells?

MR. JAMES CROOKS: Ralph Heath could probably give you more information because the USGS is doing considerably more research on groundwater than EPA. EPA is reaction oriented through most of its efforts as you well know. The USGS, of course, has years of experience in collecting data, analyzing it, and building analog models of groundwater systems, and I do not think that we in EPA generally have the expertise to get into that kind of work.

MR. RALPH HEATH: The USGS is doing a great deal of research relative to underground waste disposal in deep wells. The Bay Park study on Long Island is actually being done by the Survey. The Florida recharge area north of Pensacola and several other areas are being studied by the Survey. The Survey has just completed a study of Norfolk relating to injection of excess fresh water in salty water zones which the city could withdraw during the summertime when they had higher rates of use. There are a great many other places we're studying, but these are some of the new ones. In almost every place that we've made these studies we have encountered unforeseen problems. Among the worst of these problems, I think, are the reaction of the fluids that are being injected and the fluids that are already in the ground and the aquifer itself. It is very difficult to take both sets of material and the implaced fluid and bring them up to the land environment and carry out your tests in the surface environment. So we are still in for a lot of surprises with deep waste injection.

QUESTION: What steps are being taken to improve the operator training and management of existing waste treatment facilities?

PROFESSOR JAMES C. BROWN: We have made some progress in training with the development of regional schools where the training is more locally available for the operator. The reorganization of the training and development of new curricula, some of which I've been involved in, is a help; but no amount of training is really going to do the job because training, although very important, is probably not the real problem at the treatment plant. The problem is to pay a salary sufficient to attract and retain competent and responsible people. The second is probably to greatly expand the capacity of the regional offices to maintain surveillance on these plants. I think that the salary level has to be increased. I would like to see it done on a local level, but it probably isn't going to be done there because most private citizens are mainly concerned that wastewater drains away from their homes and generates no nuisance. We don't really pay much attention to the sewage treatment plants except in two cases: (1) when the plant is going to be expanded, when we think our sewer rates and taxes will go up, and (2) when it smells. Those are the only two times the average citizen cares much about the sewage treatment plants. So it may be difficult to raise salaries at the local level given this amount of disinterest by the citizen. Therefore, it may be necessary for the federal or state government to allow some sort of operating financial support to maintain adequate salaries.

PROFESSOR DAVID H. HOWELLS: Having trained, qualified personnel for waste treatment plants has always been a major problem. Until employees see some opportunity for growth and advancement, I believe this problem is not going to be resolved. Regional management systems would provide these career opportunities. Through contractual arrangements or other mechanisms the regional management system could be large enough to have professional personnel and adequate laboratory equipment to really operate these waste treatment facilities.

PROFESSOR JAMES C. BROWN: I certainly concur with that, and one other thing I think I mentioned in my paper was the desirability of regional management. But one other point I think Dave is making is that all of us want somebody, our boss or the people we work with, to recognize that what we're doing is an important contribution. If you are the only operator in a small town and the rest of the people don't care, you may lose interest. If you are a member of a large organization where not only your boss but your colleagues are interested in what you are doing, where there is communication in this regard, there is more incentive to try to do a good job. That is another point in favor of regionalization.

MR. JAMES CROOKS: With regard to regional management systems, EPA is trying to develop the process as it works with the states. Each state will soon be developing water quality management plans as a part of 303(e) and the 208 planning efforts. The 208 planning effort is limited generally to urban areas. We are now including non-designated areas or non-urban areas which means that each state will have a statewide plan. Part of that water quality management plan will include regional management systems for the entire state.

In a water quality management plan developed for the Pascagoula River Basin in Mississippi, a key element was not accomplished in that there was no designation of the implementing agency to implement the plan. The State of Mississippi retained that authority and responsibility, but the one who developed the plan, primarily the planning agency, was the Water District. The District proposed a management system which would include the training of the operators and providing them with adequate salaries. There would be a central point where personnel would be trained and then would have the responsibility for sampling, checking, and monitoring treatment facilities to provide a good management system. This is part of the water quality management plan. I think this is about the only way you are going to get to this thing. The state has the responsibility for such planning. In North Carolina, this would be the Department of Natural and Economic Resources.

In an effort to promote this concept, we plan an early meeting with the people in North Carolina to try to do a pilot study in rural areas. Our emphasis on this form of management will be particularly towards non-point source pollution control. We will be considering the best management practices for controlling non-point sources and preventing pollution. Not to treat the wastes but prevent degradation is the best way. The regional management system will have to develop and incorporate non-point source management systems as an integral element of the base plans or statewide water quality management plans. The state will have to incorporate that into the pollution control program and include provisions for proper salaries and proper training. Many of us have seen treatment plants and are appalled at what we see--just millions of dollars to put up treatment plants and then we come back later and find out that someone has been paying the guy $15 or $25 a week to operate a costly treatment plant. You can't expect any better than that. You've got to train that man and get his sincerity and his feeling for his job. One way to achieve this is to get proper personnel, train them, and pay them adequate salaries. This can only be done, I think, through this water quality management planning system.

QUESTION: (Mr. J. Luke Hause) Dr. Brown, would you comment on non-point source pollution and its significance? Do you know of any work being done on getting baseline data and means of control?

PROFESSOR JAMES C. BROWN: I recognize this as a problem, but I don't have any answers. By definition, non-point sources generally consist of water sources that become polluted, either through running over the natural ground, or over agricultural land and then discharging into surface water in a condition which may degrade the surface water quality. David Howells and the Water Resources Research Institute has sponsored some research along these lines, particularly some efforts to assess the effect of discharging from urban and agricultural areas. The current 208 study in North Carolina is addressing this problem quite seriously. Hopefully, in the next few years we will have some ideas. How we can reasonably control non-point runoff will present some difficult economic and technical problems.

GROUNDWATER SUPPLIES OF THE COASTAL REGION

Harry E. LeGrand
Consulting Hydrogeologist
Raleigh, North Carolina

INTRODUCTION

Groundwater is a valuable resource throughout the southeastern states, but it is an essential resource in coastal areas. In this discussion, the groundwater conditions will be outlined, the nature of the problems will be defined, and suggestions will be made about future management policies.

The critical factor in developing groundwater in the coastal regions is the quality of water rather than the quantity of water. The volume of water in storage is large, the many hundreds of feet of sands, clays, and limestones underlying the land surface being completely saturated with water except in the sandy surface soil. Unfortunately, much of the underlying water is salty.

The extension of brackish surface water inland for some distance from the mouths of coastal streams limits the use of surface water for municipal water supply and places a burden on the groundwater supplies. Problems have developed locally because of heavy pumping, but the region still has large areas of undeveloped groundwater.

The withdrawal of groundwater is unevenly distributed. Pumping is concentrated in populated beach areas and where cities and industries use groundwater. Proper management of the groundwater resources of the region is very important to prevent salt-water encroachment, which could permanently damage parts of the water-bearing systems, or aquifers.

Useful studies of the groundwater resources of the region have been made, chiefly by the U. S. Geological Survey and various state agencies. Intensive studies were started where heavy groundwater withdrawal was already in progress, including: Miami, Savannah, Brunswick, Parris Island, Myrtle Beach, and the North Carolina phosphate area of Beaufort County, North Carolina. A study that would integrate the available information and cast it in a form for regional management is still lacking.

GROUNDWATER FEATURES

The Coastal Plain is no more than a few hundred feet above sea level along its inner margin, and it slopes gently to the sea, extending beyond the coastline as the submarine Continental Shelf. Beneath the plain, beds of sand, clay, marl, and limestone of Cretaceous, Tertiary, and Quaternary age dip seaward. The geologic materials commonly are soft and unconsolidated except for some limestones. They lie on a floor of hard consolidated rocks that are similar to those of the Piedmont exposed along the inner margin of the Coastal Plain. The bulk of the sediments accumulated beneath the sea, which invaded the region and retreated many times.

The most striking structural features of the Coastal Plain are (1) the seaward dip of the beds, (2) a coastward increase in thickness of individual beds, and (3) a coastward increase in number of beds. The beds commonly dip only a fraction of one degree--toward the Atlantic Coast to the east.

The Coastal Plain is underlain by an immense artesian system--simple in general terms, but complex in many details. The alternate layers of permeable and relatively impermeable beds and their gently seaward slopes are ideally suited to the occurrence of artesian water. Aquifers, which commonly are medium to coarse-grained sands or limestones, and intervening impermeable beds which are commonly clays or shales, vary greatly in thickness and areal extent. Some geologic formations contain several aquifers and several impermeable layers, whereas other formations compose only a part of an aquifer. Many aquifers are separated by beds that are lenticular and not altogether impermeable. Thus, there is considerable leakage between many aquifers where there is a difference in artesian head between them.

Beneath all of the Coastal Plain, except a narrow belt along the inner margin, the groundwater occurs in three zones in downward succession. They are: (1) the zone of unconfined water at shallow depths, (2) the zone of naturally fresh artesian water, and (3) the zone of salty artesian water. The shallow zone is the water-table aquifer, which extends throughout the Coastal Plain and contains fresh water everywhere except in a few localities near coastal surface waters and in some swampy parts of southern Florida. The zone of fresh artesian water occurs throughout the Coastal Plain except beneath a thin strip along the inner margin and locally along the outer margin of the Coastal Plain; it is commonly thickest in the hinterland where it ranges in thickness from a few hundred to about 2000 feet. The salt-water zone includes the basal beds in the outer two-thirds of the region. The salt-water zone occupies much more than half of the total aggregate volume of sediments in North Carolina, Georgia, and Florida, but not in South Carolina.

The chemical quality of groundwater in the Coastal Plain ranges greatly. In most places, the water in the shallow water-table aquifers is low in total dissolved mineral matter but is slightly acid and corrosive. Fresh artesian water in limestone is largely of the calcium bicarbonate type, and the hardness commonly ranges between 100 and 300 parts per million. Where the fresh artesian water occurs in sands, the mineral content generally increases gradually with depth in each aquifer, and the water changes from calcium bicarbonate to sodium bicarbonate to chiefly sodium chloride.

Almost all of the sediments either were deposited in sea water or had sea water introduced into them at some time in their history. Yet, almost nowhere do the sediments now contain water identical to that of the sea. Movement has been the keynote to changes in the character of the water, for all the water has moved some distance and in doing so has been influenced by the character of sediments and by the character of contiguous water in its path. Water from precipitation has flushed out the former salt water in most of the beds along the inner margin of the Coastal Plain and in the uppermost beds in most of the coastal areas. Thus, we must make a distinction between the water that is fresh and potable and water that is salty.

For the purposes of this report, water containing less than 500 ppm of chloride is considered fresh.

The water table is near the ground in many places, and excess water is lost by evapotranspiration or is diverted to surface streams. Some water from the water-table aquifers moves downward to the underlying artesian beds at high inland places, but generally at a slow rate. Where artesian water occurs at depths of several hundred feet or more, the natural rate of movement may be in feet per year, or even in feet per century. Most rapid groundwater circulation occurs in the water-table aquifers and in the shallow parts of the artesian aquifers. The rate of movement is also quickened around wells that are pumped.

In Figure 1 the water table and uppermost artesian aquifers are incised by streams, resulting in relatively rapid movement of water to the streams. The zone may be considered as extending 100 or 200 feet beneath the base of the streams, and the rate of movement may be considered in terms of feet per day to feet per year. The base of Zone 2 is also arbitrary and may be considered to extend to a depth of several hundred feet or perhaps to a depth at which the water is salty; the water in Zone 2 has no good discharge facilities, and its rate of movement may be considered generally in terms of feet per year. Zone 3 contains only salty water and has extremely poor facilities for discharging water; the rate of movement may be considered in terms of feet per century. It must be realized that withdrawal of water from wells or introduction of fluids through wells would steepen the hydraulic gradient and would greatly quicken the flow in any of the zones.

Conditions in Figure 1 are typical of those slightly inland from the coast in North Carolina and northeastern South Carolina. In this region several fresh-water artesian sand aquifers are separated by clay beds. Toward the coast, however, the brackish water zone tends to rise so that the fresh-water zone may be much thinner than that shown in Figure 1.

The well owner in the coastal area is concerned with the depth to salty water under normal, non-pumping conditions, but he is more directly concerned with the possibility of encroachment of salty water which might impose limitations on the withdrawal of water. If salt-water encroachment is known to be possible in an area, the difference in specific gravity between fresh water and sea water is an important factor to be considered.

As sea water has a specific gravity of about 1.025, 40 feet of sea water will balance about 41 feet of fresh water. This difference in specific gravity of fresh water and sea water has led to the general rule of 40-to-1 ratio. Where the rule can be applied, the depth in feet below sea level to the contact between fresh and salt water theoretically will be 40 times the number of feet the static water level of fresh water is above sea level. Although strict application of the rule requires a stable relation between the fresh and salt water, a condition that probably does not exist in nature, it serves as a useful measure in studying problems of salt-water encroachment.

The relation of fresh to salty water under shallow water-table conditions is shown in Figure 2A. Where artesian conditions exist,

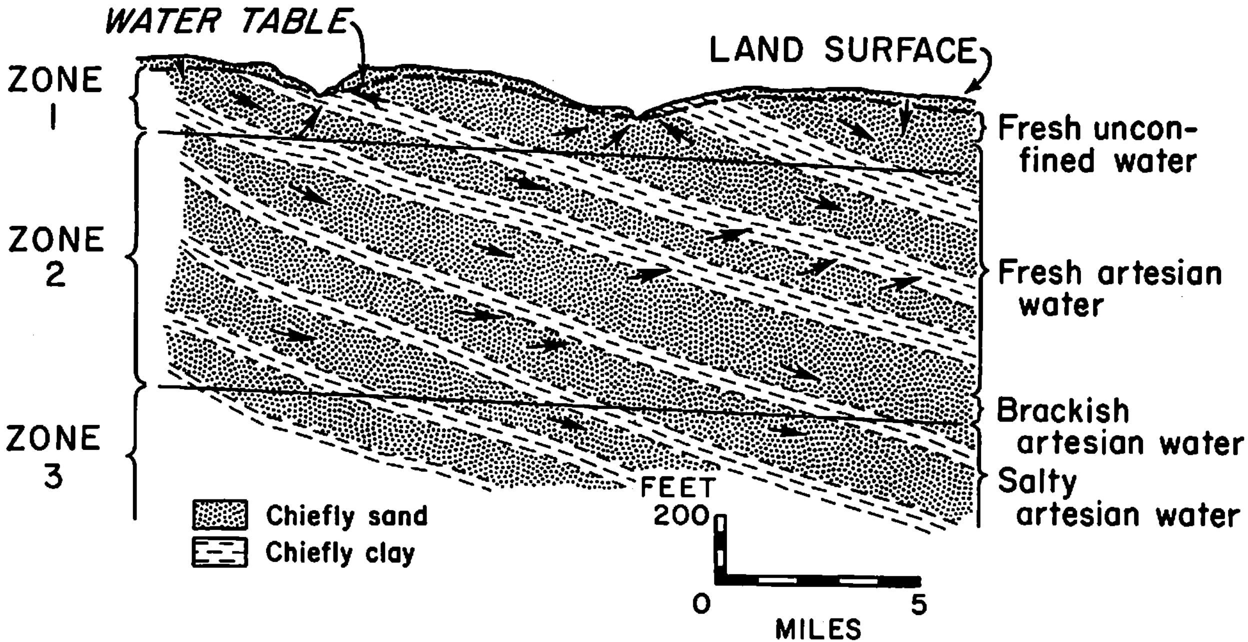


Figure 1. Vertical zones of the Coastal Plain, showing movement of water at different rates. Zone 1 includes the water-table aquifer and the shallower part of the uppermost artesian aquifer; discharge of water is considerable, and movement may be considered in terms of feet per day. Zone 2 includes most of the fresh artesian water and perhaps some salty artesian water, several aquifers generally being involved; water moves slowly, to some extent downdip and coastward and to some extent upward through relatively impermeable layers, but facilities for discharge are poor. Zone 3 contains salty water at considerable depth; water is so confined that movement may be considered in terms of feet per century. The thickness of each zone may vary considerably from place to place. The multiple aquifer shown is typical of that in Horry County, South Carolina, and western Pender County, North Carolina; but the general zonation applies also to the limestone aquifer. (LeGrand, 1962)

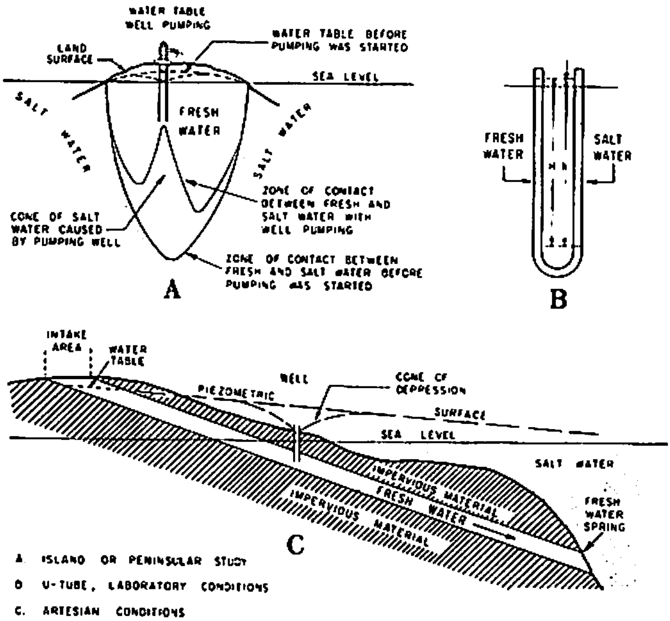


Figure 2. Relation of salt water to fresh water in aquifers of coastal areas (after Warren, 1944).

as in Figure 2C, sea water has access to the aquifer at its outcrop beneath the sea where it is not covered by confining beds. The relation between salt and fresh water under these conditions may be compared to those conditions in a U-shaped tube, as shown in Figure 2B, one side of which is filled with salt water and the other with fresh water. One leg of the tube is comparable to the sea and the other to the aquifer, and the walls of the tube represent the confining beds (Stringfield, 1966, p. 156).

PROBLEMS OF THE SHALLOW (WATER-TABLE) AQUIFER

Groundwater suitable for domestic water supplies occurs at shallow depths throughout the coastal region. Sands cover most of the region, and these sands represent the water-table aquifer except in the Miami area and a few local spots where limestone is the shallow aquifer.

The water table lies within a few feet of the land surface, resulting in the abundance of relatively inexpensive drive point wells for most individual water supplies. Most yields range between 5 and 100 gallons a minute for the shallow sand aquifer, although higher yields may occur where clay beds do not underlie the aquifer at relatively shallow depths.

Problems of quality of water in the shallow sand aquifer are widespread. The problems are related to the natural quality of the groundwater, to salt-water encroachment, and to pollution from man-made sources.

Water in the shallow aquifer tends to be low in dissolved mineral matter but picks up carbon dioxide in the soil zone, which makes it corrosive. This corrosive water may dissolve iron and other metals from pipes causing stains on plumbing fixtures.

The subject of salt-water encroachment, discussed in a general way earlier, is important to well owners on the beach and near salt-water estuaries. Excessive pumping within a few hundred feet of the shore may lower the fresh-water head enough to cause salty water to intrude into the aquifer. Techniques for preventing encroachment of salty water into a shallow sandy coastal aquifer are described by Winner (1975).

The most serious overall quality-of-water problem concerning the water-table aquifer is pollution from septic tank effluent and other waste products. The problem is especially severe in beach areas and other developed areas where lots are small and wells and septic tanks are closely spaced. Sanitary engineers working in the region have learned that individual wells and septic tanks in a development on lots as small as one-half acre and smaller often lead to polluted drinking water. Studies have been made to evaluate the potential for wastes to pollute nearby wells, using hydrogeologic factors (LeGrand, 1964); the results of these studies are in general agreement with the "lot size" and "ground distance" regulations that counties and states enforce to guard against undue groundwater pollution.

Hydrogeologic factors need to be studied carefully for sites that are considered for disposal of wastes in the region. Concern about polluting estuaries and beaches is placing emphasis on disposing of wastewater in the ground. The high water table, resulting in the aquifer being near land surface, is an unfavorable factor and indicates that the aquifer can be polluted easily from waste disposal operations. However, the spread of polluted water in the shallow aquifer from a single disposal operation is not likely to be great, partly because the aquifer is thin and the permeability is rather low; thus, it is likely that useful compromises may be reached--trying to protect the aquifers from pollution in general but allowing some disposal of wastes even if small segments of an aquifer are polluted. This is not a drastic policy because the water-table aquifers beneath our towns and cities in the Coastal Plain are partly polluted because of leaky sewers, storm runoff, and leaching of oil wastes and other materials at land surface.

PROBLEMS OF THE ARTESIAN AQUIFERS

Broad useful generalizations, such as those made about the shallow water-table aquifer, do not apply as well to the artesian aquifers. The artesian aquifers range in character and in chemical quality of their waters from place to place, and special studies and maps are essential. Two major types of artesian aquifers occur in the region--the limestone aquifer of Tertiary age and the underlying multiple-sand aquifers of Cretaceous age.

Limestone Aquifer

The extent of the Tertiary limestone aquifer is shown in Figure 3. Considered in its entirety, it is one of the most productive aquifers of the world. The economics of Florida and coastal Georgia are dependent on it, and it is important in parts of coastal South Carolina and North Carolina.

In coastal Florida and Georgia, the limestone aquifer is at least several hundred feet thick and is covered by thick impermeable clays that confine the artesian water. The relatively high permeability of the aquifer has resulted from circulation of water in the geologic past that has led to enlargement of openings in the rocks by solution action. Some large caverns exist, but the permeability results chiefly from a widespread network of small solution openings. As is characteristic of most limestone systems, the permeability is unevenly distributed. A part of the aquifer system is so impermeable, for example, northwest of Charleston, South Carolina, that the city uses an unlined tunnel in the rock to transport water from the Edisto River.

The limestone aquifer becomes thinner and less well covered northeastward from Savannah, Georgia, and is near land surface in the Charleston area. It is absent in the northeastern coastal plain of South Carolina but is present again at shallow depths in the southeastern coastal region of North Carolina. In parts of Brunswick County, North Carolina, it is so thinly covered by sands that it is a water-table aquifer. Farther northeastward, as in Carteret County, it is confined and yields fairly large supplies of artesian water. It thins to the north in Beaufort County, North Carolina, and is not present northward into Virginia.

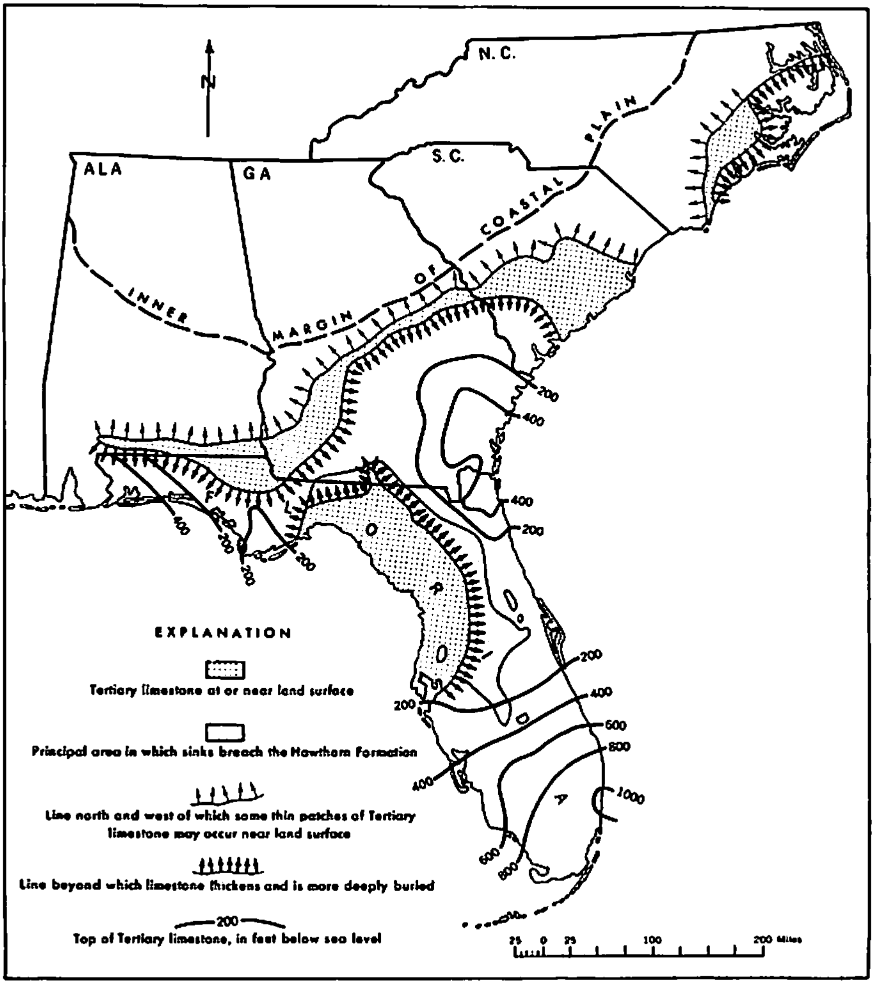


Figure 3. Maps showing distribution of limestone at the land surface and beneath it (Stringfield and LeGrand, 1966).

The artesian pressure in the limestone aquifer is caused by its confinement beneath clays near the coast and to higher intake and recharge areas in the interior part of the Coastal Plain. Some of the water enters in the ground in south central Georgia at elevations of a few hundred feet causing a high fresh-water head along the Georgia and north Florida coast. The upper part of the aquifer contains fresh water in some places a few miles off the coast of Georgia.

In spite of the great fresh-water head in many places in the limestone aquifer, the presence of salty water or concern about salt-water encroachment is still a vital problem. All of the aquifer contains salty water in southern Florida, parts of southeastern South Carolina, and parts of extreme eastern North Carolina; elsewhere the lower part of the system contains brackish water along the coast. It is understandable that where heavy concentrated pumping has occurred there has either been encroachment of salty water or fear of encroachment.

The limestone aquifer yields a hard calcium bicarbonate water. The hardness generally ranges between 100 to several hundred parts per million.

The odor of hydrogen sulfide is present in much of the artesian water. The iron content of the water is generally low, the high iron content in Craven County, North Carolina, being an exception.

A center of heavy pumping from the limestone aquifer at a phosphate mine on the south side of the Pamlico River estuary at Lee Creek, Beaufort County, North Carolina, has caused a lowering of water levels in a large surrounding area (Peek and Nelson, 1967). In order to mine the ore body, it was necessary to dewater the base of the ore by pumping from the limestone aquifer that lies just below the ore. A total pumping rate of about 60 million gallons of water a day is required to accomplish the dewatering. The dewatering wells showed an almost immediate increase in saltiness because of upward flow from mineralized water in the lower part of the limestone aquifer. There is a hydraulic gradient from the brackish water estuary to the center of pumping, but because of beds of low permeability within the path of the water, the likelihood of salt-water contamination from this source is not likely in the near future. The concern of salt-water contamination in this region has resulted in an intensive study and monitoring system by the North Carolina Department of Natural and Economic Resources.

The City of Savannah, Georgia, and several nearby industries have been pumping, in aggregate, more than 50 million gallons of water a day for more than 20 years. A large cone of pumping depression occurs in the limestone aquifer. Counts and Donsky (1963) report that salty water in the aquifer northeast of Savannah is moving very slowly toward the center of pumping. Large additional supplies are available if the pumping is distributed more widely and if the additional water is withdrawn from the aquifer 15 or 20 miles west, northwest, and southwest of the city. McCollum and Counts (1969) estimate that about 40 mgd is the maximum that can be pumped indefinitely without lateral movement of salt water toward Savannah if pumping centers are not dispersed.

In Brunswick pumpage of more than 100 million gallons a day has reduced the head in the limestone aquifer enough so that trapped brackish water underlying the fresh water is infiltrating into the fresh-water zones (Karuse and Gregg, 1972). With the aid of digital modeling, the U. S. Geological Survey has made future predictions of drawdown of the water level and of movement of contaminated water under various pumping conditions.

A composite cone of pumping depression occurs at St. Mary, Georgia, and nearby Fernandina Beach, Florida, where in 1971 about 40 million gallons a day of water was pumped and about 70 million gallons a day at Fernandina Beach. Although the center of the cone is more than 10 feet below sea level, salt-water encroachment is not yet a problem.

Artesian Sand Aquifers

Where the limestone aquifer is absent in much of coastal South Carolina and some of southeastern North Carolina, sands and clays represent the usable artesian system. These beds, of Cretaceous age, are generally layered in alternating fashion, each bed commonly being less than 20 to 35 feet thick. Each of the sand beds is water-bearing to a certain degree. In developing water for cities and industries from this type of aquifer system, the procedure is to place a screen or slotted pipe opposite each sand bed so that water from several beds can be used. Such multiple-sand wells are common in the interior parts of the Coastal Plain of Georgia and the Carolinas, where they represent a chief source of water supply. They are the source of supply also at Georgetown and Myrtle Beach, South Carolina. The sand and clay artesian systems extend to great depths, but the lower parts are salty everywhere eastward from the central part of the Coastal Plain. Most of the multiple-sand wells yield as much as several hundreds of gallons per minute.

The chemical quality of the fresh-water part of the sand artesian system is generally good. By moving through natural water-softening materials in the ground, the water is of the soft sodium bicarbonate type. The fluoride content is generally high enough to retard tooth decay; but locally, the water may contain several parts per million of fluoride which is somewhat more than desired.

Salt-water encroachment in the artesian sand aquifers is not yet a serious problem, but excessive concentrated withdrawal of groundwater in this region could lead to serious salt-water problems. Along the coastal parts of North Carolina and Georgia, the multiple-sand aquifers naturally contain salty water and are buried beneath the limestone aquifer.

Studies of the multiple-sand system by the U.S. Geological Survey and state agencies are being made in the Myrtle Beach region because of the concentration of people in this coastal part of South Carolina.

A cone of depression in the multiple-sand aquifers resulting from heavy pumping at Franklin, Virginia, extends its lowered water levels into northeastern North Carolina. Studies by Peek and Nelson (1967) and Brown and Cosner (1974) show a gradient in the water levels from the eastward salt-water zone toward the fresh-water zone at Franklin.

These workers endorse a monitoring program to determine the extent of migration of the salty water.

Centers of pumping from the multiple-sand aquifers at (1) Kinston, by the City of Kinston, (2) Grifton, by DuPont Company, and (3) Cove City, by the City of New Bern, have resulted in cones of depression in the water levels that have overlapped. The inland nature of this composite cone of depression and the fact that salty water in the aquifer is not in close range prevent an immediate problem of salt-water encroachment in this area.

Almost everywhere in coastal regions around the world the brackish water in aquifers gets saltier with increasing depth. This is not the case in the Charleston and Beaufort Areas of South Carolina, where water in the multiple-sand aquifers is fresh below salty water in the overlying limestone aquifer. Siple (1965) reports the presence of fresh water at a depth of 2800 feet in a well at Parris Island, representing the deepest fresh water on the Atlantic Coast. The water is warmer than most aquifer water. Some limited development of the aquifer is possible, but the danger of salt-water encroachment is potentially great because a lowering of fresh-water head could cause encroachment of salt water from both overlying and underlying beds.

MANAGEMENT PHILOSOPHY

The remainder of this discussion is somewhat philosophical, but the attitudes taken toward managing the groundwater resources of the region are very important. The often-heard statement that "groundwater is a renewable resource" needs to be qualified because there is evidence that the volume of usable groundwater in the region is progressively shrinking by salt-water encroachment. To prevent or retard this shrinkage is a management goal that needs further consideration.

Being a renewable resource which is derived from abundant precipitation in the region, the total volume of groundwater hasn't changed much through the years. In a sense, the aquifers are so full of water that the water table is near land surface, and much water seeps out into streams and into the ocean. The problem is, then, one of competition of space between contaminated and uncontaminated water. The contaminating water includes (1) the naturally occurring salty water in the ocean and estuaries and in the underlying deeper artesian system, and (2) the contaminated water from waste disposal and other man-made operations. Both types of contaminated water have made inroads into space formally occupied only by uncontaminated water. The salty water is especially prone to encroachment in certain places where the fresh-water head is lowered by pumping of wells.

The contaminated water cannot be removed readily from the fresh-water aquifers. Such features of the natural environment as air or surface water can generally be restored to pristine conditions rather quickly by removing the source of pollution. In only a few places is the movement of groundwater fast enough to eliminate the contamination in a short time; in some shallow permeable water-table aquifers, as in the Miami area, any contaminated water may move as much as several tens of feet per day and be replaced by water from precipitation. However, in most of the aquifers, the movement of groundwater is slow, and the contaminated water does not find a ready discharge outlet, especially in artesian aquifers. Thus, parts of aquifers in the Coastal region are permanently shrinking in size and can be permanently damaged if they are not managed properly.

Some intensive groundwater studies have been made of parts of the Coastal region, but these studies and other regional knowledge need to be integrated into a framework that can be used properly for management of the total resources of the region. The fresh-water and salt-water contacts in the water-table aquifer and the upper artesian aquifers are irregular in distribution and have not been mapped regionally.

Considering the irregular distribution of fresh groundwater in coastal areas and the delicate encroachment possibilities of the salty water, it is safe to say that the groundwater resources cannot be managed *ex cathedra* from the state capital by simply enforcing a set of laws and regulations. Good regulations and controls are essential, of course. The *capacity use* law in North Carolina, which limits groundwater withdrawal in certain critical cases, and the regulation that deep oil tests must be properly sealed to prevent salty water from leaking into fresh-water beds are examples of good regulations that apply to the coastal areas. Yet, the great ranges of hydrologic conditions locally are not amenable to rigid regulations because some decisions would not prevent contamination of water whereas others would deny use of water without fear of contamination. A good approach would be a blend of useful regulations that can be modified with provisional or compromising decisions based on a thorough knowledge of the hydrology of the region.

The past policy toward managing the groundwater resources of the region has been to let a problem develop before taking action. This approach has led to intensive studies by the U. S. Geological Survey and various state agencies at certain coastal areas where problems have developed including: Miami, Brunswick, Savannah, Myrtle Beach, and Beaufort County, North Carolina. Since the aquifers extend across county and state boundaries and since no systematic regional study has been done, the following recommendations are made:

I. *In the hydrological field* -

A. Make a regional study of coastal groundwater hydrology. The study should include the preparation of appropriate maps of the fresh-water artesian system showing: (1) water levels, (2) distribution of permeability, (3) depth to salty water, and (4) location of deep wells in the salt-water zone that could contaminate the aquifer. The study should also include assessing local and regional features of the water-table aquifer, such as: (1) defining current problems of pollution, (2) evaluating areas for disposal of wastewater and solid wastes, and (3) outlining areas of future problems.

B. Develop a reasonable monitoring system so that additional problems can be forestalled, especially those relating to the quality of groundwater.

C. Prepare predictive models which will show danger spots and danger conditions and will show consequences of actions by man relating to the ground environment in the region. (The hydrologic studies recommended should be along two lines. The excellent specific studies by the U.S. Geological Survey in cooperation with state agencies in progress should be supported strongly. Because of the specific and local character of these studies and because the aquifer systems cross state boundaries, a broader type of study is essential. Thus, a regional study that synthesizes all work and integrates findings for management officials is necessary. It is recommended that a special team of hydrologists be assigned this task).

II. *In the management field* -

A. Review all current and proposed regulations, keeping in mind that some apparently good regulations may not be suitable when the hydrologic conditions that range in space and vary with time are considered.

B. Request that hydrologists provide current information that can be related to management of the resources.

C. Be prepared to cope with a management enigma that might be called *incremental permissiveness* (we may define *incremental permissiveness* as a separate action which appears to do little overall harm, but which, if repeated many times, may be harmful enough to prohibit it; for example, a little withdrawal of groundwater, which lowers the artesian head a little near salty water, may not cause any encroachment but an increase beyond a certain degree would cause encroachment).

D. Be prepared to cope with plans for a better distribution of withdrawal of groundwater at inland places to be used at coastward places. All anticipated problems dealing with the concept of subsurface trespass should be in the management policy.

E. Have suitable guidelines for assessing disposal plans of wastewater and solid wastes.

What is the outlook for the future of groundwater resources in the region? One can be pessimistic if the past and present water management practices are continued. Justification for this outlook is based on predicted increase in use of water in the face of some bad waste disposal practices and some shrinkage of the fresh-water artesian system by salt-water encroachment. However, one can be optimistic if proper management is developed. This optimism is based on the fact that enormous volumes of usable groundwater are still wasted by discharging naturally into the sea and estuaries. By salvaging some of this wasted water, by selectively dispersing the centers of heavy withdrawal of water from wells, and by carefully managing waste-disposal practices, it will be possible to greatly increase the withdrawal of groundwater in the region. It is difficult to see how programs of water and land use management in the region can be successful without improved hydrogeologic input.

In the final analysis, a touch of skillful brinkmanship is involved because we must go almost to the brink of pumping contaminated water to get optimum use of uncontaminated water. We will never know in all cases how far we can go without getting into trouble, salt-water encroachment being the major source of trouble. The management proposed is not intended to sound wishy-washy but is intended to allow as much development of groundwater resources as possible without contamination damage to the system.

REFERENCES

1. Brown, G. A. and Cosner, O. J., 1974, "Ground-water Conditions in the Franklin Area, Southeastern Virginia," U.S. Geol. Survey Hydrologic Atlas, 538, 3 sheets.

2. Counts, H. B. and Donsky, Ellis, 1963, "Salt-water Encroachment, Geology, and Ground-water Resources of Savannah Area, Georgia, and South Carolina," U. S. Geol. Survey Water-Supply Paper 1611, 100 pp.

3. Krause, R. E., and Gregg, D. O., 1972, "Water from the Principal Artesian Aquifer in Coastal Georgia," Georgia Dept. Natural Resources Hydrol. Atlas 1, 1 sheet.

4. LeGrand, H. E., 1962, "Geology and Ground-water Hydrology of the Atlantic and Gulf Coastal Plain as related to Disposal of Radioactive Wastes," U. S. Geol. Survey TEI-805, 169 pp.

5. ______, 1960, "Geology and Ground-water Resources of Wilmington-New Bern Area," N. C. Dept. Water Resources, Ground-water Bull. 1, 80 pp.

6. ______, 1964, "System for Evaluating the Contamination Potential of Some Waste Sites," Am. Water Works Assoc. Jour., V. 56, No. 8, pp. 959-974.

7. McCollum, M. J. and Counts, H. B., 1964, "Relation of Salt-Water Encroachment to the Major Aquifer Zones, Savannah Area, Georgia, and South Carolina," U.S. Geol. Survey Water-Supply Paper 1613-D, 26 pp.

8. Mundorff, M. J., 1945, "Progress Report on Groundwater in North Carolina," N. C. Dept. Cons. and Dev. Bull. 47, 78 pp.

9. Peek, Harry, and Nelson, Perry, 1967, "Ground Water Problems in the Coastal Plain Related to Heavy Withdrawals," Water Resources Research Institute of Univ. of N. C., Proc. Symposium on Hydrology of Coastal Waters of N. C., pp. 62-80.

10. Siple, G. E., 1965, "Salt-water Encroachment in Coastal South Carolina," Conference Proc. Hydrologic Activities in the South Carolina Region, Clemson Univ., March 17-18, 1965, 33 pp.

11. Stringfield, V. T., 1966, "Artesian Water in Tertiary Limestone in the Southeastern States," U. S. Geol. Survey Prof. Paper 517, 226 pp.

12. Stringfield, V. T. and LeGrand, H. E., 1966, "Hydrology of Limestone Terranes in the Coastal Plain of the Southeastern United States," Geol. Soc. America Special Paper 93, 46 pp.

13. Wait, R. L., 1965, "Geology and Occurrence of Fresh and Brackish Ground Water in Glynn County, Georgia," U. S. Geol. Survey Water-Supply Paper 1613-E, 99 pp.

14. Wait, R. L., and McCollum, M. J., 1963, "Contamination of Fresh-Water Aquifers Through an Unplugged Oil-Test Well in Glynn County, Georgia," Georgia Mineral Newsletter, V. 16, Nos. 3 & 4, pp. 74-80.

15. Warren, M. A., 1944, "Artesian Water in Southeastern Georgia, with Special Reference to the Coastal Area," Georgia Geol. Survey Bull. 49, 140 pp.

16. Winner, M. D., 1975, "Ground-water Resources of the Cape Hatteras National Seashore, North Carolina," U. S. Geol. Survey Hydrol. Atlas 540, 2 sheets.

THE AVAILABILITY OF DESALTING FOR WATER SUPPLY FROM SALINE SOURCES

Walter L. Barnes, Jr.
Office of Water Research and Technology
U.S. Department of the Interior
Washington, D. C.

The title of my contribution to this conference is *The Availability of Desalting for Water Supply from Saline Sources.* In our work at OWRT, *Saline Water* covers the entire spectrum of waters from the so-called *brackish* right on up to seawater. In addition to working with seawater, a very large part of our earlier (and on-going) work had to do with brackish water of less than 3000 ppm total dissolved solids (TDS) from underground sources. I expect that most of you have greater familiarity with that category of water as opposed to seawater. Having said that, I hasten to assure you that I recognize I'm talking here to a peer group whose collective knowledge of down-to-earth water problems and their solutions is far superior to my own. Consequently, I shall attempt to tell you what desalting technology is available, what is being applied, and perhaps some information about costs. The characteristics of individual water supply cases will determine whether or not desalting is a viable alternative either for total supply or augmentation.

For the benefit of those who had familiarity with the two offices, Water Resources Research and Saline Water, we have been consolidated to form a new entity, the Office of Water Research and Technology (OWRT). The consolidation was triggered by the National Water Commission's report, *Water Policies for the Future*, which spelled out those recommendations it believes necessary for the efficient and environmentally responsible management of our water resources.

A statement by Secretary of the Interior Rogers C. B. Morton sums up the marriage in very succinct fashion: "This consolidation provides a broader-based organization for implementing our water research development program and will simplify research program coordination and administration." The new office will continue the functions assigned to the Department as previously carried out by the parent organizations.

The official demise of the Office of Saline Water, then, does not bring to an end the ambitions and goals so enthusiastically projected by the original OSW. A small group of former OSW people is still on board under an assistant director for Saline Water Conversion. Accordingly, those communities faced with chronic water shortages or poor quality water may still review the results of government-sponsored research and development in considering alternatives for relief.

The Saline Water Act, as re-enacted by the Congress in 1971, which extended the activities of the OSW to include cooperation with state and municipal agencies, continues in force, although the funding for such activities is now virtually nil. However, the needs which brought the OSW into being are still with us. The need for good quality water continues to expand as the average salinity content of most U.S. water supplies continues to grow. Our mission "to develop practical means for economical production of water suitable for agricultural, municipal and other beneficial uses from sea or brackish water," has not changed. As you are aware, the part about *economical production* has always been difficult to define quantitatively; and under current economic conditions, the degree of difficulty has increased.

Briefly speaking, desalting processes fall into two categories: The first embodies a phase change, either the evaporative-condensing cycle (distillation) or crystallization (freezing) process; the second embraces all those processes which remove the salts from water in the liquid phase either by reverse osmosis (RO) or electrodialysis (ED) or by ion-exchange, each of which employs a different principle. RO forces water from the contaminated stream through a membrane by the application of pressure; ED drives both positively and negatively charged ionized solids through a membrane by electrical energy leaving a relatively pure residual stream. Ion-exchange, as the name implies, involves an actual exchange of ions.

All of you here today have certainly had more than just a nodding acquaintance with the energy dilemma, a thing which has made all of us energy-conscious to a degree never realized before. In view of this energy consciousness within the United States and other energy-importing nations as well, the potential applications for the distillation processes for large-scale desalination appear to be somewhat limited, except in dual purpose power/water plants or in combination with solid waste incineration or other waste heat availability situations or those areas of the world where energy is abundant, such as the Middle East. Distillation processes around the world now account for about 93 percent of all desalination--something in excess of 400 million gallons per day (mgd). The United States accounts for 60 mgd of this total. Those countries having an abundance of oil and natural gas will undoubtedly continue with the distillation processes for a long time to come, but we think a transition is bound to occur.

The distillation process development activities of the Office of Saline Water were ended late in 1972 due in part to the successful achievement of certain goals and in part to the sharp curtailment of R&D funds. Some of our facilities were closed. The distillation plants at Freeport, Texas, and San Diego, California, have been dismantled and the sites restored to their original conditions. The elimination of funds for further development of distillation technology resulted in termination of many contracts. The Thermodynamic Processes Division has made a major effort to publish and make available to the public the resulting sudden influx of technical material including final reports on a wide range of projects related to the distillation processes. Our only remaining distillation project involves evaluation of the VTE/MSF module at Orange County, California, which is now in the start-up phase of operations. The combination of vertical tube evaporators with multi-stage flash pre-heating is currently the most advanced distillation technology available.

The membrane processes, along with ion-exchange, historically have been the preferred methods for desalting brackish waters.

Chronologically, electrodialysis is the oldest of these in terms of research by OSW. The techniques for producing ion-selective membranes were developed at about the time of OSW's original charter and were the subject of some of our earliest contracts. The lessons learned in bringing the quarter-million gpd plant at Webster, South Dakota, to an acceptable level of performance contributed immeasurably to this area of desalting technology. The question as to preference of ED over RO is sometimes argumentative; the break point lies somewhere in a gray area which can be resolved only by a process of optimization taking into account all the factors from feedwater quality to final cost. Technically speaking, there is no upper limit to the salinity of a water that can be desalted by ED; current density and residence time are the governing factors.

Reverse osmosis follows electrodialysis by about 10 years in the OSW chronology.

We've come quite a long way from that day when Professor Reid at the University of Florida first forced water from a saline source through a cellulose acetate membrane and came up with desalted water. In the academic world, this was an event comparable to the splitting of the atom. It was the first time that dissolved solids were separated from water without a phase change. It wasn't until Dr. Sidney Loeb's entrance on the scene, however, that a membrane yielding a sufficiently high flux was developed to enable the consideration of reverse osmosis as a viable desalting process. Even so, the early experimental membranes were something less than perfect; they degenerated under certain conditions, they were subject to pinhole leaks; they compacted to an unacceptable degree under the necessary high pressures.

Because of these limitations, it seemed for a long time that RO would be limited to relatively low-pressure use with brackish water. But through a program of controlled research and development, greater flux was achieved along with lowered pressure, sophisticated modular systems were developed, and a conviction began to grow that by multiple staging water of greater salinity could be desalted and, ultimately, seawater. Approximately five years ago experiments were initially aimed at desalting seawater in a two-pass reverse osmosis system.

A highly condensed version of all the events leading up to the successful culmination of this sometimes torturous program would produce quite a lengthy book. All the research done by so many people, the progression of cellulosic membranes through the diacetate and triacetate formulations, the rekindling of interest in the hollow fiber membrane leading to the introduction of the polyamide hollow fibers, all have been milestones in the progression to the commercial availability of RO and ED process equipment for producing high-quality water from brackish water sources. Additionally, through the continued development and refinement of the technology of membrane systems, we have arrived at another important pinnacle of success. During FY-75, we constructed and are presently operating a test unit of 25,000 gpd potable water capacity, single pass, at less than 900 psi here at Wrightsville Beach. The results thus far indicate that RO may become economically superior to seawater distillation.

Under the redirected Saline Water Conversion program, the area of major development activity has centered on reverse osmosis for desalting seawater. The Wrightsville Beach Test Facility has become the OWRT *workshop* for seawater conversion operations. The facility was redesigned some time ago for pilot plant evaluation of new seawater reverse osmosis and crystallization processes and is today the major testing ground for new and improved membranes and membrane systems. As an integral part of these systems, a 300 gpm central feedwater pretreatment system has been incorporated into the facility. In the past, there has been a tendency to look on pretreatment somewhat as the proverbial orphaned cousin, but we have learned that there can be no realistic appraisal of membrane desalting costs without adequate knowledge of the type and degree of pretreatment necessary for a given feedwater. This is particularly true for the many types of brackish water where the required pretreatment can vary extensively. In the case of seawater, it appears that chemical pretreatment procedures, once established, are very likely to be applicable at any shoreline site, modified to some extent for saline tidal estuarial waters and for turbidity.

A considerable degree of flexibility has been built into the central pretreatment system at the Wrightsville Beach Test Facility in order that the several methods utilized for suspended solids removal may be examined. The high degree of clarification necessary to avoid membrane plugging and consequent decrease in flux can be arrived at by experimentally varying the sequence and degree of subtreatments making up the central pretreatment system. As one example, a recent problem involving exceptional turbidity was solved by using just such experimental techniques. The 20 percent less salt than normal seawater being fed to a four-inch diameter module of polyamide was subjected to alum coagulation, sand or diatomaceous earth filtration, followed by chlorination and pH adjustment by acid addition. Residual chlorine was removed by adding sodium hypochlorite or by activated carbon treatment. At 800 psig and 30 percent product water recovery, the unit produced 1500 gpd water of less than 500 ppm at over 99 percent salt rejection.

Shifting the scene for a moment and laying out a little groundwork for a somewhat different viewpoint, the seawater membrane desalting systems operate at a relatively low product water recovery factor, approximately 30 percent. The *limitless* supply of feedwater from the sea puts the recovery factor into a relatively nonessential category process-wise. At inland locations, the supply of feedwater is more limited, and brine disposal becomes an important consideration. Such a problem is currently undergoing investigation at our Roswell, New Mexico, test facility. A High Product Recovery (HPR) system will attempt a product water recovery of 90 percent or more, probably to the upper limit of dissolved solids concentration in the brine stream at which certain compounds begin to precipitate. In this system, several pilot plants each comprising one stage of the HPR system, are operated in series. A first stage accepts feedwater of 3300 ppm; each succeeding stage operates on the brine from the preceding stage. Some amount of product water is withdrawn at each stage; total recovery from the HPR is currently 87.5 percent. The final effluent, then, is a very low percentage of the feed and is at a concentration well above 200,000 ppm, well advanced toward dryness.

It is at Roswell, too, that much of the ground work on the Colorado River Salinity Control Project is being laid. The Wellton-Mohawk plant, as it is familiarly known, to be built at Yuma, Arizona, will process salt-laden waters from the Wellton-Mohawk Canal. The Wellton-Mohawk Irrigation District receives water for irrigation by diversion from the Colorado River. The ground-water level is controlled by a system of pumps which release water to the drainage canal which returns to the river. This water carries with it salts leached from the soil and seasonal suspended solids. One hundred and thirty mgd of canal water will be desalted yielding 100 mgd of product water for blending with the remainder of the drainage water prior to reentry to the Colorado River. The TDS of the river will then be satisfactory to Mexico.

The total flow of the Colorado River is allocated for use by various water agencies including a treaty-controlled quantity for delivery to Mexico. The waste stream from the desalting plant will not be credited toward the required amount of water to Mexico; therefore, the waste stream constitutes a loss from the Colorado River system. The need for high recovery becomes apparent by virtue of the necessity for reducing the waste stream to the absolute minimum.

Other development work at Roswell, recently made possible by a supplemental appropriation by Congress, will be directed toward equipment improvements to reduce the capital and operating costs of the Wellton-Mohawk Desalting Plant.

The quality of the Colorado River as it enters Mexico has long been a source of diplomatic concern between our two countries. It is gratifying that technology developed by OWRT will contribute to the solution of this long-standing diplomatic problem between our two countries.

Good progress has also been made here at Wrightsville Beach on the development of a new freeze desalting process in a 75,000 gpd pilot plant. The plant has been operated producing potable water at full capacity for short periods. Various mechanical problem areas have been defined and are being corrected. Some modifications to obtain improved efficiency of individual components and to obtain system reliability are programmed.

All the advantages that originally attracted OSW's attention to the freezing process are still there, in theory at least; and in practice, we believe such a process may approach near perfection. In the absence of elevated temperatures, the corrosion/erosion problems are reduced to a bare minimum; and since there are no internal process heat transfer surfaces, scaling and fouling will be non-existent. Best of all, however, and perhaps most important from the standpoint of operating costs is the absence of the need for pretreatment.

The eutectic freezing process for the reduction of effluent brines to a solid component, along with the production of a potable water stream, has moved from the conceptual design stage to the detailed design of a 10,000 gpd pilot plant. A complete construction bid package will be available this fiscal year, and development of this unique process will proceed when funds are available.

The eutectic freezing process must be evaluated in terms of a process for final brine disposal or a specialized salt recovery operation. In cases where the disposal of brine from a desalting plant is either not feasible or represents a significant increase in the overall production cost of fresh water, reduction of the brine to solids must be considered.

Eutectic freezing offers a process universally acceptable for all types of saline waste streams without pretreatment. As a side benefit, over 99 percent of the initial saline water is recovered as potable product.Therefore, the preliminary desalting would be accomplished by the most advantageous desalting scheme dictated by site factors and by the inlet water conditions. The eutectic process would be used on the reject brine stream and its costs would be evaluated considering:

1. additional pretreatment for greater product recovery,
2. brine disposal costs, and
3. credits for additional potable water production.

More relevantly, in terms of specifics as they might be related to your current or potential water supply problems, everyone, of course, has a pretty fair general idea of what good water should be; we'd like it to taste good, smell good, certainly look good, and it shouldn't contain any toxic elements or harmful bacteriological forms. The U. S. Public Health Service has gone beyond all this and defines the standards which determine whether or not the water you use really is suitable for potable purposes. Among these, of course, is the requirement concerning the amount of total dissolved solids (TDS) permissible, and that's where desalting may enter the picture. If the source of supply contains excessive salts in solution, a desalting process may be needed.

The practicality of desalination in these southeastern coastal areas is being proven in south Florida where there are a number of desalting plants operating on the abundance of brackish water found there. Again, comparisons are difficult, and each problem involving brackish water desalination must be analyzed on the basis of local factors. As a very general statement, it may be said that desalting costs for brackish water are less than $1 per thousand gallons.

There are a number of subjects of interest to us that would be discussed at some length. I've tried to avoid discussing subjects that other speakers have been assigned as outlined by the program. At OWRT, we are very much interested in the recycling of wastewater, for example, and there will certainly be many instances for the application of desalting know-how in that area. We're told the world's overall supply of water will last us well into the next century--but nature hasn't always put the good water where it is needed--and in those areas, treatment and reuse will reach their most advanced application. Some of the figures projected for future needs are mind-boggling; the processing of oil shale, the development of coal reserves in the western U. S. may require all the expertise available in the purification and reuse of industrial wastewater along with the ultimate disposal of aqueous wastes.

So as we see it, the future for desalting is a bright one, and appreciation of its promised potential will grow as the need becomes more apparent. The greatest enthusiasm for continued development will come, naturally, from the water-short areas. Our saline water conversion group will continue research and development to the extent possible on all methods of desalination with greater emphasis on those processes which promise the greater yield. None of the processes will be completely neglected; we learned long ago that there is always room for improvement, and we'll always be looking for the least energy consuming, lowest cost characteristic to put us a little closer to the optimum process for a unique situation.

QUESTIONS AND DISCUSSION

QUESTION: (Dr. Philip Singer) You mentioned the limestone artesian aquifer with some sulfide content and not much iron. Could you illustrate perhaps on your slide what region you are talking about when you do find the sulfide? I believe in certain aquifers you will have fairly high iron content.

MR. HARRY LEGRAND: That was a rather sweeping statement, of course. There appears to be a lot of iron in the limestone water in the New Bern area and in a few other places. I'm inclined to think overall throughout the region iron is not a big problem in the limestone aquifer. It may be in North Carolina, but it certainly is not very important in Georgia and Florida.

DR. PHILIP SINGER: I think in Florida it is really significant.

MR. HARRY LEGRAND: It is a problem locally--there's no question about it.

QUESTION: (Professor David H. Howells to Mr. Barnes) Would you give us information as to how energy hungry each one of these systems is in relative terms such as kilowatt hours? This is a matter of considerable interest at the moment.

MR. WALTER BARNES: The desalting plant which we are proposing for the Colorado River Project is in the planning stage. The Wellton-Mohawk plant will be a reverse osmosis or combination electrodialysis-reverse osmosis plant of 100 million gallons per day using about 30 megawatts for the 100 mgd. In distillation processes, the performance ratio varies from about 10 pounds of water per pound of steam up to about 15 pounds of water per pound of steam depending on the type of distillation process selected. In terms of cost of steam, in the plants we are looking at for areas such as the Middle East, we are using at least 70 cents per million btu. Generally speaking, reverse osmosis is less energy consuming than distillation. Brackish water reverse osmosis is 15-30 kw per thousand gallons of product. Seawater reverse osmosis is 25-40 kw per thousand gallons. Freezing is about 35-50 kw per thousand gallons. I believe when we talk to the individuals at the Wrightsville Beach Test Facility tomorrow, they will be able to give you additional information on energy for the various processes. The freezing process, the seawater reverse osmosis system, and some other units will be working. You'll get an on-the-spot, up-to-date energy report when you talk to the individual pilot plant operators. Generally speaking, cost of energy in a distillation plant runs about 40 percent of the operating cost.

QUESTION: (Professor F. E. McJunkin) Could you link the energy input with the total dissolved solids by process?

MR. WALTER BARNES: In electrodialysis (ED), the higher you go in total dissolved solids (TDS) the more energy it takes. The break point in economy and whether a reverse osmosis (RO) system is to be selected versus an ED system will depend on the salinity, probably around 2500 to 3000 parts, and the constituents of the water. The ED people will deny this, but we found that, generally speaking, beyond 3000 ppm feed it's less expensive to go to RO. The energy requirement is less. Then, too, the question of plant size enters into it. Those kinds of comparisons are awfully difficult to make. We haven't really done enough with high temperature ED to be able to make any accurate predictions either for brackish water or seawater.

QUESTION: (Mr. Leo Ormiste) Mr. LeGrand, you said that for the purpose of your paper water containing 500 ppm or less chloride content is considered fresh. From the standpoint of the consumer, what could be an optimum concentration of chlorides--250, 400 or 500 ppm?

MR. HARRY LEGRAND: I was merely using the figure 500 parts per million to distinguish water in the aquifer that might be suitable from that which is unsuitable. I could have used 250 parts per million just as easily because, normally, the fresh water in both the water table aquifer and artesian aquifer is commonly less than 25 to 50 parts per million. When the chloride begins to rise to 200 parts per million, there is a suggestion that encroachment may be near. It's an eye-opener, so to speak, and I just arbitrarily used 500 parts per million for my purpose.

QUESTION: (Mr. Warren Stiles) My question has to do with both desalting and your question of how much salt is too much. Our operators over at the Saline Water Plant have found that the non-smokers could detect the taste of salt at the TDS of about 200 ppm. The non-smoker has better taste buds so you have to consider the consumer. I had the opportunity to install one of the earliest commercial RO units in North Carolina in the beach cottage of a millionaire down at Sunset Beach. They had water from a 400-foot well with 2400 ppm, and his wife was allergic to salt and had a heart condition. The RO units brought it to about 40 ppm.

QUESTION: (Mr. Mike Bell) Mr. Barnes, the State of North Carolina has studies for a desalting plant for water supply with Ocracoke Island. This will be our first municipal water supply using a desalting process. Although this island is surrounded by the Pamlico Sound and the Atlantic Ocean, the proposal is to get the water from the deep well. Could you mention any advantages or disadvantages of going to well water rather than the surrounding water?

MR. WALTER BARNES: I presume the well water is brackish, or is it seawater?

MR. MIKE BELL: It's brackish.

MR. WALTER BARNES: The advantage, I suppose, is that it's less costly to desalt brackish water than it is seawater. I don't know the quality of the water either. For example, if it has H_2S and other such things that are detrimental to membranes, the pretreatment system may be expensive and add considerably to the cost of water. I presume you've calculated these already; but generally speaking, if it's a good quality brackish water, it's less expensive to desalt than seawater.

WASTEWATER REUSE IN COASTAL AREAS

F. Eugene McJunkin
Associate Professor of Environmental Engineering
Department of Environmental Sciences and Engineering
University of North Carolina
Chapel Hill

Apropos my subject, I have *some good news and some bad news*. The *good news* is that by 1985 we will be drinking treated sewage. The *bad news* is that there won't be enough to go around!

Reuse is a topic more and more in the public domain. After all, as the saying goes, "If we can put men on the moon, why can't we make pure drinking water from sewage?" This paper will review in a general way the prospects for wastewater reuse in the southeastern coastal zone, not only for human consumption but for other, more probable, near-term uses.

WHY REUSE WASTEWATER

Wastewater reuse serves several purposes:

1. *Pollution Control*. Wastewater reuse and the associated increased wastewater treatment result in less pollution discharged to receiving waters. The *dual* of this observation is worth noting: as treated effluent requirements become more stringent--e.g., *1983 zero discharge*--the effluent becomes more attractive, cost and quality-wise, for reuse.

2. *Water Supply Augmentation*. Wastewater reuse reduces the need for development of new sources and/or importing distant water. Environmental disruptions by new reservoirs and transmission lines are lessened. Interbasin transfers may not be required.

3. *Economic Alternative Source*. Reuse may be a less expensive alternative. This has been widely demonstrated for many industrial and agricultural uses and even, in unusual circumstances, for domestic use as at Windhoek, South West Africa (Clayton, 1972).

HISTORY OF WASTEWATER REUSE

Reuse of sewage for farming is an ancient practice. Sewage farming with effluent collected in sewers from the community goes back even in the United States well over a century. Land irrigation with treated wastewater has been recently *discovered* anew although over a hundred small communities have followed this practice a decade or more.

Perhaps the first *conventional* wastewater reclamation plant in the United States was the activated sludge plant constructed in 1926 at Grand Canyon National Park in Arizona (California Department Water Resources, 1973, p. 9). This facility was designed to provide reclaimed water for disposal of wastes from park restrooms and for lawn sprinkling, cooling water, and boiler-feed water at the Grand Canyon power plant.

In 1929 Pomona, California, began irrigating lawns and gardens with municipal effluent. San Francisco has been using reclaimed water from an activated sludge plant in Golden Gate Park since 1932 for irrigating lawns, shrubs, and gardens and for several recreational lakes within the park.

More recent California reclamation projects include Whittier Narrows in Los Angeles County, Santee in San Diego County, and Indian Creek Reservoir at Lake Tahoe. At Whittier Narrows, treated effluent is used for replenishment of ground water; at Santee, to maintain several artificial lakes and irrigate a golf course; and at Tahoe for water recreation and agricultural irrigation. Over 200 reclamation plants are in operation in California with most of the effluents used for irrigation.

Reuse of both cooling and process water in industry has become an established practice. The gross use of water by the manufacturing industry in the United States in 1965 was 90,000 bgd. Only 40,000 bgd of this were withdrawn from available natural water resources. Thus, each gallon of water was, on the average, recirculated two and one-quarter times before being discharged or consumed (Water Resources Council, 1968).

Another form of industrial reuse of water is illustrated by the practice of the Sparrow's Point mill of the Bethlehem Steel Company in Baltimore, Maryland, which uses more than 120 mgd of effluent from the nearby Back River municipal sewage treatment plant (2,3).

An abbreviated list of industrial users of reclaimed municipal wastewaters is shown in Table 1.

"NATURAL" REUSE

Raw wastes or partially treated wastes, when discharged to a stream or body of water of better quality, immediately undergo dilution by the receiving body of water. The degree of immediate improvement of quality in the combined bodies of water, over that of the wastewater, is dependent on the relative quantities and quality of the two. The dilution approach may be suitable for those areas in which the amount of wastes being discharged is relatively minor and the water resources available for dilution are abundant. However, while these situations do occur at some locations throughout the United States, they are apt to occur less frequently in the future. They are rare in this area.

Wastes discharged to a receiving stream undergo a natural process of self-purification given enough time and if biologically de-

Table 1

INDUSTRIAL USERS OF RECLAIMED MUNICIPAL WASTEWATERS
(From: Sawyer, Chem. Eng., July 1972)

Industrial User	Usage	Flow Million gal/day	Municipal treatment	Industrial In-plant treatment
Power				
City of Burbank, Burbank, Calif.	Cooling	1.0	AS	A, C, Ci, AF
Grand Canyon National Park Grand Canyon, Ariz.	Cooling	0.2	AS	F, C
Lansdale Municipal Power Lansdale, Pa.	Cooling	0.3	TF	L, AL, FL, F, FF
Los Alamos Scientific Lab Los Alamos, N. M.	Cooling	0.5	TF	C, A, SA, Ci
Nevada Power Co., Las Vegas, Nev.	Cooling	3.0	AS	C, L, AL, FL, Ci, AF, A
North American Rockwell Corp. Canoga Park, Calif.	Cooling	0.2	AS	C
Providence Sewage Disposal Works Providence, R. I.	Cooling			
Southwestern Public Service Co. Lubbock, Tex.	Cooling & boiler	3.0	AS	L, A, C (F, D Boiler)
Amarillo, Tex.	Cooling	3.0	AS	L, A, C
Petroleum Production and Refining				
Champlin Petroleum Co., Enid, Okla.	Cooling & boiler	1.0		L, AL, C
Cosden Oil & Chemical Co., Big Springs, Tex.	Boiler & process	0.2	TF	HL, F, Z, DA, AF, Ci
Humble Oil & Refining Co., Andrews, Tex.	Process	0.6	PR	L, FL, C (1963-68)
Long Beach Oil Field Producers Long Beach, Calif.	Oil-well flooding	8.4	AS	None (Start in 1972)
Schaefer Oil Co., Matoon, Ill.	Oil-well flooding	1.0	AS	C
Standard Oil Co. (Ohio), Lima, Ohio	Boiler feed	1.5	AS	L, FL, F, D, DA, AF (1970-71)
Texaco, Inc., Amarillo, Tex.	Cooling & boiler	0.8 0.5	AS AS	L, AL, AF, A, C, HL, Z, DA, C
Mining and Metals				
Bagdad Copper Co., Bagdad, Ariz.	Ore processing	0.2	AS*	None
Bethlehem Steel Co. Sparrows Point, Md.	Cooling & process	100	AS/TF, AL	C
Escondido Sand & Gravel Works Esconuido, Calif.	Washing & dust control	1.0	TF	None (ended 1965)
Inspiration Consolidated Copper Co., Inspiration, Ariz.	Ore processing	0.1	ST	None
Kaiser Steel Corp., Fontana, Cal.	Cooling	0.5	TF*	C
Kennecott Copper Corp., Hurley, N. M.	Ore processing	0.4	ST	L
Phelps Dodge Corp., Morenci, Ariz.	Copper-ore processing	Not Available	ST	None
U.S. Steel Corp., Provo, Utah	Cooling & process	0.7	TF*	C
Manufacturing				
Black & Decker Mfg. Co. Hampstead, Md.	Cooling & process	0.1	TF*	C
Chemicals				
Dow Chemical Co., Midland Mich.	Cooling, process fire	6.5	TF	C, OP
El Paso Products Co., Odessa, Tex.	Cooling & boiler	6.0	AS	L, F, Z, D, DA, AF, Ci, C

A Acid addition; AF Anti-foam; AL Alum; AS Activated sludge; C Chlorine; Ci Corrosion inhibitors; D Demineralization; DA Deaeration; F Filtration; FF Foam fractionation; FL Flocculant aids; HL Hot line; L Lime; OP Oxidation pond; PR Primary treatment; SA Soda ash; ST Septic tanks; TF Trickling Filter; Z Zeolite

*Sanitary waste is generated on site.

gradable. The concentration of pathogenic bacteria will eventually drop to low levels. In addition, chemical and physical processes, such as sedimentation, aid in alteration and removal of contaminants. Some have described this self-purification process as a *natural cycle of water reuse.*

DIRECT REUSE

If the treatment necessary to meet effluent or stream quality standards results in a very high quality effluent, such that very little additional cost would be required to make it of drinking water standards, the possibility of reuse in domestic systems, even for potable water, becomes a possibility. This has been described by some as the "direct cycle of water reuse." Thus, there may be a potential for combining the facilities needed to meet water quality standards with those for increasing municipal supplies, particularly in areas of critical shortage, in a true joint-use manner.

Although not widely recognized, much of the water withdrawn for municipal purposes has seen prior use. Koenig (1966) has pointed out that in 155 municipalities, representing 34 percent of the total population of the United States served by surface water supplies, the median reuse of water from upstream sources during the low-flow months in 1961 was about 3.5 percent of the flow. Thus, one gallon out of every thirty gallons diverted for use had passed through the wastewater treatment facilities of upstream cities. In extreme cases it was as much as 18 percent. Koenig also pointed out that if industrial wastewater were included, the median reuse factor would rise to 50 percent and in extreme cases to 300 percent.

Karl Imhoff observed during the dry summer of 1929 a large part of the water of the Ruhr (W. German river) used to supply water to the heavily industrialized area of North Rhine-Westphalia had for a short time been passing through the water/wastewater/water cycle three times over without any adverse effect on the water supply situation or public health in the area. A similar cycle in the dry summer of 1959, however, disrupted water quality, particularly taste. Non-degradable detergents in drinking water rose to 1.7 milligrams per liter (mg/l) (Mullër, p. 8, 1969). The change to a *chemical* society and its effects on water quality between 1929 and 1959 should be noted.

The recycling of treated wastewater for drinking, while not widely accepted for ordinary situations, does have historical precedent in unusual situations. During two months of a serious drought at Chanute, Kansas, in 1956, the domestic sewage effluent, diluted as much as possible by the low river supply, was used after a well-controlled water purification process had made the water potable. No ill effects were noted even though there were enteric viruses present in the treated wastewater. Also, for two months during an emergency situation, the city of Ottumwa, Iowa, used treated river water containing one-third to one-half raw sewage from the upstream city of Des Moines. This author has wondered about the water intakes at Raleigh and Smithfield on the Neuse River during the 1968 drought. Perhaps half the flow in the river was upstream wastewater effluent.

As previously mentioned, the metropolitan area of Windhoek, in South West Africa, is meeting one-third of the water supply for a population of 84,000 by returning its treated wastewater effluent directly to the city's supply system. This is in an area where new sources of water supply are virtually unattainable. This procedure was initiated in late 1968 with complete public acceptance. Similar plans are being considered for Pretoria and Johannesburg. By the year 2000, South Africa expects to be reusing 600 mgd of reclaimed wastewater.

Another form of reuse often practiced in coastal areas which has not been widely recognized as such is the return to ground waters of septic tank or other such effluent by percolation through the soil. In properly designed and managed systems, septic tank effluents improve in quality as a result of purification processes within the soil. Such reuse has been termed the *indirect cycle of water reuse*. This leads to the possibility of returning sewage plant effluent, by percolation or well injection, to ground water aquifers where depletion or salt-water intrusion has occurred. In some situations, further treatment may be required prior to percolation or injection.

AREAS WITH POTENTIAL FOR REUSE

The attractiveness of direct reuse of wastewater is simple to demonstrate; for example, if a city or a factory were to recycle 80 percent of the water it uses, its existing fresh water supply would effectively be increased by 400 percent.

The potential for direct and indirect reuse of wastewater increases in regions where municipal water supply problems exist. Problems of arid and semi-arid regions are obvious. Although southeastern coastal communities have ample rainfall, there are still many cities and towns whose demand for water exceeds conventional sources of supply. They include areas where ground water supplies are unable to keep up with demand because of depletion or salt water intrusion and regions where the cost of supplying water from distant sources will exceed the cost of purification for reuse. They may even include localities where, despite adequate water resources, the cost of installing and maintaining needed new water supply and sewage treatment facilities will be higher than the cost of building and operating a treatment plant for direct reuse alone.

Reuse for industrial supply appears to offer the greatest potential for the near future for increasing available water resources. Nationwide self-supplied industrial withdrawals of fresh water for process purposes totaled 46 bgd in 1965 while municipal withdrawals were only 24 bgd some of which also was used for industrial purposes. Replacement of slightly more than half of the industrial supply by reclaimed wastewater would have doubled the available municipal supply. In addition, steam-electric power requirements for cooling water were 63 bgd in 1965. With continued growth of cooling water use, it also offers a considerable market for future treated wastewater.

As development of natural water supplies becomes more expensive and as natural supplies become limited either totally or seasonally, reuse will receive greater attention. Also, as wastewater technology develops, decreases in cost, and becomes more widely known, advanced treatment of secondary effluent will have a greater utility for supplying high-quality water for industrial and municipal purposes.

In short, the reuse of treated wastewater is an alternative that should bear equal consideration to other alternatives for meeting future growth in water use.

OBSTACLES TO REUSE

Only economics seems to limit increased wastewater reuse by industry and agriculture. The technology to meet quality standards required by the majority of industrial and agricultural uses is readily available. Public acceptance is not a barrier.

However, reuse of wastewater for human consumption is beset with more serious problems which can only be briefly highlighted here. Okun (1975) has summarized these as follows:

> "If using polluted sources is uncertain, the direct reuse of wastewaters for drinking, being urged upon us by many, including dedicated environmentalists, may pose greater hazards. The benefits and protection afforded by (1) time in transit between the point of discharge of wastewaters and the point of recovery from the stream for water supply, (2) the dilution afforded by fresh water in the stream, and (3) the disinfection by sunlight, sedimentation, and natural biochemical degradation that takes place in natural water courses are not available where direct reuse of wastewaters is practiced.
>
> "Direct reuse of wastewaters for potable water supplies poses other problems:
>
> 1. Water and wastewater treatment plants that are now available or that are likely to be economical in the foreseeable future do not assure the complete removal of chemical contaminants that are likely to be present in wastewaters from urban centers.
>
> 2. The operation of these facilities is almost always below the design intention, particularly in smaller installations. Often the quality of the operators, their supervision by regulatory agencies, and the lack of investment in maintenance preclude efficient performance of treatment plants.
>
> 3. The technology for analysis and routine monitoring of potable waters is just not available to assure their continuous safety when they are drawn from highly contaminated sources.
>
> 4. *Fail-safe* technology for treatment and monitoring is not yet available.
>
> 5. The public is understandably reluctant to ingest its own wastes."

"The American Water Works Association, in a Policy Statement in 1971, indicated that the Association encourages an increase in the use of reclaimed wastewaters for beneficial purposes, such as industrial cooling and processing, irrigation of crops, recreation, and . . . ground-water recharge . . . current scientific knowledge and technology in the field of wastewater treatment are not advanced sufficiently to permit direct use of treated wastewaters as a source of public water supply, and it notes with concern current proposals to increase significantly both indirect and direct use of treated wastewaters for such (potable) purposes. Nothing since 1971 has indicated any basis for a change in this policy.

"The proponents of direct reuse, particularly the South Africans responsible for the off-cited facility at Windhoek, the capital of the territory of South West Africa, still the only direct-reuse facility in the world, claim that it is entirely feasible for such facilities to meet *Drinking Water Standards.* Such claims are misleading, particularly to the public. These standards, whether the 1962 PHS standards, the new standards now being promulgated by EPA, or the WHO standards, are all recognized as being inadequate in identifying organic chemical and virus limits, in part because of their uncertain health significance and in part because of the difficulty of monitoring for them. Instead of depending entirely upon *numbers,* these standards call for protection of the source with sanitary surveys to assure raw water quality, and they call for drawing supplies from the best available source. By definition, a wastewater treatment plant outfall cannot be considered the best available source, as in every instance, higher quality water is available even if in limited quantities only sufficient to meet drinking water requirements."

TECHNOLOGY*

An understanding of the processes and potential for advanced treatment and reuse requires, *first*, an appreciation of the primary and secondary wastewater treatment processes and, *second,* of the types of pollutants which can be removed only by advanced treatment.

Primary treatment consists of plain sedimentation for the removal of about 90 percent of the settleable solids from raw sewage. From 40 to 70 percent of the suspended solids are so removed.

Secondary treatment processes reduce the amount of organic matter in sewage through bacterial action, oxidation and synthesis. The most common methods are the trickling filter and the activated sludge processes. These processes, following primary treatment, typically remove 90 percent of suspended solids, 90 percent of bio-

*This section draws heavily on Gavis (1971).

degradable organics, 60 percent of non-biodegradable organics, 50 percent of nitrogen, 30 percent of phosphorus, and over 99 percent of pathogenic bacteria and viruses. Total unit treatment costs for this stage (including debt service) are typically 8 1/2 cents to 11 cents per 1000 gallons for a 10-mgd plant and 4 1/2 cents to 6 1/2 cents per 1000 gallons for a 100-mgd plant.

After secondary treatment, the following impurities usually remain in the effluent:

1. suspended and colloidal solids;
2. refractory organic matter that is resistant to biological treatment, such as pesticides, and the products of bacterial metabolism;
3. plant nutrients, principally phosphorous and nitrogen compounds;
4. dissolved mineral matter, such as sodium chloride and other mineral salts, all of which are present in an original water supply but are usually increased by use; and
5. bacteria and viruses, some of them pathogenic.

Suspended and colloidal solids are mostly poorly or non-flocculated bacterial cells, debris from dead cells, and extra-cellular insoluble products of bacterial metabolism. Suspended solids comprise only 20-30 percent of the total organic matter in secondary effluent (1) but account for most of the biodegradable organic matter present.

Refractory organic matter includes all organic material in solution which resists biological treatment. Most substances in this group have remained unidentified, but such materials as ABS detergents, pesticides, some organic compounds in industrial waste, products of bacterial metabolism, tannins, lignins, and other color imparting substances have been found. Generally, these are high molecular weight compounds. Estimation of concentrations are difficult to make and have not often been reported because of the lack of identification of the substances and the lack of standard measurement techniques that can give unequivocal and reproducible results (3). Secondary effluent contains an average concentration of 50 ppm of non-degradable organic matter (4).

Plant nutrients include organic phosphorous and nitrogen compounds. Phosphorous occurs in secondary effluent mainly as the phosphate ion. About half of it is introduced into wastewater as a constituent of detergents and other cleaning aids, but some appears as a product of the degradation of organic wastes.

Nitrogen occurs as ammonia, nitrate, and nitrite. Nitrogen is a constituent of organic waste matter and is released in the form of ammonia or ammonium ion upon degradation of the waste. Some of the ammonia is then oxidized and produces nitrite and nitrate ions. A small amount of soluble organic nitrogen may remain in secondary effluent as a result of incomplete degradation.

Inorganic substances are dissolved mineral matter in sewage and are not removed in conventional treatment plants. Usually, about half of the total mineral content originates in municipal water supplies; the remainder is added during use. Minerals occur in solution as ions. Although mineral content of water varies throughout the country, major ionic constituents in secondary effluent include sodium, potassium, calcium, magnesium, chloride, bicarbonate, sulfate, and silicate.

Ammonium, nitrate, nitrite, and phosphate ions, although classified as nutrients, are actually inorganic substances. If these are included, the total mineral content averages about 875 mg/l (compared with sea water at 30,000 mg/l)! In addition to the ions listed, smaller quantities of such ions as ferric iron, cooper, and zinc occur. Also, waste from industrial processes may contribute relatively large concentrations, in particular instances, of other less widely distributed metallic ions.

Secondary treatment removes most of the pathogenic bacteria in wastewater. Those that survive are a potential hazard in secondary effluent, but known techniques of disinfection are capable of removing the hazard. Although the activated sludge process can remove as much as 90 percent of the pathogenic viruses in wastewater, those remaining constitute a potential hazard which disinfection by present methods may not be able to cope with satisfactorily.

The technological problem in wastewater reuse is the reduction of the concentrations of the contaminants to acceptable levels, at a cost commensurate with the cost of alternative water supplies. Despite the fact that the total concentration of contaminants is usually less than 2000 ppm in secondary effluent (i.e., the water is more than 99.8 percent *pure*), separation of the contaminants is not a simple process. No process has yet been devised which is able to remove all of the contaminants in a single step economically, at the flow rates encountered in practice. At the present time it is necessary to apply a series of successive processes, each specific for a single group, or at most for two groups of contaminants.

The residual suspended and colloidal solids that remain after secondary treatment can be removed by any of several filtration methods, at the relatively low costs of one cent to two cents per 1000 gallons. It would also remove non-soluble biodegradable organic impurities.

The principal plant nutrients in secondary effluent (phosphate, nitrate, and ammonia) induce algal growth. Upon death, the algal cells become food for the bacteria which consume the oxygen dissolved in the water and so may produce septic conditions. The nutrients can be reduced by chemical processes to concentrations that will prevent growth stimulation, at a cost of about 14 cents and 8 1/2 cents per 1000 gallons, for a 10-mgd and 100-mgd plant, respectively. Suspended solids are removed at the same time.

Non-biodegradable (refractory) organic matter can be reduced to the very low concentrations present in natural water supplies by adsorption by activated carbon for a cost of about 10 cents and 7 cents per 1000 gallons, for a 10-mgd and 100-mgd plant, respectively.

Pathogenic bacteria can be removed by chlorination at a cost of less than one cent per 1000 gallons. Viruses are removed in large part by the secondary and advanced treatment processes, but there is considerable difference of opinion as to the degree of hazard that remains after the treatment processes are completed. The consensus seems to be one of extreme caution--most scientists agree that it has not yet been proven that a hazard does not exist. However, some sanitary engineers and health officials have expressed the opinion that the probability of virological hazard is low. Ozonation is another alternative.

Dissolved mineral concentrations may be reduced from about 850 ppm to the Public Health Service drinking water standards of 500 ppm by electrodyalysis, for an additional cost that is in the order of 12 cents per 1000 gallons. Other methods also are available; e.g., ion exchange, reverse osmosis--at a higher cost. Present technology limits this process to a plant size of 10 mgd.

In considering the costs of advanced wastewater treatment, it should be recognized that many of the processes used in advanced waste treatment (such as sedimentation, coagulation, filtration, chlorination, activated carbon, aeration and demineralization) also are used, to varying degrees, in treatment of alternative sources of water supply with which reuse should be compared. Thus, it is not simply a case of comparing the cost of advanced treatment for reuse with the cost of an alternative means of physically supplying water; they must be compared on a common basis. If the alternative water supply source includes treatment, the treatment cost must be added to it to compare with a reuse source. Similarly, of course, any cost of conveyance to bring a reuse supply to a common point with an alternative source must be included in the reuse cost.

It is quite conceivable, therefore, that the *net* cost of advanced treatment to make water available for reuse will be quite small. Other than a desalting alternative, most alternatives to reuse will incur significant treatment costs, which must be added to the alternative cost to compare it with the purified supply made available by advanced waste treatment. In effect, then, the net advanced treatment costs are equal to its total costs less the treatment costs of the alternative supply, plus or minus any difference in conveyance costs to bring alternative supplies to a common point.

The status of wastewater technology is summarized in Table 2.

The 7.5-mgd plant at South Lake Tahoe, California, exemplifies the capabilities of present technology for removal of contaminants from secondary effluent. It consists of an integrated series of processes which, being complementary to each other, maximize the effectiveness of each process and thereby reduce costs. Each process, individually, may eventually prove not to be the most desirable one for removal of a particular type of contaminant, but the plant illustrates what can be done at today's level of technological development.

At South Lake Tahoe, secondary effluent is subjected to two-stage lime precipitation for the removal of suspended solids and phosphate ion. Ammonia is removed by air stripping between the

Table 2

STATUS OF TECHNOLOGY FOR REMOVING COMMON CONSTITUENTS OF WASTEWATERS
(After Sawyer, 1972)

Constituents	Processes	Status			Percent removal	Cost ¢/1000 gal.
		Common practice	Established technology	Development technology		
Coarse Solids	Screening	X			90	0-5
	Comminuting	X			--	0-5
Suspended Solids	Sedimentation	X			60	0-5
	Flotation	X			60	5-20
	Coagulation & Floccula.		X		80	5-20
	Microstraining		X		60	0-5
Soluble Organics	Stabilization Basins	X			50	0-5
	Activated Sludge	X			60	5-20
	Trickling Filter	X			60	5-20
	Aerated Lagoon	X			50	5-20
	Anaerobic Contact		X		50	20-40
	Activated Carbon		X		70	20-40
Oils	Gravity Separation				95	0-5
	Air Flotation	X			90	5-20
	Adsorption	X			30-80	5-20
	Filtration	X			90	0-5
Acids, Bases	Neutralization	X			99	5-20
Bacteria, Viruses	Chlorination	X			99	0-5
	Irradiation			X	99	5-20
	Ozonization			X	99	0-5
Fine Suspended Solids	Coagulation & Floccula.		X		70	5-20
	Filtration		X		70	0-5
	Microstraining		X		60	0-5
Ammonia	Nitrification		X		90	5-20
	Stripping		X		85	5-20
	Chlorination		X		99	5-20
	Ion Exchange			X	90	5-20
Nitrogen	Denitrification			X	85	5-20
	Ion Exchange			X	90	5-20
	Algae Ponds			X	50-80	5-20
Phosphorus	Precipitation		X		95	5-20
	Ion Exchange			X	90	5-20
	Biol. Uptake			X	30	5-20
Trace Organics	Activated Carbon		X		95	20-40
Soluble Inorganics	Electrodialysis		X		90	<40
	Ion Exchange		X		90	<40
	Distillation		X		95	<40
	Reverse Osmosis		X		90	<40
	Precipitation		X		20-95	5-20
	Freezing			X	80	<40
	Liquid-Liquid Extract.			X	80	<40
Heat	Evaporative heat Exch.		X		70	5-20
	Reservoir		X		70	0-5
	Non-Evap. heat Exch.			X	70	20-40
Sludge Dewatering	Coagulation & Floccula.	X			--	5-20
	Flotation	X			--	0-5
	Thickening	X			--	0-5
	Evaporation	X			--	0-5
	Centrifugation	X			--	0-5
	Vacuum Filtr.	X			--	0-5
Sludge Reduction	Aerobic Digestion		X		--	0-5
	Anaerobic Digestion	X			--	0-5
	Wet Oxidation		X		--	0-5
	Incineration	X			--	5-20
	Calcination	X			--	5-20
Ultimate Disposal	Marine				--	0-5
	Land				--	0-5
	Air				--	0-5

FROM: Sawyer, G. A.; "New Trends in Wastewater Treatment and Recycle," Chemical Engineering, pages 120-128. (July 24, 1972).

stages. The lime is recovered upon calcination of the precipated sludge. Some of the recovered lime is sent to the primary treatment plant with fresh lime used as make-up in order to prevent calcium phosphate build-up. The carbon dioxide produced is used in the second-stage precipitator. After filtration in continuous gradation, mixed media filters, the effluent is passed through activated carbon adsorption columns to remove refractory organic matter, and discharged after being chlorinated. Actually, the final effluent is not discharged into Lake Tahoe but is pumped 29 miles to Indian Creek Reservoir to be used for irrigation and eventually for creation of an artificial lake for recreational use involving body contact sports.

The capital cost of the 7.5-mgd South Lake Tahoe plant, exclusive of the cost of engineering studies and of land, was about $3 million; operating costs of about 13.4 cents/1000 gallons were incurred as of May 1969.

PUBLIC ACCEPTANCE

Public acceptance of the concept of reuse for potable water supply will be a major obstacle. Some experiences in this area indicate that acceptance was obtained when the need became acute. The emergency experiences in Chanute, Kansas, and Ottumwa, Iowa, cited earlier are indicative. So, also, is the continuing experience in Windhoek, South West Africa, and the plans that are being made in South Africa for additional installations. Plans underway by Denver, Colorado, also indicate a belief that public acceptance can be won.

On the other hand, the long history of fluoridation battles, the current concern with carcinogens in water as exemplified by the New Orleans controversy, increased *consumerism,* and bureaucratic *timidity* as illustrated by the ocean outfall discussions at this meeting indicate more opposition than many reuse *enthusiasts* may suspect.

The question of risk to human health is the major obstacle to widespread acceptance and use. If we do not *have to* drink reclaimed sewage as in desert areas such as Windhoek, prudence would seem to indicate a *go slow* approach pending resolution of some of the basic health-related questions and the development of *fail-safe* technologies.

Partial reuse--i.e., reuse for purposes other than drinking--is an idea whose time has already come. Reuse by industry and agriculture will *stretch* the current supplies and, thus, indirectly affect the human consumer.

REFERENCES

1. California Department of Water Resources, "Waste Water Reclamation, State of the Art," *Bulletin No. 189*, 43 pp., March 1973.

2. Clayton, R. J., "The Water Reclamation Works at Windhoek (South West Africa)," *Aqua*, No. 3, pp. 14-18, 1972.

3. Gavis, Jerome, "Wastewater Reuse," *Report NWC-EES-71-003*, National Water Commission, Arlington, Va., 161 pp., July 1971, Available from National Technical Information Service, Springfield, Va.

4. Koenig, Louis, "Studies Relating to Market Projections for Advanced Waste Treatment," *Publication No. WP-20-AWTR-17*, U. S. Federal Water Pollution Control Administration, Cincinnati, Ch. 2, 1966.

5. Mullër, W. J., *Re-Use of Waste Water in Germany,* Organisation for Economic Co-Operation and Development, Paris, 29 pp., 1969.

6. Okun, Daniel A., "A Potential for Water Reuse - Dual Supplies," Paper presented at American Water Works Association Seminar on Water Reuse, Minneapolis, Minn., 12 pp., June 8, 1975.

7. U. S. Water Resources Council, *The Nation's Water Resources*, U. S. Government Printing Office, Washington, D.C., p. 4, 1968.

SUMMARY: TECHNOLOGICAL ALTERNATIVES FOR WATER SUPPLY AND WASTEWATER DISPOSAL IN THE COASTAL AREA

Billy L. Edge
Associate Professor
Department of Civil Engineering
Clemson University
Clemson, South Carolina

Introduction

The title of this paper is somewhat misleading. I do not pretend to offer you a simple chart listing all of the technologies available for water supply and wastewater treatment for the Coastal Zone along with a unit cost for each. Instead, my charge in this paper is to discuss those alternatives that have been suggested by the previous speakers and perhaps to go into some additional possibilities that have not been mentioned from a conceptual view. I will feel free in this presentation to make a point to refer to the previous papers whenever appropriate.

In October a year ago, the famed ocean explorer Jacques Yves Cousteau testified before the Oceans and Atmosphere Subcommittee of the Senate that unless man acts and acts quickly, not only will the oceans be dead in 50 years but so will you and I. We can certainly not disagree that man is closely intertwined with life in the sea. Cousteau continued to state that from his own observations life in the oceans has diminished by as much as 50 percent in the past 20 years. According to his testimony, there is only one kind of pollution because every single chemical whether in the air or on the land will end up in the oceans. What is flushed into the harbor at Rotterdam or even Minimata Bay will end up on the shore of Wrightsville Beach. DDT and herbicides which have been washed out of Iowa fields can be traced down the Mississippi into the Gulf, into the food chain, and even into the tissue of the Polar Bear in the Arctic and the tissue of the penguin in the Antarctic.

The author, anthropologist and movie maker Thor Heyerdahl, has also testified before the same Senate subcommittee concerning the vast amount of *filth* stretched across the Atlantic Ocean which he saw when he crossed in the *Ra II*. Imagine, if you will, a solid stretch of polluted water all the way from Morocco to Barbados.

Now I know that our job at this meeting is to study the technical aspects of water supply and wastewater disposal in coastal areas. Nevertheless, I want to impress upon you the importance of considering the global aspects of ocean pollution and in dealing with our coastal areas. Engineers, scientists, and laymen alike must begin to look at pollution as a whole. This is the obstacle we must face, and the sources of our troubles in this area are insidious and diverse; they include: domestic sewage, agricultural runoff, industrial wastewater, oil spills, thermal discharges, dredge spoil, and radioactive wastes.

The solution to all disposal in the coastal zone could be recycling. Most probably, this will notbe the optimum (in some sense of the term) for all waste disposal operation. Rather, for some wastes it maybe best to seek ocean disposal techniques that cause very little or minimal damage to the ecosystem, and that ecosystem includes you and me. The problems of controlling ocean disposal are very broad in scope and require the interaction of many disciplines (and agencies) before adequate solutions can be posed to the decision makers. As I see it, you and I have a very important role in the solution of these complex problems.

So far in this symposium the feasibility of ocean disposal has been discussed much more in depth than any other form of disposal. The arguments given on both sides have been generally quite sound and are making the decision process much more difficult. I say this in spite of the negative approach EPA is taking according to the earlier presentation by Mr. Hopkins. There are other groups in EPA who do not consider this subject as negatively as does Region IV. For example, Robert Dean of the Ultimate Disposal Research Program of EPA said:

> "Disposal to the ocean takes advantage of the hugh dilutions available and is often the best method, considering all alternatives. For example, sodium chloride, calcium chloride, and magnesium sulfate brines will be undetectable against the natural background of these salts in the ocean--even hydrochloric acid can safely be diluted in the ocean--whereas since these substances are water soluble and cannot practicably be converted into solid precipitates, their disposal on the land or into fresh waters is highly objectionable."
>
> Between the obvious perils of mercury and the obvious safety of sodium chloride, there is a vast range of substances whose candidacy for disposal in the ocean is not so clear-cut. General organic wastes that settle to the bottom, including garbage, will be decomposed by marine bacteria. Iron salts will form ferric hydroxide minerals, which are already present in ocean sediments along with many other minerals. The key to safe disposal of such substances is control of quantity. "Certain nutrients, both organic and inorganic may be beneficial in increasing the harvestable crop from the ocean, and in colder waters thermal wastes may also be useful."

While there has been very little work on the effects of sludge and dredged spoil disposal at sea, sewer outfalls have been carefully investigated, and these studies point to the rather surprising conclusion that such outfalls if properly designed do not constitute serious threats to the environment as some would have us to believe. The Hyperion Plant in Los Angeles is a good example of this. Dr. Brown mentioned that this morning.

In a recent issue of *Civil Engineering*, Harvey Ludwig was quoted as saying:

"We could be making a colossal mistake in pouring billions of dollars into upgrading waste treatment plants in our coastal cities. Many of the large cities of the world are located close to oceans. Typically, their waste treatment plants dump effluents into estuaries and bays. Yet, the really critical ecology, the most productive areas on earth for synthesizing living matter, are precisely in these estuaries, bays, and shallow waters (less than 100 ft.) along the sea. The oxidizing capacity of ocean is vast. Thus, there is no sense in wasting money to remove organic materials to reduce BOD. Because traditional design is geared up to remove BOD, civil engineers blithely copy the same old thing."

On the other hand, Donald O'Connor of Hydroscience has cautioned, "Why spend millions on a pipeline only to find out we're doing damage out there? Is the ocean really an infinite sink?" This is a point well taken and one which emphasizes that engineers and scientists know pitifully little about the impact of wastes on the marine environment. This point also adds importance to the comments of Wicker yesterday; i.e., should the economic life, and consequently the productive life, of a disposal scheme and consequently the life of a bond issue be ten years (or 1985-1975)?

Let me now address a remark made yesterday by Colonel Paul Denison and others. There is, indeed, a major amount of money allocated to 208 and 201 studies of the coastal areas. Where does this manna come from--heaven? No, it comes from your pocket and mine. The question asked yesterday was, "Will EPA provide additional money to do the baseline field study and all the monitoring studies that will be required according to Mr. Hopkins' remarks?" They are going to be spending excruciating sums of your money to make these studies possible to obtain information which in some cases is of questionable value. For example, EPA wants settling rates. Settling rates of what? Moreover, are these again to be the traditional settling rates of the wastewater suspended solids as determined in distilled water so that it can be related to an equivalent size of round quartz or will they be conducted in saline solutions indicative of the water chemistry at the site? This small difference may affect changes in answers on the order of a factor of 10 or 100. What will be done with this data once it is presented to EPA? Will they throw in some magic factor to account for turbulence, concentration and pycnocline to predict where the material will go? Even if this data were available, would they have been able to predict the observed movements of the taconite tailings from Reserve Mining Company or the internal surface slicks from the acid disposal of National Lead on the pycnocline that moved out of the disposal area? I concur with the need for detailed information on fiddler crabs, polycheates, and featherduster worms, but I remain uncertain just how this information can be properly evaluated.

At the 1972 Coastal Zone Pollution Management Symposium in Charleston, South Carolina, Erman Pearson of the University of California said:

"Today there is no significant scientific basis to support the arbitrary upgrading of all open coastal primary treatment plants having effective outfall dilution-dispersion systems to secondary treatment. The cost-benefit ratio or cost-consequence of such action appears to be extremely high. Expenditures of such magnitude likely could have more profound and beneficial effects on the local ecology if they were expended in determining in the field the significant and currently undocumented pollution problems of concern. This would insure that future expenditures for waste treatment would deal with the substantive problems rather than perpetrating tradition at the expense of the environment."

Let us turn from surface disposal to subsurface disposal. Dr. Humenik did an excellent job this morning of showing us just how successful certain projects for land disposal can be. He did not, however, allude to any failures that others may have been associated with. Now his suggestions may well be appropo on the mainland, but I would question their use on high-priced ocean frontage except on golf courses. Surface land disposal was considered at North Myrtle Beach and found to be infeasible. However, treated sewage is to be transported to the mainland and land owned by International Paper. Lastly, I understand that a very large-scale application of municipal waste in Michigan is not considered healthy by the local people.

Mr. Turnage offered the personal opinion that the major reason for high fecal coliform in shellfish areas is due to indiscriminant use of septic tanks. I will have to take exception to the application of that on a broad basis. In particular, I am thinking of the Charleston area.

What about deep-well disposal? A good argument has been given for this practice in many situations although specific criteria are not really available. Allow me to refer to a recent article in *Science* which provided a convincing argument that some of our food additives may be responsible through the aid of lengthy residence times (i.e., if we don't eat enough bulk to push food through our system more rapidly) for creating complex compounds that have been linked to cancer. Now it is logical to ask the question, "What will be the effect of high pressures and long residence times on these wastewaters which are injected into deep well whether treated or not?" Will new long chain chemicals be produced that may be considered very detrimental to human life not to mention the rest of the ecosystem. Now let's add one more complication, some of many aquifers (we really don't know which) emerge at some place, maybe (most likely) the ocean. If this situation has any possibility of actually occurring, however remote, can we afford to ignore it?

Conclusion

"Remember the bologna sandwich on the Alvin." How many times will we be reminded of that sandwich which went down with the research submarine Alvin and was lost for a year. You probably recall that the sandwich and a thermos of tea was recovered with the Alvin after laying at 900 feet for nearly a year and that the sandwich, though soaked throughout, was still edible. "Why didn't the bacteria destroy the sandwich as they would in open air?" is the question that has been raised so many times by biological oceanographers. Certainly, there are secrets of the oceans which we will never unveil; but why must we be blinded by that veil? We must make decisions on the basis of what we know instead of what we don't know.

QUESTIONS AND DISCUSSION

QUESTION: (Mr. Leo Ormiste) Considering the facts and figures we now have in the field of water supplies and wastewater disposal in coastal areas, how good an indicator is the coastal zone of the well being of the ocean and the mainland?

MR. BILLY L. EDGE: In reports done by Skidaway Institute of Oceanography about a year or so ago, they were looking for mercury concentrations in the ocean, and there they were noting that the mercury concentrations behaved exponentially as one went out towards the ocean. The conditions in the Savannah estuary indicated much more severe state of affairs than were actually apparent when one was 20 miles offshore. You consider that concentrations there were undetectable compared to what was coming down the estuary, and I think that the estuarine zone in that case was not such a good indicator. We've heard earlier this afternoon that the organism that lives in the delicate balance that exists in the estuaries is much more delicate than that in the ocean. In the ocean, the critters are very able to get along with large changes in temperature, large changes in chemical composition, and large changes in turbidity. They seem to be able to adapt themselves pretty well. In the estuaries, it's not the case. The instability there can come a lot quicker than in the ocean.

QUESTION: (Professor David H. Howells) I'm not a biologist, but I'd be a little concerned about depending too much on decay, as such, unless I knew what was going on in the biological system. It just could be that uptake is occurring and materials are moving into the life system. I think one would have to know not just what was in the water but also what was in the whole system. It could be more troublesome than a solution, could it not?

MR. BILLY L. EDGE: Yes, sir; I'll agree with that, and I'll also agree that probably all that uptake is done by organisms in the estuary or near the estuaries and not 20 miles out.

QUESTION: (Mr. Frank R. Reynolds) You are associated with the facilities plan in the Grand Strand area where there is a peak population now of approximately 300,000 people, and it is projected to go to about 500,000 people in the next 20 years. The study there shows that it's better to dispose of the treated wastewater into a coastal waterway canal than to go to ocean outfall. The study at Wrightsville Beach with a volume projected to be 1.3 million gallons per day shows it to be more cost-effective to go to an ocean outfall rather than to discharge to an estuary. It would seem that those two results were sort of contradicting each other because it would seem that the more volume you had the more the ocean outfall would be cost-effective. Could you comment on what you know about the situation and what your feelings are concerning ocean outfalls?

MR. BILLY L. EDGE: I'd be glad to. This is my first chance to make an official statement on that. I suggested to the contractor working on that plan for the State that they consider the feasibility of an ocean outfall. They went back to the office, and the next morning they called me and said, "Okay, we've thought about it." That's the tentative comparison you can draw between the situation there and the situation here. They thought about it down there; up here, they did the calculations.

QUESTION: (Mr. A. C. Turnage to Professor McJunkin) What is your feeling about the possibility of ball contamination with domestic sewage used on golf courses? Land disposal in an unoccupied area is one thing; land disposal in an area habitually used may be something else. Would you comment?

PROFESSOR F. EUGENE MCJUNKIN: It's not my field, but I'll comment just the same. I wouldn't worry about it if it were done under prescribed conditions, the timing were good, and under proper weather conditions. This has been discussed in connection with the land disposal meeting that Dr. James Stewart and Dr. Frank Humenik and others organized in Raleigh about two months ago. Frank, could you comment on that?

DR. FRANK HUMENIK: I think everyone appreciates the need to be concerned about public health and to be very cautious about the disease potential of aerosols; but if we become too obsessed with airborne pathogens or viruses and emphasize the hazard so much that we neglect practical and historical evidence, the utilization of land disposal systems will be severely hamstrung and possibly for little justifiable reason. Chlorination can always be exercised prior to land irrigation of wastewater as need dictates; but to universally require this technique could represent unwarranted expenses and have an inhibiting effect upon the soil-plant microflora mandatory for waste stabilization.

By means of an example, I would like to re-emphasize points made earlier concerning whether the hydraulic or process load would limit terminal land application and correspondingly the applicability of our work on concentrated wastes to very dilute wastewaters such as domestic sewage. A wastewater flow of 27,150 gallons/day, which equals one acre inch, would be a very convenient hydraulic load. Assuming a nitrogen concentration of 10 ppm, the pounds of nitrogen to be handled per year would be $27{,}150 \times 365 \times 10 \div 10^6 = 900$ lbs. Pasture fertilization recommendations for fescue grass are 400 lbs N/acre/year and about 600 lbs for coastal bermuda; therefore, approximately 2 1/4 acres of fescue of 1 1/2 acres of coastal bermuda pasture would be required to accommodate this nitrogen load. The hydraulic load of 27,150 gallons/day or one acre inch/day would require 7 acres if the plant-soil receiver system could accommodate one inch/acre/week. In this situation, land disposal is limited by the hydraulic load because about 7 acres are necessary to assimilate the liquid and only about 2 acres for the waste nitrogen. Assuming that the hydraulic application could be increased to 2 or 3 inches/acre/week, then the hydraulic and process load would be matched, and such system optimization would result in minimum acreage requirements. If the nitrogen content would increase to about 100 mg/l, then about 15 to 25 acres would be required. This would far exceed land required for the hydraulic load. In this case, degradatory pretreatment pursuant to nitrogen removal would be appropriate to allow a more equitable matching of the acreage required for both the process and hydraulic load. Therefore, for weak waste such as domestic sewage, the hydraulic load generally limits; and thus, minimum pretreatment is required while for stronger industrial and agricultural-type waste the process load generally limits and degradatory pretreatment helps reduce the acreage required for terminal land application when disposal rather than utilization is directive.

DR. B. L. CARLILE: I would like to get back to the comment that Mr. Turnage and Mr. Edge made earlier about applying wastewater to our coastal soils and sandy beach soils. Dr. Humenik alluded to this problem a little bit this morning. The activity and the treatment aspects of soils really occurs near the surface. This is especially true for the deep sands we've got. If you examine one of these deep sands, you'll find all the activity is near the surface in this rooting zone in the upper 6 to 8 inches. This is true for all soils but even more so for these sandy soils. What we are doing in the Outer Banks is putting wastes three feet below the surface. We are using septic tanks with nitrification fields three feet below the surface and below any activity in the soil. Getting back to this question, is it better to put it on a golf course or put it in a septic tank in nitrification fields? If we're trying to get the maximum treatment, trying to balance the capability of a soil with the water, we would be far ahead by putting it on a golf course, at least putting it up on the surface.

How much land is needed will depend on the capability of that particular soil and the characteristics of that wastewater. We need to get it near the surface where we have the maximum capability for treatment. Nearly 95 percent of the treatment for nutrients, bacteria, viruses, and organic compounds occurs in the top foot of soil. This is really critical in these sandy soils where you don't have any activity down in the 3-foot level.

Getting back to the question on some of the failures that we've had, yes, we've been observing land disposal systems in this State and in adjoining states. There have also been surveys made of systems in west Texas and California. There have been failures and for the reason Dr. Humenik alluded to. Failures occur when people designed systems without understanding the capabilities of the land. They were trying to design a system in west Texas based on information that was gathered in Michigan or they tried to design a system in North Carolina based on information that was gathered in Texas, and it doesn't work. I think that we have more information on the soil and the type of systems we can design and could operate successfully on land application than we do on many other types of systems including ocean outfalls. There is a lot of information that has been gathered from observing land application systems that have been in operation for 30 or 40 years. We do have a great deal of information, and I think if we know what's in the waste and the characteristics of the land, then we can design a system that will operate successfully most of the time.

PROFESSOR F. EUGENE McJUNKIN: Let's go back to the question of viruses and having to have absolute certainty to prove something. In anything we do, there is a hazard. It infuriates me to hear a regulator, whether he's in Human Resources or EPA, standing with a cigarette in his mouth, inhaling it, and telling me that he has to be absolutely certain about advising on spray irrigation of golf courses, advising someone else when he's puffing away on his lung cancer. I am serious, though. With many of these ideas, we should point out that they have been around a long time. There are the questions in land application and the aerosol transport of viruses into the atmosphere and how far they are transported. We've gone for years and years with virtually no attention to the activated sludge aeration tank which is spraying out an unchlorinated aerosol. That has been around a while, and we accept that. The question is how much absolute certainty can we pay for and how much of a risk can we take. Anything in life is a risk. I haven't noticed many steel umbrellas stacked in the corner today. When you walk out to your car, you may be hit by a meteorite; you have to be ready. This has happened seven times in the history of the world. It becomes easy for a bureaucrat to hide behind making a decision for some of these new outfalls or for land application. He is making the decision by making no decision. Wrightsville Beach cannot wait five years for perfect information, much less pay for it. They've got to get this permit. You can never be criticized for making the conventional decision. On the other hand, if Wrightsville Beach invests millions of dollars in this outfall and it doesn't work, it has a crushing weight of bonded indebtedness. There may be people like swine processors, chicken producers, and other industries who may run the risk a little more than public services and pioneer these efforts. Maybe we can find an industry on the Carolina coast that can set up an ocean outfall.

COMMENT BY MR. SAM MORRIS: I believe the failure which was referred to earlier was actually from cannery wastes where an operator had left a valve open. In that instance, you had a personnel failure rather than a failure in the process itself.

DR. PETER ASHTON: I'd like to commend Gene just now for that comment on rationality in decision making. I'd like to make one comment with respect to deep-well injection which we were talking about earlier. First of all, in the hundreds and hundreds of examples that there are of deep-well injection in this country, I think there's only been about two failures. So we've got the same kind of argument going here again. We have to make the decision one way or another, and sometimes you can't make the decision with absolute certainty. The two examples you hear of are the Denver and the Pennsylvania situation, which were from engineering misdesign and nothing else. Also, one should not forget or overlook the potential of deep-well injection in terms of occupying groundwater. Simply writing off an aquifer as a social objective and using it as a disposal area might have a higher and better use in a disposal area than it has for a groundwater supply area. These things should perhaps be recognized and not come to any hard and fast categorical decision about blanket denial of deep-well injection as a system of disposal.

MAN DISCOVERS THE COASTAL ENVIRONMENT: A FOOTPRINT IN THE SAND

James C. Wallace*
Professor
University Studies
North Carolina State University

Some four hundred years ago, the English and Spanish were exploring such shores as the one on which we sit tonight, finding this fringe of the new world, in the words of North Carolina's *Lost Colony*, to be the "goodliest land beneath the cope of Heaven."

Giant trees extended to the water's edge. Clear water was abundant, suitable as habitat for Hiawatha's celebrated sturgeon, which moved its fins "on the bright sandy bottom" of those pristine sounds and rivers; and through the clear air the birds of the sea's margin wheeled and cried.

As the years passed, the great forests became boats from which to fish along the shore; the dunes disappeared; and the restless, unending wash of the sea took the sand to the southwest.

And now we return to this fragile strip of sand, to the most youthful portion of the continent whose birth was as recent as five thousand years ago. But this time, unlike the first, we come to it from the *land* and not from the sea; and instead of that great original purity, we find evidence that we have been here before. Many of our kind have preceded us and have left footprints--and much else--in the sand.

The sounds are lined with septic tanks and grow more nutritious every day. The slender bubble of fresh water that rises so perilously atop the saline ocean below is in danger of irremediable contamination as health department officials sow several crops of these permits each year, much in the manner of an infamous sale of indulgences long ago. The wastewater from this dinner, and what has preceded it, will enter an overloaded system which operates at the sufference of the State.

The consequences of lack of planning, of poor planning, and of excessive multiple-use planning are everywhere. Consider the coast of North Carolina alone, remembering that much the same thing can be said for the other states represented here. One enters the State by passing through a wildlife refuge on the way to Currituck, an area now being developed. South of this still natural area lies the Kill Devil Hills-Nags Head complex over twenty miles in length with vast summer populations--an area *with* a water system and *without* a wastewater system. Beyond lies Hatteras Island where roads are breached by every major storm cycle, and improperly located motels are swept away amid great clamor for public assistance. Morehead City sports a major terminal and continual maintenance dredging. Bogue Banks is naked, its brush cover having been ripped off, and its phalanx of

---

**Note:* Banquet speaker on April 3.

trailers awaiting the first hurricane to sweep them away. Topsail Beach and Surf City are trailer and sepsis ridden, and subdividers plan homesites where water from a major high tide will lap against the doorsteps. Open Grounds, Inc., a 46,000-acre Italian-owned super cattle farm, proposes to drain the area of its fresh water and discharge it into the South River which is brackish and currently classified for shellfish. (Which shall take precedence--the shellfish or the cattle?)

Wilmington, like Morehead, is a major terminal; and its beach area, Wrightsville, this very spot, is a mecca for tourists. Many stay at this place, the Blockade Runner, where once the old Ocean Terrace stood. Others stay at the Holiday Inn which is built upon the site of a closed inlet and which, by all rights, should be known as the Holiday Inlet for surely the inlet will come again! At Southport, there stands the greatest obscenity of all--the Brunswick Nuclear Power Reactor whose ominous, bulbous concrete containment vessel protrudes awesomely above the natural cover of undulating marsh grass. Below its concrete bottom lies the Castle Hayne aquifer, water supply for much of the Carolina coastal region. By its condensers wends a huge canal and a diversion of the Cape Fear River to cool its core. Soon it will start up; and thus, will Uranium, heat, water, and biota be nearly conjoined, co-existing in a state of perpetual tension and unease representing still another casting of the dice in our on-going Faustian Bargain with Nuclear Energy and still another and supererogatory genflection to the bloated fetish of multiple-use which bestrides us like a colossus and would-be god.

And all the while the fishermen, fin and shell, ply their ancient trade even as the vital marshes are drained, land is sucked into existence from bottoms, pumps lower water tables, coliform counts close shellfish beds, swamps go dry as hardwoods fall, and excess nutrients and obscure pesticides percolate at great removes.

Offshore there lies still another great resource which has not yet been addressed. North Carolina has 14,000 square miles of continental shelf. Already great pressure is beginning to build for its exploitation. Possible plans include offshore drilling, dumping, sewage outfalls, mining, and offshore nuclear plants--all of these items in addition to continued use by commercial and sports fishermen and sports divers who already use the shelf extensively.

Thus, by way of introduction, I have painted a picture of coastal contradiction and confusion; and I insist that what we do in the future must transcend in both power and concept what we have done thus far.

Emerson in his Phi Betta Kappa oration entitled *The American Scholar*, remarked that "public and private avarice make the air we breathe thick and fat. The scholar is decent, indolent, complaisant. See already the tragic consequence. The mind of this country, taught to aim at low objects, eats upon itself." This call for leadership, made at Cambridge in 1837, possesses an even greater urgency today.

If we are to save the coastal environment,or any environment for that matter and Man along with it - then, it is clear that we must have a great deal of planning. It is also clear that our planning must be of a kind quite different from the inadequate process which is currently masquerading as planning. (Please bear in mind during the remainder of these remarks that I speak not as an unloving critic nor as an uncritical lover but as a loving critic who is acutely impressed with our collective tardiness and with the great damage, the irreversible damage, which has already been done.)

When Emerson was speaking, the city was an island in the forest. In our own time, the forest is becoming an island in the city whose fringe skirts the sea. This sobering circumstance is both a measure of how far we have gone in urbanizing America and a warning that our natural bounty has precise limitations associated with it.

So it is that we must have planning. And planning we have, at least in name. Towns and counties have planning boards. Regional councils of governments have planning staffs. States have planning departments. Everywhere one looks, in fact, there are planners. The word *planning* has in recent years experienced a tremendous vogue, and the word *ecology* though suspect by some (especially in a period of economic recession) emerges as a good word to be dropped in the right places.

At a recent public hearing in a nearby town, a developer--well-fed and prosperous in appearance--after having finished his usual spiel added a wholly unexpected filip by proudly announcing that his subdivision would not damage the ecology of the area. The planning board involved was thunder-struck. Whatever the motivations, and I don't think we should bother with such obscure items, many people are now speaking the language of planning, most of them for the first time.

Unfortunately, planning, as it is now practiced, is, at worst, a false prophet and, at best, a rationalizer of an unplanned world. Today's zoning ordinances and subdivision regulations, boards of adjustment and all the rest, represent the application of a set of rational procedures through the use of which a feeling of local security can be generated. The hidden parameters which lie beyond these exercises are seldom glimpsed and never tackled.

No city, no region, and no nation can ever be planned unless one first knows how many people will live there and the type of existence they would identify with the good life. To attempt piece-meal jerry-building in the name of planning while one is hooked to an uncontrolled Gross National Product--the crudest measure of quantity yet to be employed by mankind--and to an ascending population with ascending appetite to match is to dream the fatuous and to indulge in the irrational.

Yet, this is precisely what we do: first, we project a population increase. This is the most important unplanned parameter. Then, we make certain economic assumptions. This is the second unplanned parameter which is closely connected with the first. We then take the space available within the jurisdiction and distribute the people therein. Finally, we connect it together with a sufficient number of sewer pipes, provide a water supply and utilities including wastewater disposal, dot the map--between clusters of development--with green streaks of open space, and presto! The *plan* is finished. Or, more accurately, the *plan* is started. The chances are astronomical against its ever being finished.

Why is this so? Never have we had so many planners. Never have we needed so much planning. Why, then, if the need is so acute and planners so plentiful don't we resolve some of our more pressing crises? The answer, alas, is that the planners are, after all, only servants. They propose, but the appropriate decision-makers call the tune. Thus, it is that a local planner is quite pleased if he is successful in getting a small fraction of his latest *20-year plan* implemented by the board which pays his salary. More often than not the 20-year projections are briefly discussed and then filed and forgotten.

What we are now hailing as progress in the field of planning is merely the averting of disaster and gaining another day during which serious planning can be put off. Despite the platitudes to the contrary--whether they are calling for city planning, regional planning, state, national, global or inter-galactic planning--despite such protests, and I think that we are beginning to protest a little overmuch, it is still clear that we don't want real planning. Rather, what we are really talking about is *accommodation* in the cheapest way possible to the wholly unplanned parameters of growth and greed.

What we are pleased to call planning is only action in the microcosm, the essentially small-change rationalizing of a worsening situation which was brought about or is being brought about by forces over which we have no control. We must realize that zoning and subdivision regulations, however brilliantly drawn, are ultimately futile unless they can exist within the broader and protecting context of a planned environment.

The planner's task, as it is presently constituted, is an impossible one. He is unable to determine the population of any area with which he is concerned; and he finds it difficult to guess at its future geographical boundaries. Without such fundamental determinations as these, it is not even possible to *identify* the patient much less do anything about making him well. Add to this amorphous situation the fact that commercial enterprise within the area, whatever the area happens to be, will eventually succeed in warping the community out of shape. And, last of all, the planner has virtually no money available to him in order that he might stave off some of the worst consequences of disappearing open space.

Given such massive limitations as these, one wonders what there is left to plan? And with what tools will such planning be done? Thus, we are forced back to the microcosm, the tiny world of zoning and subdivision regulation, the world of Lilliput. We are forced to go at our task with a penknife, and with this small weapon we attack the carcass of a whale. And the affluent Gullivers who crowd the hearing rooms with their attorneys and their sheaves of plans (for it is they, in truth, who do most of the planning) are vastly amused as citizens complain about such things as *spot zoning* and tearfully bemoan the fact that their neighborhood, which they thought was *protected* by zoning, is going to the dogs.

Fortunately, there are indications that our planning enterprise is now undergoing major changes both in relation to scale and to degree of specificity. Thus, it is possible to foresee our being freed from the Lilliputian box. While federal land use planning is not yet a reality, it is reasonable to expect some motion in this direction in the near future. Also, while we wait upon this development, there have appeared several collateral devices which are supportive of larger and more effective planning programs. The Federal Coastal Zone Management Act is just a first step but an important one. The Clean Air Amendments of 1970, while not a substitute for a land-use plan, can have a significant--even determinative--influence on development. The FWPCA Amendments of 1972 can exert a similar effect regarding our water resources and especially so if EPA's broad interpretation of *navigable waters* should prevail over the more narrow view of the Corps of Engineers.

Finally, the individual states themselves are taking some belated--though very welcome--action. And this action is due in part to the growing recognition that there is real value in what has heretofore been considered valueless: the dunes, the marshes, the green belts, the clean air, the clean water, and the unspoiled hills. This recognition, in turn, owes much of its force to the rapid advances in quantifying these environmental amenities, so-called, which have been achieved by the new generation of ecosystem analysts. The guilt feelings of romantics, bird-watchers, and old-time conservationists have finally been undergirded by some hard facts! At long last, in other words, two can play at the benefit-cost game.

The North Carolina Coastal Area Management Act, deficiencies and all, is a case in point. At least an effort will be made to identify areas of *environmental concern*, and in the dialogue something of value will have been accomplished.

While I welcome such a development (and hope we have a similar act for the Mountain area), I am confident that it will succeed only if it limits the vast spectrum which until now has characterized the fuzzy doctrine of multiple use. The application of this doctrine by the federal government has been and continues to be a damaging disappointment. It is simply not possible, with any satisfaction to the parties, simultaneously to graze on, camp on, raise wood on, hike on, and mine the same irrigated farmland. Yet, some of our multiple use fantasies verge upon being this absurd.

Von Neumann has demonstrated that it is not possible to maximize for more than one variable. Optimization for many variables means, *per force*, maximization for none. And the more items we try to optimize, the lower the optimal level common to them all.

Thus, we cannot simultaneously achieve a desirable situation with components so diverse as oil and gas wells (virtually all of North Carolina's coastal waters are under lease for exploration purposes), ocean outfalls, nuclear reactors, fish and marine life, mining phosphate lying under rivers (North Carolina receives rentals on such deposits each year; yet, it is difficult to imagine how they will ever be extracted without marine life catastrophe), tourism and agriculture.

What is to be permitted must be rather severely limited if we are to succeed at all. The critical watch word must be *compatability*. Marshes, rivers, fishing, conventional small-farm agriculture, and tourism (supported by municipal or regional water and wastewater systems) would seem to be a compatible arrangement. Ocean outfalls, after advanced treatment, *might* prove acceptable, given sufficient depth and distance, but piping effluent to the mainland would be superior to subsurface disposal. Large farming operations, necessitating extensive draining, ground exposure, fertilizing, and pesticide use should be discouraged as should mining and possibly offshore drilling activities, although the last might possibly be made acceptable.

We come, finally, to this essential proposition and guidepost: let us permit development, yes; but let us permit it as the temporary and changing thing that it is to occur only within the context of preserving our great permanent natural resources.

Let us bring an end to an environment which in the words of Emerson "eats upon itself," and let us teach the "mind of this country" to aim at higher objects. Ours is a moment of great opportunity. The stakes are vast, and the outcome is crucial. No challenge could be greater than the one before us.

FIRST THE WATER, THEN THE SEWER, THEN LAND USE PLANNING: COASTAL PLANNING IN RETROSPECT AND IN THE NOW

James R. Hinkley, *AIP*
North Carolina Office of State Planning

Here I am, a land-use planner, talking to a conference on water supply and wastewater. Land-use planners have been responding to people such as you for years. In many instances, not only in our coastal areas but elsewhere in our nation, land-use planning for community development decision-making has been beside the point whether plans to follow existed or not. Water and sewer extensions and street and highway construction since time in memorium, and recently, zoning, very unfortunately have been the setters of land-use and growth patterns. In coastal North Carolina, these three growth pace-setters, individually and in concert, can be considered to be growth management and direction mechanisms. In most all cases, these *planning tools* have been applied unconsciously, without benefit of comprehensive municipal, county, regional, state, or federal planning.

Let me define comprehensive planning for the purpose of this presentation. Comprehensive planning is a process which includes goal setting, policy formulation, survey and analysis of existing conditions, design, implementation tool development and application, community facilities planning, public improvements programming, and capital improvements budgeting. The process applies not only to land use but to all the infrastructure which is necessary to serve a community, county, or region. The process, out of necessity and general democratic principle, includes the participation of the citizenry to a high degree. For not to include the people is to spell doom for even the best of plans. Planners have finally come to this realization after learning the hard way. The plans on shelves gathering dust are planners' inanimate trophies won by not leaving their ivory towers.

The American way of life is less hospitable to planning than any other. We have an independent spirit and a strong tendency toward free enterprise--"to live and let live" rather than "to live and to help live" might be our slogan. Doing our own thing is the way our country has been brought up. But for some strange reason we are preoccupied with planning; we are at least aware of its need. Planning is in Vogue. "To plan or not to plan," that is *not* the question in North Carolina's coastal area. We must plan, we know that. The real question is: "Must we implement?" The answer here is: "Of course. Why plan if we don't implement?" I am slowly coming to the conclusion, however, that planning is fairly well known to be harmless since it usually is not implemented, and that is why it is generally accepted. Recently, I heard this statement which is apropos: "To plan is *human*; to implement is *divine*."

So planning in the Southeast and in the coastal area is popular. Not because it has been accepted as an integral part of governmental management, but because it has become in many cases a step in a process for local units to become and remain eligible for federal financial assistance. In North Carolina, at least, community and county planning, and in some cases regional planning, have been going on for years. This necessary evil--planning--has been in part financed through the HUD 701 planning program. Urban, rural, and regional planning grants from the Department of Housing and Urban Development, under the provision of Section 701 of the Housing Act of 1954, as amended, were given to local units of government which matched up to one-third of the total planning cost. Most of the technical assistance has been provided by the Division of Community Assistance of the North Carolina Department of Natural and Economic Resources since the late 1950's. A large number of local units have completed the elements of the 701 planning program, but little evidence of plan application can be seen. Of the 412 active municipal corporations in North Carolina, over 200 have received assistance from the Division of Community Assistance along with about 75 counties. And at least 25 to 30 other local units of government are large enough and well off enough to hire professional planning staffs full time. Except in a very few cases, one cannot distinguish the planned towns from the unplanned towns in North Carolina. Our track record is not good. My point is: we have planned a lot; we are obsessed with planning. But our implementation record leaves much to be desired. We are hypocrites.

PATTERNS OF DEVELOPMENT IN COASTAL NORTH CAROLINA

North Carolina has been called the most rural state. It has the largest rural non-farm population in the nation. Although we rank eleventh with over 5 million people, some 55 percent live in non-urban areas. The coastal area (20 counties designated by the Coastal Management Act) is even more rural with 60 percent living in non-urban areas. Patterns of development in coastal North Carolina are not completely typical of those found in other parts of our Eastern Seaboard. There is at least one significant difference. There is a broadcast distribution of rural communities of fewer than 2500 inhabitants. Other states in the Southeast have large concentrations of population on their costs with relatively fewer incorporated municipalities.

As accessibility improved over the years, towns in the coastal area began to change in nature. Rather than each providing the entire range of services necessary to support its immediate area, many communities began to provide specialized services in order to withstand the new economic competition from more accessible urban centers.

New concentrations of population are generated by the location of consolidated schools and new industries. These kinds of *people generators* give rise to residential subdivision development. Settlements are appearing on the rural landscape in response to strategically placed special uses.

Industrialization sans Urbanization

It is not uncommon to hear of coastal residents traveling 50 to 60 miles one way to work every day. This phenomenon is marked by car pooling and crossroads parking lots which dot the countryside. North Carolina's coastal industrial development plays checkers with existing settlements. The industrial-residential checkerboard development pattern can be seen most clearly. Much of the new industry which has been lured to the coastal area tends to locate out in the wide open spaces at chief highway interchanges, along major rivers, and at large mineral deposits, but with the important factor of distance from a number of surrounding communities (which are willing to overextend themselves in providing services such as water and sewer, fire and police protection, and other services) also serving in site location. The tendency to drive long distances to earn a living is also influenced substantially by the strong ties the coastal North Carolinian has to his land. These ties provide roots and security--a homestead. Owning land is a part of the Great American Dream. The influence of this heritage continues the strongest in rural areas where the people are closest to the land.

PERPETUATING THE PATTERN

Rural Residential-Industrial Strip Development

The industrialization of eastern North Carolina without significantly adding to existing communities and without building new towns has contributed to strip development along major highways. It is becoming more uncommon to travel along a major highway and not to be within site of homes or other buildings. Most amazing is the density of yard lights that one sees dotting the countryside as he flies across the area at nighttime. In recent months, I have had the opportunity of taking Piedmont Airlines' 11:00 p.m. Raleigh-Kinston-Wilmington flight. Rural residential development along paved roads stretching out as tentacles between towns and to special use complexes is on the rise. The density accentuated at night by yard lights is really amazing.

The coastal-rural strip development phenomenon can be compared to commercial strip development which takes place between communities in metropolitan areas. NC-11 running through Bethel, the Burroughs-Wellcome and Procter and Gamble Plant complexes, Greenville, the Pitt Technical Institute complex, Winterville, Sonoco Corporation complex, Ayden, Grifton, the DuPont industrial area, Graingers, and Kinston is an example of a rural residential-industrial strip development route. The proposed Winterville-Ayden-Grifton sewer line, if implemented, will serve to strengthen this strip development.

In rural areas the federal and state governments play key roles in perpetuating strip development patterns such as this. The decision-making, by default, is not totally in local government hands--it lies with agencies such as the Farmers Home Administration (FHA), the Department of Housing and Urban Development (HUD), and the State. Water and sewer planning studies were financed by FHA in all except eight metropolitan counties in North Carolina. This planning, which in most cases received cursory review and quick approval of county planning boards and commissioners, plots mains and lines in virtually all areas where rural residential development has already taken place. The prime purpose of the *plans* was to insure that as many *existing* homes and other uses as possible would be served. Implementation of the plans (completed in 1970-71) will perpetuate and induce new strip development in rural areas. The irony here is that the Department of Agriculture in recent years also has been promoting *good land use planning*. The Department has talked about the atrocities of strip development, of inordinate prime agricultural land consumption, and of the need for differential tax treatment for farmland to protect it. At the same time, one of its agencies (FHA) promotes just what the Department preaches against.

FHA's housing assistance and HUD's 236 housing programs directed at building single-family housing units for lower to moderate income people also have been partly responsible for perpetuating strip development. Homes are built along major highways where investments for access and street paving can be kept to a minimum. An example of this can be seen along the rural sections of US-264--the Wilson-Saratoga-Farmville-Greenville strip.

State departments such as Natural and Economic Resources, Public Education, and Community Colleges influence placement of industry and institutions in rural areas. DNER has been very influential in the not too distant past in placing new plants in areas beyond where needed infrastructure exists. Evidence of new industry location just outside municipal limits or even extraterritorial land use control areas can easily be established. Community colleges and technical institutions also have had a very strong tendency to locate several miles from towns. And their existence has perpetrated the extension of services and utilities long distances into the county. Invariably, the routes of these extensions become new growth lines which will become strips of residences often times straining the services installed to serve the industrial or institutional development at the end of the line. This type of development has been promoted by the State, but the State now knows better. Several bodies and agencies are speaking out against this type of development.

You know as well as I, and even better I suspect, what water and sewer extension can do to promote growth. Let me tell you about zoning. Many county governments believe that zoning is planning. And in a sense it is, because zoning sets a pattern for land development. "Not to plan is to plan." Where abutting local units of government are not planning together, zoning can be misused, abused, and tragic in consequences.

An example here is the strip zoning by counties of governments major arterials radiating from communities. The zoning sets the stage for development. What happens is that the county, although it has no idea what it is promoting, is planning for community expansion. As communities annex land to provide more sophisticated services for developed areas, they inherit the land uses perpetrated by counties. This way, options for growth for the community are all but eliminated. Zoning can be a wolf in sheep clothes. A specific example of this miscarriage of planning tool application can be seen between Raleigh and the Durham County line on US-70 and between Raleigh and Garner. Raleigh is inheriting the poor development practices promoted by Wake County.

In short, planning coastal North Carolina has not left a good mark. The mode has been unplanned growth, or more accurately, growth without regard for plans. The response to the demand for services has been unplanned and more like panic response to need without long-range financial consideration. In one instance, I know of a city council which was surprised by an announcement in the newspaper that stated that the local school board was going to build a new high school just outside the municipal limits. To the amazement of the council, the article went into detail as to how the new school would use city water and sewer. Without reference to the city plan and without the courage to say, "*no*, this is not applicable," the council moved into a response mode: "How do we meet the school board's needs?"

Another case is typical. A small industry located just beyond a town to take advantage of lower taxes in the county, but the new plant wanted a 10-inch town water main to insure proper operation of its sprinkler system. The sprinklers were to be installed to allow the company to benefit from lower fire insurance rates.

In still another case, a plant was situated just beyond a town's extraterritorial planning limits so that it did not have to meet zoning and subdivision standards. The town installed a water main and the county paid for the materials. Subsequently, along the main a number of homes and a convenience shopping center were built. Before long, water pressure required by the plant was insufficient. The town considered building another water tower and laying a larger pipe parallel to the existing main. Every move the town and county made after that to respond to this need seemed to get them in deeper and more expensive trouble. The plant which was lured to the area hired 50 people of which only two or three resided or shopped in the town. Many lived out in the country or in surrounding communities and counties.

Solutions on the Horizon

The 1974 North Carolina General Assembly passed two pieces of landmark legislation--the Coastal Area Management Act and the State Land Policy Act. A Coastal Resources Commission and Coastal Resources Advisory Council have been activated to guide the formulation of land use plans in each of 20 counties and their respective municipalities in the coastal area. In addition, the Commission will designate areas of environmental concern including marshlands, beaches, sand dunes, navigable waters, national and state parks, and areas of historical importance. Use of these areas is not prohibited but will require extreme care. A permit system will be put into effect. Any development within an area of environmental concern must have a permit including: projects of greater than 20 acres, drilling and excavating, construction of one or more structures in excess of 60,000 square feet, and any projects currently needing state permits. Local units of government will be asked to issue permits.

In this case, local units of governments are called upon again by a higher authority to plan. This time, through the auspices of the Coastal Management Act, it is the state rather than the federal government. Some have questioned the need to do land use planning for whole towns and counties when the thrust of the Act tends to emphasize the importance of Areas of Environmental Concern. We must gear ourselves to plan as comprehensively as possible. To leave out elements is foolish. Urban and rural development affect water quality, air quality, vegetation, wildlife, and other elements of the environment. We must look at our situation as a unit. I *do not* believe that we are biting off more than we can chew, and I *do* believe that land use planning is an integral part of managing the coastal area--at the municipal, county, regional, and state level in concert. The pitfall which must be faced in coastal planning is the arch-enemy of all planning--apathy. This can be avoided by insuring strong citizen participation--an element which is being emphasized in coastal management for North Carolina. If participation is successfully achieved, the coastal management effort will be a success. If it is not achieved, it will fail. In the words of Jim Wallace, "Commercial enterprise will succeed in warping the coastal area out of shape."

The land of North Carolina is a resource basic to the welfare of her people. As we become more industrialized, as we continually change our places of residence, and as our population increases, the demand for land for residential, commercial, industrial, transportation, institutional, and energy production purposes increases. This demand appears to have taken precedence over our one-time basic dependence upon the land for sustenance--food production, wood and fiber supply, and water and mineral extraction.

North Carolina's towns and cities are growing, and they are consuming lands at an increasing rate which have been historically valuable for other purposes. Many communities of necessity and convenience were settled in the midst of the State's best farmland. As these municipalities expand, conflicts in land use must be faced. These conflicts present us with some very difficult decisions. We are called to insure that the very land resource upon which we have depended for so long is not completely consumed or destroyed by nonsustentative needs. To enable preservation and enhancement of our land resource, to come to grips with inordinate use and consumption of land in North Carolina, and to deal realistically with necessary trade-offs, the 1974 General Assembly passed the Land Policy Act.

The Land Policy Act is a state law which gives state government the responsibility for formulating policy for direction of land conservation and development. The Act also requires the creation of a land classification system for counties to use in guiding future use of land. Through a land classification system, counties and municipalities will be given some new land use planning tools to provide direction for growth, utilities extension, and to protect local amenities from desecration and destruction.

In accordance with the State Land Policy Act, a Land Policy Council and an Advisory Committee on Land Policy have been appointed.

Land Policy Council. The Council is a 14-member body consisting of: the principal officers of the State Departments of Administration, Agriculture, Commerce, Cultural Resources, Natural and Economic Resources, Revenue, Human Resources, and Transportation; the Lieutenant Governor and a senator appointed by him; the Speaker of the House and a representative appointed by him; and two elected local officials, one each selected by the Association of County Commissioners and the League of Municipalities. The Council is chaired by the Secretary of Administration.

The Land Policy Council has been charged by the General Assembly to formulate the policy and land classification system. The Council's broader purpose is to promote orderly growth and development in a manner consistent with the wise use and conservation of North Carolina's land resources: (1) preparing a land use information system for the State and local units of government; (2) considering interstate aspects of land use issues; (3) accounting for institutional and financial resources for land use planning; (4) establishing a method of identifying areas of environmental concern; (5) providing the technical assistance and training programs in land use for State and local agency personnel; (6) instituting a method for coordinating all State and local programs and services which significantly affect land uses; and (7) preparing a system of valuation of property related to public services available in land classification. The Council will hold six public hearings--two each in the Coastal, Piedmont, and Mountain areas during the first half of 1976.

Advisory Committee on Land Policy. The Committee is a 24-member body appointed by the Governor. Twelve members are selected (six each) from a list of elected officials recommended by the Association of County Commissioners and the League of Municipalities. Twelve are selected from a broad cross-section of interests including farming, agribusiness, forestry, land development, home building, manufacturing or extractive industries, parks and recreational management, the tourist industry, the environmental and/or health sciences, and public interest organizations. The Governor designates the chairperson and vice-chairperson of the Advisory Committee on Land Policy.

The Committee advises the Land Policy Council in formulating policies and management techniques, in securing full public participation, in developing the Land Classification System, in identifying possible future problem areas, and in providing assistance in other ways. The Committee serves as the chief link with the people. One of its prime purposes is to openly disseminate proposals and alternatives, provide opportunities for public comment, and develop information and education programs in support of the Council's determining State Land Policy.

The North Carolina General Assembly has proclaimed that the land is a basic resource. It has also found that there have been inconsistencies in policy and inadequacies in planning for the present and future uses of the land resource. These shortcomings stem from a lack of: coordination of governmental action; clearly stated, sound and widely understood guidelines for planning; and systematic collection, classification and utilization of information regarding the State's land resources.

The General Assembly also has found that governmental agencies responsible for controlling land use and private and public users of land are often independently unable to develop guidelines for land use practices. This ability is basic in providing adequate and meaningful direction for future demands on the land resource while at the same time allowing current needs to be met. It was also stated that systematic and sound decisions as to the location and nature of major public investments in key facilities are crucial. Sound planning cannot be done without a comprehensive State policy regarding North Carolina's land resource.

The General Assembly declared that all those who would be affected by a State land use policy and decisions must be given an opportunity for full participation in the policy and decision-making process. The process must allow for the final implementation of policy by local governments. The State is charged to do what it can to encourage and assist local units of government in meeting their responsibility to control current uses and to guide future uses of the land resource.

Let us look at the State land classification system which is emerging. The system consists of five simple classes of land called Developed, Transition, Community, Rural, and Conservation. Each of these five classes is mutually exclusive; taken together they will cover all the lands of the State.

The land classes will accommodate all types of land uses. Local land use plans frequently contain from ten to twenty different land use categories. There are only five land classes in the system. Simplified land use plans could result.

The classes represent degrees of land development intensity or population density. Ranging from *Developed*, which is urban in nature with a high density, to *Conservation*, which is completely undeveloped, the classification system covers the entire range of development intensity.

The land classes are a clear expression of *commitment to public facilities and services*. Some of the classes of land will require few or no public services, as in the case of *Conservation*. Other classes will entail a commitment to a complete range of urban services, as in the *Developed* and *Transition* classes. The demand for public services is geared to the intended land use and the intensity of development.

The classifying of lands will be the responsibility of local government. The State will formulate the rules and standards by which all lands are to be classified. As lands are classified by local government, the State will ensure that funds for new facilities, purchase of land and easements, and regulation of development will be consistent with the land classification plans. Hence, implementation will be based upon the intent of land use planning. Local units will commit themselves to growth management and economy in service and utilities provision.

Land classification serves as a basic tool for coordinating numerous policies and regulations at the local and State levels. Coordination may be described in five applications:

1. The land classification system is a method of linking local land use plans and State land use policies. The land classes are applied in practice by local government but within the context of State Land Policy.

2. The system provides a framework for budgeting and planning for investments in land in advance of need and development. Lands classified *Conservation* will alert State and local agencies to areas that should be given high priority for buying land for recreation. Likewise, land classified *Transition* will alert local and State officials to begin acquiring land and easements for water, schools, fire stations, recreation, streets and sewers. By identifying such lands in advance, State and local governments can work together toward common ends by budgeting for use in advance.

3. The system provides a framework for budgeting and planning for community facilities such as water and sewer, fire and police protection, etc. Resources of many State and federal agencies are expended in grant programs to assist with construction of water, sewer and many other community facilities. The State-local system of land classification will lead to coordination of all these diverse programs.

4. The system provides a framework for coordinating regulatory policy. For example, lands classified *Conservation* deserve special attention from State regulatory agencies. In *Transition* lands, local government needs to mobilize its zoning powers and subdivision regulations based on land use plans within the context of classification to assist in orderly growth and development.

5. The system provides a framework for the equitable distribution of the land tax burden. Private lands classified for *Rural* purposes need to be taxed at a rate that is compatible with the use of the land as a resource, while land that is provided with more public services needs to be taxed at a rate that reflects the higher density of development.

In short, land classification is a system for joint local-state involvement in land use planning and management. It provides a wide range of choices for local government in deciding its own future. At the same time,it provides an opportunity for the people of the State to ensure that their needs are met.

Along with EPA 208 planning, these two Acts (Coastal and State Planning) may turn land use planning into a viable management tool rather than the sham or *false prophet* that it is today. Through strong public involvement the new planning tools coming down the pike have a good chance of being of value.

In addition to involving the general public, there is a dire need to work evangelically among public utility directors, city and county engineers and managers, and local elected officials to bring them around to participating in comprehensive planning and to seeing its value. Importance must be placed in comprehensive land use planning by people such as you for it to also gain acceptance by the general public.

I hope that I can someday title a speech: *First the Planning, Then the Water, Then the Sewer: Coastal Planning in the Now.* I can only wish that I can live long enough to deliver it someday.

Thank you for your attention.

ECONOMIC IMPLICATIONS OF COASTAL WASTE DISPOSAL ALTERNATIVES

Ronald M. North
Associate Director
Institute of Natural Resources
University of Georgia

Our topic for discussion contains three insurmountable opportunities--economic implications, coastal areas, and waste disposal. The three combined should be sufficient to challenge our minds and imaginations for a half hour. It seems that the majority of our speakers have engineering backgrounds. I presume that a large number of you participating also have engineering and related technical backgrounds or at least work regularly with engineers in solving water supply and waste disposal problems of your communities and clients. Given your professional interests and with a disregard for the fact that economics has been a major growth profession between the two great depressions, I wish to give a few definitions and statements of principles.

Such basic reminders to ourselves and to those with whom we communicate are as essential for economists as for other professionals. It is the simplicity of the principles which we must remember whether it is Boyle's Law, Newton's Law, or Gresham's Law. These principles were astutely formulated and have been both intuitively and empirically demonstrated thousands of times.

Our first concern is the most basic of economic principles which might apply to our discussion and to our effort to provide some systematic analysis to the job of improving wastewater disposal in the coastal areas. The general theory of political economy can be summarized by two laws of economics. The first law: "There ain't no such thing as a free lunch;" and the second law: "Them that has gets."

You recognize, of course, that these laws define the full range of implications for all economic decisions. Furthermore, these laws define the real implications of most choices made in society whether those choices are consciously economic or political or technical or operational. The first law is obviously the economist's fetish with efficiency. Every choice involves a complex matrix of costs either monetary or opportunity. Every decision incurs or imposes costs, either to the decision maker or to someone else. The minimization of these costs or its equivalent, the maximization of profits, provide the objective functions and criteria by which we measure efficiency in a competitive, free-market economy.

The second law is the iron law of distribution which determines the incidence of benefits and costs which results from any economic or political decision and from most technical decisions. This is the familiar equity or distribution impact of such decisions. This impact is resolved in the competitive economy by decisions to transfer certain economic or welfare gains and losses among affected groups--those both favorably and adversely affected. The final distribution of economic goods is determined by the net result of ownership of or access to resources plus the transfers which are effected either voluntarily or under duress.

Therefore, the result of any policy decision, political maneuver, technical development or operational activity is likely to spawn two consequences: an efficiency consequence; i.e., how much is produced or saved, and a distributional consequence; i.e., how is the product factored among the owners of resources and among others in the economy. These two impacts occur rather simultaneously, and it is often difficult to precisely define the magnitudes. However, for those economic goods and services and resources with an established market one can make reasonable estimates of both efficiency and equity impacts.

The case of wastewater disposal is one exception of sorts since water is usually a negative economic good, and waste disposal is a negative economic service. We only need to realize that we incur costs to dispose of wastewater without any corresponding benefits except in those activities where reuse and recycling produce a valued by-product. Therefore, the intuitive reaction to waste disposal is to avoid costs by discharging our wastes directly to our land, our water courses or our air and in so doing rid ourselves of liabilities or negative economic goods. The accepted and institutionalized approach to wastewater disposal is to discharge the effluent at the least cost to ourselves directly. We wish to disown or to dispossess ourselves of waste as quickly as possible. We only want ownership and responsibility for positives--not negatives.

The efficiency argument for direct discharge of wastewater to the environment is based on the concept that Mother Nature can dispose of the waste by recycling at the lowest possible cost; *viz.*, at zero cost and, hopefully, at some positive replenishment of resources. Unfortunately, the limits of nature's assimilative capacity are quickly reached when populations are dense and when industrial processes are concentrated.

We observe that for at least two classes of goods and services we do not have established markets. These are the public goods and the option goods. Briefly, the public goods include all those goods and services which we acknowledge the need of but which we can somehow avoid the payment for without compulsion. Option demands are those cultural and environmental values we reserve and pay for privately without any particular expectation of direct benefit. Wastewater disposal is one of those public goods which we deem free until such time as we recognize the social costs imposed on all of us by ourselves. Since we as individuals do not wish to assume responsibility for waste disposal as long as nature will assimilate such wastes or as long as we can transfer waste disposal costs to another group, we are faced with the necessity for public measures to protect all of us collectively from ourselves individually. Even though waste disposal seems to be a public good, we cannot avoid the need to consider both the efficiency and equity consequences of the numerous technical and institutional alternatives for solving the problem.

The economic implications of waste disposal are derived from these dual considerations of efficiency and equity. First, the efficiency consideration is that of "how much wastewater disposal must we have and what is the least cost method of getting the amount we need?" Secondly, the equity consideration is that of "who is to pay for the wastewater disposal we need?"

It becomes abundantly clear that the mostly subjective decisions of what quality of water we want and the mostly technical decisions of the least-cost method of achieving a given water quality are directly related to the question of who pays or how do we distribute the costs. A third factor also related to those of efficiency and equity is the existence or development of an institutional system for managing our water quality. In fact, the institutional arrangements are likely to affect the efficiency and distribution impacts of wastewater disposal more than the choice of the technical alternatives. Without our development and acceptance of new institutional arrangements, we are not likely to use the best technical solutions for maintaining water quality. If we are not willing to adjust jurisdictional boundaries or to impose taxes and fines for effluent discharges, our costs for wastewater disposal are likely to be much higher than they should be, and we are likely to impose adverse transfers of these costs.

Before further discussion of economic implications and wastewater disposal, I would like to address the central theme of this conference which involves the coastal environment. First, the environment is where we all live and always have lived, but we didn't know it until a few years ago. The coastal area is a difficult simultaneous equation. It is at once both a very sensitive ecological area and a very tough natural system. I once heard a paper entitled, *The Pamlisum*, which described this remarkable paradox (Eller). The author was familiar with coastal ecology generally and, in case you recognized the term *Pamlisum*, he was also familiar with the great Pamlico Sound to the north of us.

This thesis was that man's efforts to tame the coast, especially the Pamlico Sound, were ultimately futile given the great forces which formed, maintained, and reformed the coastal environment. His examples were the great man-made drainage projects for agriculture and the historical sites of man-made settlements, neither of which could survive the natural forces of wind and water and sun. But the *Pamlisum* lived on. He also noted the substantial ecological damages produced by the improper alterations of the *Pamlisum*, such as excessive silt from the drainage projects or the beach erosion from building on the protective dunes or the waste loads from the towns and industries.

Professor Eller, as many of you, was aware of the fragility of both the coastal ecological system and of the coastal economic system--both of which could be damaged easily by the intrusions of man. He was also aware of the powerful forces of the *Pamlisum* which could correct the intrusions with the next storm or wear them away with the relentless tide, and winds and sun. Our coastal areas in the Southeast were the first settled and are yet the least developed because of the heavy costs of trying to maintain a superficial economic system.

If we build our motels and summer houses on the beach, that beach disappears in a few years to be replaced by rock riprap or concrete or by so-called beach nourishment programs paid for by investors from the hinterlands or by the taxpayers through the Corps of Engineers. The superficial coastal community is maintained by large imports of capital. Also, if we build our industries on the estuaries where there must be (in our mind's eye) infinite sources of dilution water for our concentrated wastes and unlimited groundwater for our processes, then we are soon faced with empty or contaminated oyster beds and salt-water aquifers. In this instance, there are dual economic implications. First, we are subsidizing consumers of these products by not including the full costs of their production in the prices. Secondly, we are imposing significant costs on the natural and survivable coastal industries to subsidize consumers elsewhere until such time as we recognize this problem and act to internalize these costs or cross subsidize the disinherited industries. In summary, the coastal zone has particular problems in combating the adverse effects of wastewater disposal both from its own effluents and from those disposed of upstream.

These observations are not made with any intent to suggest that we should not use our coast, that we should not build homes and motels or factories or plant soybeans. However, I am suggesting that the alternatives we speak of in economics must include the full costs of our activities and demands if we are to pursue and preserve both a viable economy and a healthy, attractive environment. This means that we should intensify our efforts to identify and to implement both the technological and institutional alternatives for waste disposal and water quality along the coastal zone.

The coastal zone is faced with the dual problems of accepting the unassimilated waste loads from the hinterlands and of providing the buffer or transition zone between the marine and upland environment. These stresses are particularly severe when there are low flows from upstream catchments or droughts or heavy waste loads from malfunctioning treatment plants or storm runoff from non-point sources. It is the coastal zone which bears the real costs of stream or estuary degradation. This means that the coastal zone may be asked to share a disproportionate burden when stream standards are critical or when upstream effluents are not properly managed. Also, the effluent from the coastal communities will often be the marginal increment of waste load which degrades the system below its optimum assimilative or environmentally sound capacity. This is particularly true of the estuaries.

It is imperative that I use this time to address the economic and institutional alternatives for coastal zone wastewater disposal in greater detail than the technological alternatives. The technological alternatives of biological and chemical treatment, deep well injection, direct recycling, ocean outfall, land treatment, and other variations have been well treated by specialists in these methods. My greatest challenge in a meeting such as this is to outline the economic alternatives which produce the incentives to achieve the required water quality standards efficiently and equitably for the sensitive coastal zone.

We approach these economic alternatives with the four basic questions of economic choice: (1) How much water quality (or wastewater treatment) do we want and with what degree of certainty? (2) What system of technological alternatives will provide our water quality demands? (3) What institutional arrangements are required to achieve an efficient and equitable wastewater disposal system? and (4) Who is to pay for the water quality achieved? The final achievement of any water quality level will rest with the choices made for each of these questions.

The following outline of economic alternatives are sufficient to show that the real progress in achieving improved water quality in the coastal areas will rest in the implementation of the appropriate technical systems, or combinations of technical systems--not on their development. As we can see, the technical alternatives are well known, but it is our reluctance to adopt the least-cost alternatives which inhibit our progress in wastewater disposal.

OUTLINE OF ECONOMIC ALTERNATIVES FOR COASTAL WASTEWATER DISPOSAL

How Much Water Quality?

What is the demand function for water qualities?

What is the demand function for wastewater disposal?

What are the economic uses of water downstream?

What are the benefit-cost relationships for effluent discharge versus zero discharge?

What are the ecological parameters of various stream qualities?

What are the assimilative capacities, nutrient needs of given streams and estuaries?

What are the life support needs of given streams and estuaries?

How much water quality can we afford?

What Institutional Arrangements are Required?

Should organizations for wastewater management be local only or river basin or estuary?

Should legal systems be redefined to increase responsibility for waste disposal?

Should permits be issued for variations in effluent or stream standards?

Should effluent standards or stream standards or a combination be adopted?

How Should the Water Quality Levels be Paid for?

Should costs be internalized by law so that users pay (i.e., an absolute zero discharge)?

Should effluent taxes or fees or general assessments be levied for wastewater disposals?

Should water supplies be sold with surcharges for waste disposal?

Should subsidies from general funds be continued so we can avoid direct responsibility for waste disposal?

A few examples of wastewater management studies will serve to illustrate our lack of resolve in trying to achieve an efficient and equitable wastewater management system. These studies of the Potomac and Delaware Estuaries are most appropriate for this conference where we are concerned with similar estuarine water quality problems.

In these studies the first question to answer is how much water quality? This seems to be a silly question--one which only an economist would ask. The question deserves a serious answer. First, what are our alternatives for the amount of water quality? Briefly stated, our alternatives range from that of unlimited discharge of effluents into our water courses plus the damages and degradation from development schemes to the pristine or rainwater standard. That is, in terms of economic costs, we can minimize individual or internal costs by unlimited effluent discharges and fail to provide public waste discharge services for zero direct costs and unknown social costs. Or, we can internalize all costs by demanding private or public treatment to at least drinking water standards at a rather high direct cost and minimum social costs. For today's requirements under P.L. 92-500, these levels range from no treatment to zero discharge of pollutants.

The correct approach to this question of how much water quality depends on a consolidation of much knowledge of the relationships among waste treatment levels, stream quality results, and downstream water uses. Even though water quality standards are usually based on technological parameters such as BOD_5 removed or D.O. levels maintained, the correct approach should be based more on ecological parameters such as primary productivity or diversity indices when these dynamics are more fully discovered. When effluent standards are defined and maintained for ecological rather than technological parameters, then we will be achieving a true economic efficiency for a market system in which all costs are internalized. There should be no externalities or social costs related to wastewater disposal when such ecological standards are met with polluters paying the full costs; i.e., with no subsidies.

Examples of viable alternatives for stream standards have been proposed with respect to the studies in the Delaware and Potomac Estuaries (Tables 1 and 2). In these studies various technical alternatives were proposed to maintain dissolved oxygen from 2 ppm D.O. to 7 ppm D.O. The costs of 4 ppm D.O. levels would range from a low of \$20 million for simple instream reoxygenation to \$140 million for low flow augmentation and up to \$170 million for convention waste treatment methods for the Potomac Estuary (Davis, p. 82). The costs for similar standards in the Delaware Estuary are estimated to range from a low of \$10-70 million for a range of 2.5 to 4.5 ppm D.O. with simple, instream reoxygenation to a high of \$130-460 million for uniform, conventional wastewater treatment methods (Herfindahl and Kneese, pp. 334-356).

The objective, economic choice must be made with respect to the expected marginal benefits and marginal costs for the most efficient solution. For the Delaware Estuary, this would occur at about 3 ppm D.O. level with less than 90 percent BOD_5 removal. An administrative or subjective decision to maintain a given D.O. level such as 4 ppm leaves one with only the choice of the least-cost solution to maintain that standard. For the Potomac Estuary this least-cost solution for 4 ppm D.O. was simple reoxygenation at a system capital cost of

$20 million.* For the Delaware Estuary this reoxygenation would cost only $40 million to achieve the same results as uniform conventional treatment at a cost of $3.5 million.**

Why do we spend $315 million to do a $40 million job? The answer is found in our third and fourth questions of what institutional arrangements are required for an effective wastewater disposal system and who will pay for the system to achieve some degree of equity. First, we do not have sufficient legal authority nor political initiative to adopt a system of reoxygenation which displaces the imagined local control over wastewater treatment and discharge. Furthermore, we are most reluctant to propose such institutional flexibility outside academic reports. Secondly, we have been happy to accept federal subsidies, which began in 1948 and which have grown with increasing largess, for inefficient methods because we innocently believe the Federal Government is paying 75 percent of the capital cost. All we have to do is contract for a conventional, off-the-shelf treatment plant and directly avoid any institutional innovations. The more serious economic implication of these policies is the misallocation of resources by subsidizing the most pollution industries and governments. Adoption of these policies must contribute to other problems such as inflation, which has been defined as that condition when nobody has enough money because the government and everybody else has too much. Perhaps, these inefficiencies are also explained by the modern definition of progress which occurs every year when it takes less time to fly across the Atlantic and more time to drive to the office.

---

* These costs are system costs including capital plus Operation-Maintenance-Replacement (OM&R) for a 50-year plant at a 4 percent discount rate for an estimated operation of 3.5 months annually.

** These costs are system costs based on a 20-year plant life at a discount rate of 3 percent.

Table 1

ESTIMATED COSTS OF VARIOUS COMBINATIONS OF WASTE TREATMENT SYSTEMS FOR PROJECTED 1975-80 WASTELOADS IN THE DELAWARE ESTUARY

Objective set no.[a]	Dissolved oxygen level	Conventional treatment methods[c] Uniform treatment	Zoned treatment	Cost minimization	Collective reoxygenation system[b]
	PPM	-------------	------Million	dollars--	------------
1	4.5-7.5	460	460	460	70
2	4.0-6.5	315	250	215	40
3	3.0-6.5	155	120	85	12
4	2.5-5.5	130	80	65	12
5	1.0-7.1	d	d	d	d.

a. Provides for 92-98 percent BOD_5 removal for all waste sources for all programs and includes instream aeration in critical reaches.

b. This method limited only to maintaining D.O. levels and does not consider other water quality parameters. It is also partial in that stream quality upstream or reoxygenation facilities would be lower than the waste treatment.

c. These waste treatment methods provided for 7 other water quality parameters including chlorides, coliforms, turbidity, plt, alkalinity, hardness, phenols.

d. Estimates not available. This objective would be to maintain 1964 conditions without further degradation.

Source: Orris C. Herfindahl and Allen V. Kneese, *Economic Theory of Natural Resources*, pp. 340-347.

Table 2

ESTIMATED COSTS OF VARIOUS COMBINATIONS OF WASTE TREATMENT SYSTEMS FOR THE POTOMAC ESTUARY
(Based on Standard of 4ppm DO or 90% BOD removal)

Alternative treatment system	System cost[a]
	Million dollars
1. Reoxygenation, Instream	20
2. Chemical Polymers and Reoxygenation	25
3. Step Aeration and Reoxygenation	30
4. Microstrainers and Reoxygenation	36
5. Diversions Downstream and Reoxygenation	36
6. Diversions, Conventional Treatment and Reoxygenation	45
7. Low Flow Augmentation and Reoxygenation	60
8. Low Flow Augmentation, Treatment and Reoxygenation	60
9. Low Flow Augmentation, Primarily	139
10. Conventional Waste Treatment, Primarily	170

a. Based on Capital and Operation, Maintenance and Replacement costs made equivalent to present value at a discount rate of 4 percent and 50 years.

Source: Robert K. Davis, *The Range of Choice in Water Management - A Study of Dissolved Oxygen in the Potomac Estuary*, pp. 79-83.

REFERENCES

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

2. Professor Eller, East Carolina University, Greenville, North Carolina, at a National Science Foundation-sponsored short course, New Mexico State University, Las Cruces, New Mexico, July 1967. (The exact title of the paper is, regretfully, not remembered; the message was.)

3. Orris C. Herfindahl and Allen V. Kneese, *Economic Theory of Natural Resources*, Charles E. Merrill Publishing Company, Columbus, Ohio, 1974. For additional detail on the Delaware Estuary Study see excerpts in Allen V. Kneese and Blair T. Bower, *Managing Water Quality: Economics, Technology, Institutions*, The Johns Hopkins Press, Baltimore, 1968, pp. 25, 225-234, 274-292. Also see the original study published by the Federal Water Pollution Control Administration, *Delaware Estuary Comprehensive Study: Preliminary Report and Findings*, Philadelphia, 1966.

QUESTIONS AND DISCUSSION

QUESTION: (Mr. Mark Stephens to Mr. James R. Hinkley) You stressed that there was a major problem or failure to implement land use plans. I wonder what you thought would be the key problem faced by land use planners under the Coastal Management Act?

MR. JAMES R. HINKLEY: I think one of the key problems that's going to be faced by communities in preparing land use planning is doing it within a 300-day time period. The General Assembly in all of its wisdom set a time frame for local land use planning in the Coastal Management Act at 300 days. The State wasn't ready with the guidelines of development until the first day of those 300 days. The mapping apparently still is in the process of development by the Department of Natural and Economic Resources. I suspect what's going to happen is that many plans are going to be insufficient the first time around, and they will not be approved by the Coastal Resources Commission at the end of this period. After that period the Commission's reactions will be given to local units of government. Local units may well come back with more sufficient plans to meet guideline stipulations. I suspect implementation will be difficult if the citizenry is not involved. This could turn out to be a key problem, also. However, the Department of Natural and Economic Resources has machinery now getting off the ground where public participation will become an integral part of the planning process. I believe that when people are not involved in planning, plans end up on the shelf. There is a possibility this time that there will be concerted implementation of local land use planning because the people will be involved. If local units use a process such as the one which is being used in Raleigh called *Goals for Raleigh*, there will be a good chance for implementation. If I plan for you, you are going to say, "What the hell; this is my life." If you plan for me, I'm going to say the same thing to you, but if we plan together, with the people, then the chances of our doing something together are pretty high.

QUESTION: (Dr. Peter Ashton) Why do sewer rates always seem to go up at the same time when we are seeking economics of scale, regionalization, and large-scale operations?

MR. RONALD M. NORTH: Well, I wasn't aware that they always went up, but I can give you an answer which my colleague at the University of Georgia, Professor Gene Odom, would give. He contends that the economist doesn't understand economies of scale when we say that bigger is better. He contends that bigger is not better. Of course, the theory of economies of scale includes economies as well as diseconomies. However, I think we should certainly take a serious look at regional or basin-wide treatment systems. I could see very clearly that the cost of collection systems for such basin-wide or regional treatment organizations could far exceed the costs of conventional localized treatment systems. However, the problem here is also probably institutionalized in that we are not identifying the proper alternative. For example, in the Potomac Estuary in the study by Robert K. Davis for Resources for the Future, the Corps of Engineers really looked at only one alternative. That was low-flow augmentation which would cost, on a present value, 50 years discounted basis, $140 million to provide four parts per million dissolved oxygen at various points in the Potomac Estuary. Davis' study showed, after looking at all the alternatives such as microstrainers, reoxygenation, instream aeration and others that the lowest cost alternative, which is not identified or considered by the people who made the original plan, would be reoxygenation. This alternative would cost only about $20 million on the same basis to achieve the same dissolved oxygen level. The fact is that we are not selecting the proper alternative, and we are locked in to some conventional systems which may, in fact, become increasingly expensive regardless of size because the conventional system is less efficient in the beginning.

COMMENT BY MR. WARREN STILES: With a regional management system replacing several small systems, we expect better bookkeeping; therefore, it is more likely that all costs will be tabulated and in the proper columns.

We will also have better treatment of our wastes. This presumably transfers an intangible social cost of a damaged environment to an accountable operating cost.

Professional managers, better trained and usually higher paid operators, who are not on the job because of nepotism but because of demonstrated abilities, will insist on better maintenance of equipment and operations. This cost shows up in the annual operations and maintenance budget and the savings show up in (a) a better environment, and (b) longer life of plant and equipment.

A classic example is in the treatment of wasted sludge. Many small plants have antiquated sludge drying beds which can only be cleaned manually. Lots of man-hours with pitch forks are required. If the sludge is overboarded or surreptitiously pumped out with the plant effluent, this operating cost is avoided...with the added social cost of concentrated sludge being added to our surface waters.

Another example is comparison of a regional system such as Greenville, South Carolina, where septic tank service is part of the regional system budgeted responsibility to any area where septic tank service is an individual responsibility.

These are transferred costs...where the user pays a sewer tax that is higher but avoids individual repair bills to private septic system repairmen.

Then, there is the individual who does not call a repairman but knocks a hole in something and lets the partially treated effluent go where it may. This results in a higher social cost again.

QUESTION: (Dr. Donald Francisco) P. L. 92-500 regulations do allow for the choosing of the least costly alternative. Would the addition of industrial surcharges tend to internalize part of the cost?

MR. RONALD M. NORTH: Well, it would certainly help. I see nothing but help in that area. However, in Georgia, they are not allowing the full range of alternatives under P.L. 92-500. The environmental protection division within the State of Georgia is putting considerable pressure on firms to discharge only into the municipal system. Those firms would be charged a certain allocated portion of the total cost, capital and operating and maintenance. I believe this applies only to the federal portion of the investments. This would help internalize costs. However, in Georgia, they are not allowing the firms to choose the design and build their own treatment system which may be, for those firms, a lower cost alternative than discharging into the municipal system. That would also internalize. They should have a chance to decide whether they dump into municipal systems or build their own. If they build their own treatment facilities, of course, they would have to maintain the effluent standards that are required.

QUESTION: (Professor David H. Howells) Due to pressures from cities like Chicago with old systems which have some difficulty, I guess, in dealing with industrial inputs, EPA has requested that the Act be amended to credit ad valorem taxes paid in lieu of or in conjunction with user charges. It seems to me we have just begun to make some progress on this business of internalizing cost with economic incentives. It gets a little rough as anything does when you are making a transition, and then we back off and the whole thing goes down the drain. I may be wrong on that; what was your comment?

MR. RONALD M. NORTH: Of course, if these ad valorem taxes were already paying the cost of this water system, you are just making a technical substitution. To the extent that the ad valorem taxes were not allocated for some other general purpose, then it is a substitution, and it may be that the full cost is still not being internalized because users cannot identify the ad valorem taxes with their particular uses.

QUESTION: (Professor David H. Howells) This wouldn't be the case, would it, unless ad valorem taxes were, in fact, related to waste volumes and waste composition? The ad valorem tax may not have any relationship to the waste discharge and water use. You could have a good clean electronics assembling plant that would have essentially nothing but domestic waste but a big ad valorem tax.

MR. RONALD M. NORTH: You are correct. The ad valorem tax is general, particularly in a larger town where you have more than one industry. Effluent tax would not necessarily be related to pollution load. I'm not recommending it, but I was only suggesting that to the extent the effluent tax was related to the waste discharge, then it would simply be a substitution.

QUESTION: (Mr. Frank Reynolds) What do you think of the current or prevailing tendency to build waste treatment plants which are greatly in excess of current needs, particularly with the apparent slowing of population growth?

MR. RONALD M. NORTH: The equity question is one of the most serious that we have. I see nothing particularly wrong with building in excess capacity if we have a very reasonable and judicious judgment with respect to what we expect the populations and demands to be. As a matter of fact, I'm quite in favor of the present generation incurring some of the cost of future generations. This is really the economic explanation of conservation. The present generation provides something for the future generation. So I don't have any problem with that. Whether it's fair or not may be another question. I think it is fair in the sense that we would be perhaps paying for some of the social cost of things we are consuming today or can expect for the future. I rationalize that in my own mind.

PUBLIC PARTICIPATION IN WATER AND WASTEWATER PLANNING

Benjamin C. Dysart, III
Associate Professor
Environmental Systems Engineering
and
Director
Water Resources Engineering Graduate Program
Clemson University
Clemson, South Carolina

It is a real pleasure to be with you this morning to discuss a very important aspect of water supply and wastewater in our coastal areas, an aspect which is normally afforded too little attention and even that usually provided too late. Previous speakers on the program have dealt with some critical technological subjects pertaining to water and wastewater matters in the coastal zone. I shall address the matter of public participation because it is absolutely necessary if we are to have the type of water supply and wastewater systems which are responsive to current and emerging needs of the public.

I clearly recognize that water and wastewater problems are perhaps more critical in the coastal zone than in most other areas. This is due to a number of factors which have been discussed at this meeting and which are well known to you. Now and in the coming years we will have large concentrations of people and industry located in and very near our coastal areas.

It seems that many of the very difficult problems that have arisen concerning development and public acceptance relative to environmental and water resources matters in recent years have occurred in coastal areas. I anticipate that this trend will continue in the future. I would insist, though, that the coastal zone does not have a monopoly on such problems!

I would like now to proceed into the matter of public participation. First, I would ask the question: "Why is public participation or citizen involvement needed?" The objective of a water or wastewater plan or project is to respond to legitimate mandates from the public in a socially responsible manner, considering the relevant alternatives, long and short-range factors, and the great diversity of needs. A rather recent EPA document (18) states the purpose of facilities planning as follows:

> The (facilities) planning process features systematic economic and environmental evaluation of feasible alternatives and public involvement in the choice among the alternatives.

Public works projects in general are not conceived, designed, and constructed simply to keep us engineers busy building things. In the past, goals, needs, and desires on the part of the public were much simpler and more straightforward than they are today. Now and in the future things will be much more complex. We must listen and be perceptive to changes in preferences which can occur rather quickly. Let us very briefly review two key pieces of legislation that have emphasized this in recent years.

I suppose it would be an understatement to say nothing in our field has been the same since the passage of the National Environmental Policy Act of 1969 (17). Engineers, planners, and public officials have always tried to be responsive to the needs of the public as they could see it. But NEPA told all of us that we had to look at new dimensions and consider in more depth and explicitly some additional factors.

The public had a new tool in the required environmental impact statements and a stronger voice in what sort of public works projects would be provided. Since NEPA became law in early 1970, there have been in excess of 400 suits brought charging inadequate evaluation of environmental impacts (20). These covered a wide variety of projects, not just in the water supply and pollution control field.

The public desired not simply to react after the fact to projects and plans they found unacceptable; the public wanted to *participate* in the planning (20). Section 101(e) of the 1972 Water Pollution Control Amendments (16) was quite explicit about this:

> Public participation in the development, revision, and enforcement of *any* regulation, standard, effluent limitation, plan, or program established by the Administrator (of EPA) or any State under this Act shall be *provided for, encouraged,* and *assisted* by the Administrator and the States. (Emphasis added)

This would seem to cover just about everything in the water supply and wastewater treatment field. Not only should citizen participation be tolerated but now it must be "provided for, encouraged, and assisted."

When the minimum public participation regulations called for in Section 101(e) of P. L. 92-500 were promulgated in 1973 (19), the language was clear:

> The major objectives of such (public) participation include *greater responsiveness* of governmental actions to public concerns and priorities, and improved popular understanding of official programs and actions. Although the primary responsibility for water quality decision-making is vested by law in public agencies at the various levels of government, *active public involvement in* and *scrutiny of* the intergovernmental decision-making process is *desirable* to accomplish these objectives. Conferring with the public *after* a final agency decision has been made will *not* meet the requirements of this part. The intent of these regulations is to foster a spirit of openness and a sense of mutual trust between the public and the State and Federal agencies in efforts to restore and maintain the integrity of the Nation's waters. (Emphasis added)

The guidelines (19) went on to point out, among other things, that public participation should be a *continuing* process, that it should be initiated as *early* as possible, that a *variety* of formats should be utilized as appropriate (i.e., not sole reliance on meetings and hearings), and that the process should be *convenient* to the public. Meaningful summaries of public participation programs developed and implemented pursuant to these regulations were, with certain exceptions, to be a part of all plans and grant applications submitted to EPA for approval or funding.

Public participation in agency decision-making relative to public works planning has been recognized as important for a long time. A public meeting or hearing used to suffice, but not so in recent years, especially when issues are complex and controversy is present (20). In a very recent study, the General Accounting Office reiterates the message of the EPA guidelines in insisting upon early involvement, the use of various formats for participation, and a continuing process of seeking public input (20).

So we see that one very good answer to the question, "Why is public participation needed?" is that it is *required* if we are to get the job done right today.

As public officials, planners, engineers, or citizens, we are cognizant of the fact that financial resources for social investment are indeed limited. We are more aware of this today than we have been in past years. A great concern I have is that we be effective in informing the public of the need for and the benefits resulting from environmental control and water resources developments in general.

Those of us who are extremely close to these areas seem to feel that they are justified and always will be. The public, however, with a broad array of needs and desires, is constantly trying to determine what benefits they receive from differing areas of public investment. They are becoming more aware that it is their decision. I am concerned that in our quest for environmental protection and certain other areas we may tend to overdo things with the assumption that the public supports our actions. Improved understanding of environmental control programs on the part of the general public is cited as an objective of effective citizen involvement (19).

If we tend to devote what appears to be an excessive amount of investment in this area without the public fully appreciating what they are getting, it is quite possible that the public could lose confidence in us and desire that public funds be allocated to other areas. It has been noted (20) that "citizens no longer trust government officials to make decisions in the public interest about public works projects." I, too, have encountered such apprehensions on the part of a number of citizens relative to environmental control decisions.

It is, therefore, incumbent upon us to do a good job of communicating with the public so that our projects and actions may be more responsive. My emphasis is on being responsive and not selling our projects.

If you are a consulting engineer, you are interested in getting good projects conceived, planned, and implemented in a timely manner. That is your business. If you are a public official, your principal interest is in solving a problem for your constituents in a timely manner. In any event, good public participation can help you a great deal.

The public as a whole can and will influence the future demand for activities related to the environment and water resources development. This includes all facets of water supply and wastewater treatment, as well as all other areas. Municipalities, federal and state government agencies, developers, industry, and all other parties can and must consider this as they make projections and perform their early planning as well as during the process of developing alternative courses of action (12, 13).

In recent years, we have seen a significant evolution of goals, preferences, priorities, and attitudes on the part of the public. We must be aware of the emerging group of consumers, decision-makers, voters, and citizens. Not too many years ago, *bigness* was equated with *goodness* in the minds of most. Today, however, there is considerably more interest in and concern about the *quality of life*. This is being manifested in recent legislation and guidelines pertaining to water-related planning (17, 21).

All of this will affect the future demands for wastewater treatment, development of new water supplies for expanding populations, urban and rural development patterns, etc. within any portion of the coastal zone.

We have seen trends in the past which perhaps indicate an increasing demand for certain services related to water and wastewater. Many of the projects now under construction, designed, or well along in the planning process have been based upon this. Being realistic, we are somewhat limited in the changes that we can make in the very near future.

The public, however, is going to have a great deal to say as they change their desires, consumption patterns, and attitudes toward development as it relates to demand for water-related services on into the future, out on the planning horizon where many of us are now concentrating (12). In five or ten or twenty years, these changing preferences could well be manifested and could lead to significantly different demands for water supply and wastewater activity in the coastal zone. We are inviting difficulty if we try to project too many trends of the past too far into the future without adequately involving the public.

As we get into larger-scale systems--e.g., regional water supply and area-wide wastewater systems, we see that the mix or blend of *art* and *science* changes drastically. For the smaller-scale systems--e.g., an individual treatment plant--we are more concerned with the *nuts and bolts* or *technological* matters. As we get into subjects that are of concern to most of us here, we see that an increasing facility in economic, institutional, legal, political, and social matters assumes a tremendously important role. This is contrasted with the technology, engineering, and more straightforward scientific aspects of the smaller-scale systems.

As we go into this *systems* zone where we are encountering sometimes more art than science, we must develop or utilize different attributes if we are to deal responsibly and effectively with the public (6). Included are matters such as the following: (a) communication skills, (b) sensitivity, (c) perceptiveness, (d) responsiveness, (e) openness, (f) sincerity, (g) cooperation, (h) tolerance, (i) understanding, (j) willingness to listen, and (k) willingness to work with others. Several of the latter attributes--i.e., tolerance, willingness to listen, and willingness to work with others--are especially important as they relate to working with non-technical individuals. It is important to note that these are the people who comprise most of the *public or publics*. The previously cited GAO report (20) alludes to similar needs on the part of planners. You and I may feel that we understand how decisions are made concerning public works and development matters. Too often, however, large numbers of the public or key representatives of the public feel this is done in an environment which is somewhat hostile to and insulated from public input. They feel that it is very difficult to have inputs or that comment, advice, and suggestions from the public are not particularly welcome.

It will take our very best efforts in the future to achieve a more desirable and open environment where the public feels welcome to have inputs and also where the public feels they are really having some impact upon what happens. We engineers, planners, and public officials may think we are doing a thoroughly adequate job; but it is the public's *perception* of the process which really counts.

I would now pose the question, "What is *effective* and *meaningful* public participation?" Perhaps we should ease into the matter of public participation through the side door by considering some thoughts on just what *public participation* or *citizen involvement* involves.

Really, it is much easier to talk about what public participation does *not* involve (14). First, public participation is *not* "PR." It is, or at least should be, a great deal more than just a public relations operation which is designed and conducted for the sole purpose of promoting *public acceptance* of a project.

Second, public participation is *not* overwhelming the public with miscellaneous information. Included are notices of public meetings, fact sheets, various sorts of documents, studies, reports, etc. Too frequently, the public is literally overwhelmed with such information that is not designated to do a very effective job of providing them with the information that they need to really be prepared to interface with us in a meaningful manner.

Finally, public participation should *not* be considered as identically equal to holding a public meeting or hearing in the local high school gymnasium. Such functions are usually equipped with a tape recorder so that a record might be provided, a sign-in sheet (where you sometimes indicate *before* the meeting whether you wish to speak *for* or *against* the proposal!), dedicated public servants, and prepared statements presented by opponents and advocates. All too frequently, these meetings go on for a more or less previously determined period of time, perhaps two hours, with the record held open for 30 days so that additional comments may be *received and considered in reaching a decision*. As I will indicate later, this may not be a very good way to try to achieve effective, meaningful public participation! Both EPA and the GAO have recognized the limitations of relying strictly on public meetings (19, 20).

There is a great deal of difference between *talking to* the public at a public hearing and *communicating with* the public utilizing a variety of formats and on a continuing basis.

Summarizing the previous comments, public participation should be viewed as neither a frill, a cover-up, a smoke screen, an add-on, a gimmick, an optional activity, nor an item from the "PR" trick bag. Public participation is necessary to facilitate good, sound, responsive, socially acceptable projects and plans. After all, this is what all of us, you and I, are and should rightly be concerned with.

Next, I would like to provide some comments on differing concepts of public participation. I would like to discuss briefly their effectiveness, and also suggest some approaches applicable to projects in the water supply and wastewater treatment areas.

What are the major components of a public participation program? There are three major components that somehow must be provided for in such a program (14). First, there must be a communication method to provide information necessary to evaluate project alternatives. Second, there must be a mechanism for planners and the participating public to interact. Third, there must be an iterative mechanism for planners, engineers, and public officials as well as the public or the publics to review the recommendations after comment has been obtained, additional study has been accomplished, and revisions made.

One investigator (1) has suggested something of an ascending *participation ladder* which might be as follows:

1. manipulation
2. therapy
3. informing
4. consultation
5. placation
6. partnership
7. delegated power
8. citizen control

The first two steps on this *ladder*--i.e., manipulation and therapy--are simply levels of *non-participation* for all practical purposes. The third step--i.e., informing--may in many instances also be in the realm of non-participation or merely *tokenism*. The next three steps on the ladder--i.e., consultation, placation, and partnership--are pretty much degrees of tokenism. The last two steps on the ladder--i.e., delegated power and citizen control--are indicative of some substantial degree of citizen power in the process. The sixth category--i.e., partnership--may in many instances denote some degree of actual citizen power but will normally be more in the nature of tokenism.

I am sure that all of us have seen a good bit of some of the first types of *participation* used. We may have infrequently encountered activities bordering on partnership and some level of delegated power. The latter categories or steps on the participation ladder are not frequently encountered in practice.

Another source (14) has suggested a somewhat different classification of public participation levels. These are referred to as *authority levels*. These are as follows:

1. non-participation
2. information participation
3. consulting participation
4. iterative participation
5. authorization participation

The first level--i.e., non-participation--is fairly self-explanatory. The second level--i.e., information participation--has the dimensions of informing the public but does not provide for any mechanism to interface the public in a meaningful manner with the actual planning and development process.

The third authority level--i.e., consulting participation--usually takes the form of committees or boards to review and comment upon development proposals and other activities. In this approach, the public is interfaced with the process; but there is no implied obligation to actually consider or incorporate the input or to necessarily provide a meaningful feedback mechanism.

The fourth level--i.e., iterative participation--allows a significant level of involvement by a group including representatives of the publics. The engineers, planners, and public officials are obligated to revise the plan in line with recommendations from the group up to a point. The final decision, however, as to what form the plan will take or when the participation process will be terminated is up to the development or governmental participations.

The final level--i.e., authorization participation--involves a very significant degree of participation by the public. The group, whatever form it may take, has legislated or delegated powers to override the engineers, planners, or government officials as to the final decisions relative to the project or plan.

The first three levels--i.e., non-participation, information participation, and consulting participation--are commonly encountered in practice. The fourth level of participation--i.e., iterative participation--is encountered in practice but fairly infrequently with any meaningful level of activity or accomplishment in the final analysis. The highest level--i.e., authorization participation--is extremely rare if you have encountered it at all.

I suggest that *authorization level participation* in any form should be approached with great caution on the part of public officials and developers. I say this not because of a lack of confidence in all of the parties but because all concerned should be thoroughly familiar with the ramifications and the great degree of commitment that is required at this level. If all of the parties are thoroughly aware of what they are getting into, this could be very useful and a meaningful experience which should promote wiser and more responsive planning and development in the water supply and the wastewater areas. The various parties should know what is involved for other levels of participation as well if it is to produce useful results.

In my own opinion, one of the really critical factors involving public participation is the matter of everyone's obtaining a good *feel* for the trade-offs and the cause-and-effect relationships that are present in the environmental control and water resources development areas (6, 10, 14). The public must be informed on what they are going to get as a result of various approaches, options, and levels of development. They need to be informed of just what it will cost them now and on into the future.

If they are sufficiently acquainted with the positive and negative aspects of a proposal and know the costs that they will be obligated to bear, they are in a much better position to determine whether they still want this sort of development, whether it is indeed acceptable to them, or whether they would like to look at variations of the alternatives which have been developed, or maybe even throw them all out and have additional alternatives developed and investigated (12, 13). As stated previously, with meaningful participation, the situation of having only unacceptable alternatives to present in the later stages can be minimized or avoided.

Many technical and professional people such as engineers, planners, and others have concerns about whether the public is really able to consider alternatives and to address the matter of trade-offs. The public does this all the time, just as we do, in their own personal affairs. They have limited resources which they may allocate to a variety of activities.

If you look at something as common as an electric power bill, something that is in everyone's home once a month, you can appreciate the fact that the public is seeing this sort of information on a regular basis (10). When the public considers the increase in power bills over the last year or two years, they should be aware that a great deal of this cost is due to additional pollution control devices, environmental impact studies, low-sulfur coal, environmental quality monitoring programs, and the like as well as inflation.

The public can have a great deal to say about what direction power rates are heading in the future. If they are less concerned about environmental control, they should be able to state this in a manner such that related costs to the utilities will decrease. If they are willing to pay more for greater environmental protection, this, too, will occur.

The point is that the public is dealing with matters related to trade-offs in their everyday lives. The question may be whether they are *aware* that these trade-offs exist and that they are impacting directly upon the individual, as opposed to being strictly in the domain of the technical and professional person.

Sometimes I am asked whether a topic such as *public participation* is really *engineering* or not. If we consider that an important aspect of good engineering as well as good planning and doing a good job of being a good public official happens to be developing and choosing among alternatives for the investment of public money, then I would say, *"Yes."* Public participation *is* an important part of good engineering today (6). It enables us to do a more effective and responsive job of choosing among different alternative courses of action.

And, of course, even a good plan is of no value unless it can be implemented. An EPA planning document (18) states this very concisely:

The three essential ingredients for plan implementation are *public support*, institutional arrangements, and a financial program and schedule. *Public support* is an outgrowth of the *public involvement* program. (Emphasis added)

Perhaps you can better understand why I say public participation *is* an integral part of good engineering today.

I have appreciated the opportunity to discuss the importance of good planning and good public participation with public officials, engineers, planners, environmentalists (a vague term), and just plain citizens in recent years (2-14). All have seemed to agree that it would be useful to them in their respective roles.

Today, many people seem to view environmental and water resources development matters as being simply a matter of choosing between two extremes, these being the advocates for more development and more growth on one end of the spectrum and those who would say no more growth, no more development at the other end of the spectrum.

It is a much more complex situation today. This is especially the case if you look and listen hard enough to what is going on with the public. When you consider the tremendous array of interests, opinions, and preferences on the part of the public, you can see why the conscientious engineer, planner, and public official is having a very difficult time assimilating this in the process of making wise and reasoned investment decisions (5, 10).

I have stated previously that public participation should not be confused with holding a public hearing toward the end of the design process. A question that I am frequently asked is, "Just when *can* the various publics get involved in the decision-making process?" My reaction is that the public can and should get involved from the very beginning all the way to the time the project goes on line but in varying degrees and utilizing varying formats. This contention is supported by the GAO report (20) and recommendations in the EPA guidelines (19).

To illustrate this, consider just how a municipality, any other government body, or an industry might get some sort of facility actually into operation. What are the steps that are involved in this? I have listed a lengthy set of steps below for illustrative purposes:

1. predict future conditions
2. predict future demands for water supply and wastewater services
3. investigate financing
4. preliminary review of sites and technologies
5. preliminary designs
6. preliminary reviews by regulatory agencies
7. narrow down sites and technologies combinations
8. more preliminary design
9. more information and review
10. narrow down alternatives further
11. further reviews by regulatory agencies
12. more design and information
13. select a suitable site and technology combination
14. more detailed studies and design

15. preliminary approvals from agencies
16. application for funding
17. environmental report and license application, if appropriate
18. review, hearings, etc.
19. approval to construction permit
20. final financing decisions
21. final revision of designs
22. construction
23. review, inspection, operating permit
24. start up
25. finally, produce water-related services.

As may be seen from this, there are usually many years involved between the time future conditions are predicted until the time that you actually begin producing services for the public! The public's input must be sought and obtained *throughout* the long process, not after all of the decisions of any significance have been reached. This is what we are, or should be, striving for now and on into the future. EPA indicates that public participation should be involved all the way from delineating planning areas to the completion of implementation arrangements in facility planning (18).

A variety of formats will be required throughout the project to obtain this necessary and desirable public input (14, 20). In the process of getting a project completed, public participation will tend to involve a wider and wider circle of persons and deal more and more with specifics as opposed to concepts and preferences in general.

Over many years, then, the public can have input in various manners. Whether we are talking about the need for a wastewater treatment facility, a power-generating facility, or improved transportation facilities, we go through basically the same steps. We ask, "How much of this particular service is the public going to need? Or how much does the public want? Or how much will they accept at some time in the future?" As we proceed, we determine what are the preferences of the public concerning different types of technologies and different locations for such activities.

We can and should obtain reactions to preliminary selections of alternative combinations of sites and technologies. We get feedback from discussion with the public and from a presentation of a limited number of alternatives that appear to be technologically and economically feasible and acceptable to the public. Then, we finally get a reaction to the final plan and proceed. There is no excuse for waiting until very late in the process to delve into the matter of public involvement. It can be used early in the process, and it should be, as well as throughout the process (18, 20).

As I am sure you can understand, the same format for obtaining the needed public participation is not necessarily appropriate or sufficient throughout the process. Previous citations to GAO (20) and EPA (19) documents indicate the need to utilize other formats in addition to the public meeting or hearing in many instances. The public meeting or hearing may be very appropriate for review of the small number of potentially feasible alternatives for which preliminary design has been accomplished and also for the presentation of the final plan. In the early phases, however, the number of people involved and how the whole procedure is handled must be quite different.

Putting together and actually implementing a meaningful and effective public participation program is a very complex and individual matter. I have listed below a number of factors which must be considered when putting together a public participation program (14). You will find some very interesting, stimulating, and perhaps bothersome factors in this list:

1. What interests will be represented?

2. One representative per interest group, or representation in proportion to numbers or other considerations?

3. Who nominates or selects the interests to be represented or the actual individuals?

4. All *citizens* or mix including *experts*?

5. Small versus large group? (Flexible and manageable versus unwieldy?)

6. Closed or open operation? (Quiet and constructive versus *forum for dissent*?)

7. Formal or informal?

8. Specific charge to group or wide latitude?

9. High level or low level? (How much prestige? What type of person can be attracted?)

10. Continuing, intermittent, or one-shot operation?

11. How early and how long involved?

12. What information to be made available?

13. Any staff? What types? Expert input? If so, *independent* or from concerned parties?

14. What resources will be available? Funds from what source?

15. Freedom or constrained?

16. Form of output?

17. To whom does group report?

18. How will differences be handled? Will they be reported and how?

19. Single or multiple output? Over duration of effort, at end, or both?

20. Will media be involved? When?

21. How often will committee meet? What goes on between meetings?

22. How will group be organized and led?

23. Will format change over duration?

24. How much influence will committee or results actually have? How much do they think they will have?

25. *Show-case* operation or genuine?

26. *Constructive* environment or allow conflicts to surface?

27. Etc.

There are, too, a number of different interests and publics that may be concerned with a major water or wastewater plan. There are also a great variety of techniques of public participation that may be appropriate and useful for various types of projects or at various times during the course of the project (19, 20). It is apparent, then, that the matter of putting together a meaningful and appropriate public participation program can be very involved.

The depth, format, duration, commitment, etc. can vary from one public participation effort to the next effort and should be tailored to fit certain important aspects of the situation. Included are factors such as magnitude or scale of the project, level of interest or concern, physical conditions or characteristics of the location, potential adverse effects of various types, etc. These are factors which must be evaluated for the specific project or type of project or plan with which you are concerned.

I would reiterate that simply holding a public meeting or a hearing automatically at the prescribed point or points during a project may completely fail so far as obtaining meaningful citizen involvement is concerned (20). Just as it is possible to provide too little in the way of public participation opportunities, it is also possible to provide more extensive opportunities and programs than are necessary. This is why I have a basic quarrel with any guidelines or interpretation of such guidelines which would advocate and promote a rigid and fairly limited program of public participation. You can have the situation of an overkill or a complete farce in all too many instances.

Recently, I had the opportunity to review the public participation approaches and attitudes of several major government agencies working with the environment and water resources (7). The results, many of them of a very informal nature, were rather enlightening to me; and I would like to share a couple of them in passing. It seemed that most of the persons I contacted were using public participation for two reasons. These were, first, legal requirements for the use of public participation and, second, the feeling that it was or might be good for their image or was simply the right thing to do.

Most of the agency people with whom I spoke stated that they would really like to see more public participation going on. I am not quite sure what to make of this. I am sure many of these professionals have a genuine desire to get a better feel for what the public wants and also to devise and implement plans and projects which are responsive to the public's needs.

It is likely, however, that in too many instances these individuals are not sufficiently aware of what you can get into if you really seek public participation. I am not sure all of them are interested in the level of commitment and effort that might be required to engage in what I consider to be effective, meaningful public participation.

I found a good proportion, perhaps a majority, of these persons were not really sure what was *supposed* to be involved in a citizen involvement program. They gave strong indications of a very limited knowledge of alternative formats, techniques, and approaches which might be utilized in obtaining citizen input. Most seem to feel that public meetings and public hearings, combined with the opportunity to submit written comments on proposals, was about the extent of public participation.

My conclusion was that, in most instances, what was occurring was a process of more or less going through the required motions of obtaining citizen input pursuant to legislation, requirements, and guidelines.

There is a greatly differing opinion on the part of many as to whether public participation and citizen involvement is a waste of time, a distraction, a necessary evil, a detriment to action, and a tool for delay on the one hand or whether it is useful, helpful, beneficial, and in general a very valuable tool on the other hand (7). The benefits that may accrue to consulting engineering firms, various levels of government, and all other parties is proportional to the attitude of the group which is responsible for the project, the depth of public involvement they have sought, and the commitment, perceptiveness, and responsiveness of all parties concerned.

For just a moment, let us look at public participation from the viewpoint of a government body or perhaps an industry (4, 8, 10). We should pose the question, "Why should they want and need public participation of the right kind and the right times?" They need it for at least two reasons. First, they want and value the good will and good opinion of the public. Also, they are interested in producing good service or attaining their mission whatever this may be. I think this is sufficient for the first point.

Second, they (and we) simply cannot afford not to engage in public participation today. A very strong case for effective and meaningful public participation can be made on a simple dollars-and-cents basis. This presumes, of course, that it is in the long-run best interest of the public to have some sort of development such as that which is being considered. I would concede that there are certain types of projects, developments, etc. which probably would not profit from a very open and thorough public participation program!

Consider for a moment the capital cost of a major water resources or environmental control project today. A large nuclear power plant may cost $1.5 billion. A large area-wide waste treatment system may cost $100 million. (If you include in such a system the collection system, pumping stations, etc., we are certainly talking about a large sum of money.) A dam and reservoir project can easily get into the $250 million category.

We should consider the effects of a one-year delay due to a lack of public acceptance, litigation, or any other reason. I did recently and discussed it with a group of engineers (8). The interest alone on the capital would be substantial. For the power plant, the waste treatment system, and the reservoir project, we could be talking in terms of $225 million, $10 million, and nearly $40 million, respectively. In order to be completely candid about the *costs* involved, we should also throw in the expenses of litigation, intervention, endless professional manpower tied up, wear and tear on all parties concerned, erosion of public confidence, lost benefits to the public, and many other factors. Among these *other factors* are bleeding ulcers and the like which tend to visit those who are most deeply involved in such matters.

What are the probabilities of such a delay or maybe even a longer delay due to a project's being out of line with the desires or preferences of some part of the public? Today, we have a number of groups which have the expertise, the resources, and the commitment to intervene and to fight projects very effectively. In certain instances, a major effort to influence the course of a project or to intervene in a development may be initiated and supported by a very small group of people. In such cases, we must be very careful to differentiate between broad, legitimate public interest and support on the one hand and concern and interests which have been put together for perhaps less noble or less well-informed purposes on the other.

In any event, the probabilities of delay on major projects could easily fall into the range of 10 to 25 percent. Now we may talk in terms of *expected* costs due to delays and lack of public acceptance of major projects. The expected annual cost for delays, considering only interest on the capital, is in the neighborhood of $20 to $60 million for the power plant, from $1 to $3 million for the waste treatment system, and from $4 to $10 million on the reservoir project. This is for only one year.

In my opinion, neither government at any level, development interests, industry, nor the public can afford waste of this magnitude, especially if there is a viable alternative. First, if the services of the project are needed, problems, losses, and inconveniences will result to the public and everyone else from the delay. Second, the project may well be out of line with the public's desires, preferences, and needs. As such, this could constitute a waste of resources even if it were built on time. Third, this is simply a great deal of money. The public, the consumers, and the taxpayers will ultimately bear the cost of delayed projects which are not acceptable to the public.

It is unfortunate and unnecessary for this waste and delay to occur for, as an EPA document (18) states:

> If the *public involvement* program and the environmental evaluation have been *well done*, the important issues and evaluative factors should be *known* by the time a plan selection is made. (Emphasis added)

This same source (18) makes the interesting, though sometimes overlooked, observation that "the environmental evaluation should have some impact on the initial assumptions, development and screening alternatives."

The recent GAO report on citizen participation in the planning of public works projects (20) cited a statement made in 1972 that "if (*public*) *involvement* were *well carried out*, agreements could be reached and costly project delays *avoided* in most cases." (Emphasis added)

The GAO report (20) emphasized that especially for controversial matters, "(t)he earlier issues are recognized, the greater flexibility there is in planning."

If a situation concerning a water supply or wastewater project or any other development or public works project degenerates into a fight involving government agencies, industry, other development interests, the public, or other parties, it is a foregone conclusion that all parties will lose (5, 14). It is only a matter of degree as to who will lose the most (8). When involvement comes too late, there is a "tendency . . . to defend previously determined courses of action, rather than to explore any new information or views received (20)."

This would be extremely unfortunate, as an environment of mutual respect and credibility can be established by means of effective public participation programs. In this manner, constructive input and *give and take* can replace needless polarization and adversary relationships. In some instances, it must be admitted, intervention and litigation are warranted.

It is entirely unrealistic to expect that you will ever be able to achieve total agreement by all individuals and parties in a meaningful and effective citizen involvement effort. In a situation where broad and easy agreement is obtained, one should be suspect of at least a couple of things. One is that the matter is trivial and did not warrant an extensive program to begin with. Second, it might well be that a handpicked or non-representative group of individuals are participating in order to give the illusion of public participation.

Even though unanimity may not be expected under any conditions, at least all of the parties will have the facts and, hopefully, be able to appreciate why other parties do not agree on all of the facets of the project.

Real public participation efforts require a very significant commitment from all parties concerned. This includes the public or its representatives as well as those participants from the various levels of government, industry, development interests, etc. This commitment must be to a responsive and constructive effort entered into in good faith. It must be an effort in which all parties are open-minded and respect the honest convictions of others who may well differ at the beginning and when the process is over.

When properly conceived, designed, implemented, and maintained, meaningful public participation programs have resulted in experiences which have been gratifying to all concerned. This applies to representatives of the various publics as well as those who are from government, industry, and development interests.

In the last three years, I have been involved in putting together or contributing to several major public participation programs for environmental and water resources projects with a total capital investment in excess of $3 billion. These varied from one shot efforts to continuing, in-depth programs.

I can speak with some degree of authority in saying that some very tangible beneficial results have come from these efforts. It has indicated to me, to representatives of the environmental community, to government officials, and to some responsible development interests that citizen involvement may be achieved to a meaningful degree over an extended period of time. There were many skeptics in the formative stages admittedly; but most have a different view of public participation now.

The sponsors and developers felt that the effort expended in these programs was very worthwhile and did lead to, or are leading to, developments and courses of action which are better than originally intended. They are certainly more responsive to legitimate public preferences, some of which were poorly understood or not fully appreciated prior to initiation of the programs. All have learned from the experience.

In one instance, a suggestion from a citizen participant led to a design modification which should reduce the quantity of waste released to the environment and resulted in a sizeable savings in capital cost!

In summary, I see the role of public participation and citizen involvement as being an extremely important one if we are to do our jobs as public officials, engineers, planners, and good citizens. Public participation can be a *positive* and *constructive* activity which allows the various interest groups to gain better appreciation of the opinions and preferences of others. It can and will lead to improved projects and more effective utilization of not only limited financial resources but our natural resources as well.

This must be a *continuing* process starting at the very *beginning* of a project when the needs for services are being projected, continuing on through the alternative definition and evaluation stage, and into detailed planning and design. It *cannot* wait until the end of the process to be initiated or *retrofitted.*

As public participation continues in the course as a planning effort, more and more people must become involved; and different formats of public participation are appropriate.

Effective and meaningful public participation is money and time and effort well spent if we are to serve the needs of the public in a responsible manner.

I believe in and appreciate the philosophies contained in the work of Aldo Leopold. One quote from Leopold's *Sand County Almanac* (15) comes back to me whenever I think of planning, public participation, and our challenges in meeting the responsibilities ahead of us:

. . . Man, while now captain of the adventuring ship, is hardly the sole object of its quest, and . . . his prior assumptions to this effect arose from the simple necessity of whistling in the dark.

It is not necessary that we *whistle in the dark* when we and the public can have a real input into the process of deciding on projects and plans in the environmental area. Instead, we can have informed and constructive dialogue between responsible citizens and responsible government, industry, and professionals.

I encourage you to promote and implement effective public participation. In the long run, it can make your job a lot easier and can make the results of your efforts much more responsive to the needs of society whom we all seek to serve.

REFERENCES

1. Amstein, S., "A Ladder of Citizen Participation," *Journal of the American Institute of Planners*, Vol. 35, No. 4 (1969).

2. Dysart, B. C., III, "Begin Planning Today to Meet E.P.A. Requirements in 1977 and 1983," 9th Annual Air and Water Pollution Control Seminar, Clemson, South Carolina (1973).

3. Dysart, B. C., III, "The Challenge for Informed Public Involvement in Natural Resources Decision-Making," Blue Ridge Conservation Summit, Black Mountain, North Carolina (1974).

4. Dysart, B. C., III, "A Clear Overview of Engineers and Conservationists . . . or . . . Observations from the Middle of the Pile," Annual Technical Conference of the Institute of Electrical and Electronics Engineers South Carolina Affiliation, Columbia, South Carolina (1974).

5. Dysart, B. C., III, "A Constructive Role for Citizens and Conservationists in Environmental Decision Making," South Carolina Press Association, Clemson, South Carolina (1971).

6. Dysart, B. C., III, "Educating Water Resources Engineers for Effective Public Participation," American Society of Civil Engineers National Environmental Engineering Meeting, Kansas City, Missouri (1974).

7. Dysart, B. C., III, "Education of Planners and Managers for Effective Public Participation," *Proceedings of the South Atlantic-Gulf-Tennessee Regional Conference on Public Participation in Water Resources Planning*, Raleigh, North Carolina (1974).

8. Dysart, B. C., III, "Engineers, Conservationists, and the Public Interest: Some Inside Perspectives," American Society of Civil Engineers, North Carolina Section, Southern Branch, Charlotte, North Carolina (1975).

9. Dysart, B.C., III, "Important Environmental Issues Facing Local Elected Officials in South Carolina Today and in the Near Future," Symposium for Local Elected Officials, Columbia, South Carolina (1973).

10. Dysart, B.C., III, "The Public's Role in the Environmental Decision-Making Process," Energy and the Environment Workshop, Lake Hickory, North Carolina (1974).

11. Dysart, B. C., III, "What the Public Needs to Know about Public Participation in Water Resources and Environmental Control," Environmental Protection Agency/Conservation Foundation/Audubon Society Public Participation Workshop, Columbia, South Carolina (1974).

12. Dysart, B. C., III, and A. H. Barnett, "Determination of Public Environmental Preferences in Water Resources Planning and Development," American Society of Civil Engineers National Environmental Engineering Meeting, St. Louis, Missouri (1971).

13. Dysart, B. C., III, and A. H. Barnett, "Public Preferences and Environmental Quality in South Carolina - Results of the Greenville County Study," South Carolina Water and Pollution Control Association Annual Meeting, Columbia, South Carolina (1971).

14. Dysart, B. C., III, and L. W. Curtis, "Public Participation in Environmental Planning," American Society of Civil Engineers National Environmental Engineering Meeting, Kansas City, Missouri (1974).

15. Leopold, A., *A Sand County Almanac*, Oxford University Press, New York (1966).

16. U. S. Congress, "Federal Water Pollution Control Act Amendments of 1972," P. L. 92-500 (1972).

17. U. S. Congress, "National Environmental Policy Act of 1969," P.L. 91-190 (1970).

18. U. S. Environmental Protection Agency, *Facilities Planning Summary* (1974).

19. U. S. Environmental Protection Agency, "Public Participation in Water Pollution Control," *Federal Register*, Vol. 38, No. 163 (1973).

20. U. S. General Accounting Office, *Public Involvement in Planning Public Works Projects Should be Increased*, Report B-153449 to the Congress (1974).

21. U. S. Water Resources Council, "Principles and Standards for Planning Water and Related Land Resources," *Federal Register*, Vol. 38, No. 174 (1973).

IMPACT OF WATER SUPPLY AND WASTEWATER ON THE COASTAL AND MARINE ENVIRONMENTS

B. J. Copeland
University of North Carolina
Sea Grant Program
Raleigh, North Carolina

At the beginning of this conference, we were challenged by Col. Beverly Snow in his call-to-order to direct our minds and experiences to solving the problems related to water supply and wastewater disposal in the coastal zone. He referred to our cast of characters as *experts* who will review the state-of-the-art for proper planning and management of water supply and wastewater disposal in coastal areas. We were further directed to focus special attention to defining technological and institutional alternatives, their relation to land-use planning and environmental protection, and to identifying those water and wastewater problems of significance in the coastal area. My role here today, therefore, is to serve as one of those so-called *experts* to develop two lines of thought: (1) to summarize the conference and to place it in environmental perspective, and (2) to share with you some of my experiences relating to the impact of water supply and wastewater on the coastal and marine environments.

As one of the many co-hosts of this conference, I take this opportunity to express our appreciation to all of you for attending the conference and helping to make it the success that it has been. One of our goals was to bring together government officials, engineers, scientists, planners, developers, and other groups interested in development of the coastal area along with the University community to focus upon these important issues. From that standpoint, the conference has been a resounding success, and we are ready now to bring it to conclusion. But before we do, let me challenge you to not let this be the end but to go forth from here with the action program necessary to solve the problems that have been identified. It is my pleasure to conclude this conference by discussing the two points given me by the program committee.

SUMMARY OF THE CONFERENCE

Overview

We heard at the outset that water and wastewater problems were only a part of the overall complexity of management of the coastal zone. Certainly, these are important ones, but the list facing us is almost endless. Preserving the environment, which has been said to be the key to the attractiveness to the coastal zone for economic development, is certainly an important goal.

Water supply in the local environment is quickly exceeded by man's development and gives rise to a larger spectrum of problems such as salt-water intrusion and deterioration of quality. Thus, we must consider alternatives for providing adequate water supply while protecting the public health and welfare and environmental resources.

A critical problem is the question of what to do with our waste which taxes the assimilative capacity of receiving lands and waters. A solution suggested as being reasonable was to collect, treat, and dispose of domestic waste by ocean outfalls; but before this can become a viable reality we must explore the alternatives and determine the most cost-effective and environmentally sound means of waste disposal.

Water Supply

Alternatives for augmenting water supply in the coastal zone range from utilizing underlying fresh water of varying and decreasing quality to stealing water from somewhere else and transporting it at great costs. All suggested alternatives presented considerable problems; and solving these problems is going to require coordination, more advanced technology, large costs, and detailed planning.

Groundwater sources were discussed, but little was said of their quality and degree of required treatment. Most groundwater sources on the barrier islands are limited, and great economic and environmental problems exist with their use.

Conversion of saline water to drinking water was one viable alternative described. Problems here, however, exist in economics, environmental impact, and transportation. For example, the usage of such water is uphill from the source thus requiring great energy to transport it.

Perhaps the most exciting alternative was the suggestion for reuse of wastewater. This alternative promises the potential of maximizing the demand for water with the need to dispose of the waste. There are problems, however, with costs, public acceptability, and technology.

Wastewater Disposal

Alternatives given for disposal of wastewater in the coastal zone range from individual septic tanks to regional collection systems with ocean outfalls. We were given the framework for management and financing alternatives for waste disposal. The coastal zone presents a unique set of circumstances in that local sources must support the program, but most of these activities are owned by people who live and vote elsewhere. Because of the great complexity and need for qualified management in the coastal area, state level support for these facilities will probably be desirable.

Septic tank disposal is at present a common means of waste disposal (and it was emphasized here that it is a disposal technique rather than a treatment technique); and it presents a serious problem to surface and sub-surface water quality because of seepage and contamination of those water sources. It is necessary for septic tanks to be used with caution, and at best they offer a tentative and interim solution.

Land disposal of waste has proven to be a viable means of disposing of animal waste in the Piedmont area. More work needs to be done, however, with the unique soil types in the coastal zone before land disposal can become a reality there.

Deep-well injection was suggested as a potential alternative. Problems here include the need to know the fate of the wastes and the potential for groundwater contamination.

Ocean outfalls were described as cost-effective and environmentally safe means of waste disposal in the coastal zone. Examples of working facilities from elsewhere in the country were given, but the uniqueness of North Carolina's coastal zone should be considered. A representative from the Environmental Protection Agency outlined the criteria whereby that agency would evaluate each ocean outfall case individually. We were given a list of *do's* and *don't's* that defied comprehension concerning ocean outfalls.

We were also reminded that traditional treatment facilities were still in operation and that innovations in conventional treatment can improve wastewater. There is a disposal problem here, however, that generally results in wastewaters reaching the sounds and estuaries, which may be more productive and vulnerable than the ocean.

Planning

The need for the development of comprehensive planning was demonstrated, but we were cautioned that the citizenry must be involved if it is to be a workable plan. We were told that considerable planning has been done, but there is little evidence of its implementation. A parallel case is environmental planning with little evidence of implementation and tangible results.

The enactment of the Coastal Area Management Act has established a framework for areas of environmental concern which will set forth implementation of plans for management of our coastal resources. Before any of these planning activities can become a reality, we need to develop institutional arrangements for managing water and wastewater choices along with protecting the environment.

We were told that whatever we do, including nothing, would cost us in money or in opportunities lost. It is important that these costs be accurately distributed so that we do not continue subsidizing industries at the cost of consumers and natural coastal resources.

Perhaps the most important aspect of all was the involvement of citizenry participation in any planning and management scheme. Until this has been assured, plans or implementation developed to manage the coastal zone and its resources are doomed to failure.

THE NEED FOR ENVIRONMENTAL ASSESSMENT

Built into any system for management of water supply and wastewater disposal is the need for protection and management of the sensitive coastal environment. The great variety of coastal ecological systems in North Carolina are valuable as ecological and aesthetic resources. These systems are biologically productive and, as such, provide the basis for many of the resources that man utilizes there.

Coastal ecological systems possess great complexity as well as having certain fragile characteristics. Because of this complexity and fragility, these ecosystems receive great pressures from development. Therefore, in order to maximize utilization of coastal resources we must also take firm and timely measures to protect the very environment creating the attractiveness of the coastal zone.

GENERAL ECOLOGICAL PRINCIPLES

The estuaries and sounds behind the North Carolina barrier islands are particularly vulnerable to man's activities. These ecosystems are easily accessible, they are attractive, and they present a rather complex make-up.

Estuaries serve as major nursery areas for about 85 percent of our commercial and sports fisheries species. These organisms migrate into the productive coastal ecosystems as larvae and post-larvae, utilize the great productivity there, grow at tremendous rates, and later leave as juveniles. This phenomenon is extremely critical to the maintenance of commercial and sports fisheries resources in our State.

Marsh and estuarine ecosystems are great mixing and assimilative zones for taking fresh water, nutrients, and organics from the land and creating great masses of floating and swimming protoplasm. Because of this, these systems are among the most productive systems in nature. A key to the productivity of estuarine ecosystems is the flow of fresh water bring nutrients, vitamins, organic foods, and physical energies to support that productivity. Some of our studies have shown that up to 50 percent of the productivity maintenance is reliant upon fresh water input.

Compared to other more stable ecosystems, estuaries are lower in diversity, but they produce greater amounts of these organisms utilizing them. Compared to the ocean, estuaries are 100 times more productive per unit area; thus, the magnitude of their importance.

Great precaution should be taken, therefore, to protect these important ecosystems for the production of food, aesthetic appeal, recreation, and other benefits to man. Although these systems have great recuperative ability, the resulting ecosystem may not be desirable to man. One great principle in nature is that some sort of ecosystem will result in response to whatever environmental characteristics are extant (i.e., a sewage pond is an ecosystem); but in general, these new and imposed ecosystems are low in the productivity of interest to man, and their aesthetic and recreational capabilities are generally low.

POTENTIAL ENVIRONMENTAL PROBLEMS FOR WATER SUPPLY ALTERNATIVES

Groundwater Sources

Salt-water intrusion is a likely result of excessive pumping of fresh water from groundwater supplies on barrier islands. Even though this in itself is a water quality problem, there are other, more far-reaching ramifications of salt-water intrusion. Because of the shallowness of water tables, salt-water intrusion could conceivably change the vegetative patterns of those terrestrial systems relying upon the shallow water tables for their support.

Another consequence of groundwater use is the potential for subsidence in areas where considerable pumping has occurred. Subsidence, in addition to changing land uses, can also give rise to the development of secondary land vegetative systems.

Conversion of Saline Waters

Aside from the energetic cost of moving desalinated water uphill, there is the problem of the disposal of brine wastes. These wastes are characteristically very concentrated, reaching concentrations as high as 200,000 ppm. Although the oceans and sounds may appear to be great dilution sinks, there is the problem of imbalanced ratios of ions. Unfortunately, the dissolution of sea salt is at a different chemical concentration than is the resolution. Thus, the dilution of brine wastes is not a viable solution to their disposal.

Wastewater Reuse

The recycling of wastewater through the water supply system is potentially an optimal choice of solving water problems of the coastal zone. This process would eliminate many environmental problems of waste disposal by utilizing the wastes for potable water supply. It would reduce the need to obtain new sources of water supply in an already water depressed area.

There is still the problem, however, of disposing of the solids developed in such a recycling operation. These solids could, however, be used to generate alternate energy sources by their conversion to methane gas.

Transport from Elsewhere

The most viable means of providing water supply alternatives for the coastal zone is the transport of potable water from upland areas. This, however, would require long-distance transport systems which, if not properly planned and constructed, could result in environmental problems. These transport systems could create barriers as they cross the sounds to the barrier islands interrupting normal circulation of water and materials within the sound ecosystem.

A perhaps more subtle environmental impact is the deprivation of estuaries of needed fresh water return flows. Picking up fresh water in upland areas and transporting it around the estuaries and sounds to the barrier islands where the return flows reach the lower sounds or the ocean might upset the normal rate of input of fresh water to estuarine ecosystems. As stated earlier, this could result in subtle changes in estuarine productivities.

POTENTIAL ENVIRONMENTAL PROBLEMS FOR WASTEWATER DISPOSAL ALTERNATIVES

Septic Tanks

Septic tanks are already in wide use in the coastal zone, particularly in some of the developments along the Outer Banks. Several environmental problems have been attributed to septic tanks; i.e., poor installation, exceeding their capacity, or too many per unit area.

Before more septic tanks are permitted in the coastal zone, there is a need for complete soil testing and hydrology data for realistic siting and sizing. The soils in the coastal zone tend to be very porous, and the water table sits very near the surface resulting in severe problems in the use of septic tanks.

A significant problem with septic tanks is the seepage of nutrients, organics, poisons, and pathogens into nearby surface and sub-surface waters. This, of course, would upset the use of existing shallow groundwater for water supply in water-depressed areas. There is considerable evidence now that pathogens from septic tanks have reached estuarine waters resulting in their closing for commercial shellfishing.

Land Disposal

Disposal of treated domestic waste on land may be an economical solution and at the same time provide needed fertilizers which have become increasingly short in supply. Land disposal has been worked out as a viable means of disposing of animal wastes in the North Carolina Piedmont. Work has also been done in North Carolina on the disposal of sewage on marshes where high organics and nutrients already exist.

Two types of problems exist with land disposal of wastes. Nutrients and trace metals flowing through the soil to groundwaters and then into surface waters presents one of the larger problem areas. With the porous soils and high water tables in the coastal zone, this problem is difficult to overcome. A second problem is the existence of pathogens in the sewage and their transport off the land and through the soil to nearby surface and groundwaters. If the basic knowledge of soil-water characteristics of coastal soils can be completed and loading rates equated to the assimilative and holding capacity of the soils, land disposal of domestic wastes in the coastal zone may become a reality.

Holding ponds, which are apparently necessary for land disposal pretreatment, are a potential hazard in areas with high water tables. Perhaps the provision of buffer zones of vegetation between the land disposal site and adjacent waters can help provide the necessary safety factor for land disposal. The availability of enough land area for effective disposal on the barrier islands is another problem.

Deep-well Injection

Although deep-well injection does not hold much potential as an effective waste disposal alternative in the coastal zone, it could be useful in some special areas. Here, we are faced with the contamination of precious groundwater supplies by the injection of domestic wastes into the ground. It is very difficult to determine the fate of the injected materials, and there is great potential for leakage of these into the sounds and the oceans. I do not believe that the *out-of-sight* and, therefore, *out-of-mind* technique for the disposal of domestic waste is a viable and workable solution in the coastal zone.

Conventional Treatment Plants

During the very near future, conventional treatment facilities and the disposal of treated wastes *in situ* seems to be the most presently usable solution to wastewater disposal problems. Even with various sophisticated treatments, we still must dispose of the effluent containing some nutrients and pathogens to the sounds and estuaries. This, of course, has its obvious results; and we are faced with those already.

Ocean Outfalls

A new technique for the disposal of wastewater in the coastal zone has been suggested to collect, treat, and dispose of domestic waste by ocean outfall. Of the many ocean outfalls around the periphery of the United States, some have worked well, and others have not. Critical to the environmental impact of an ocean outfall is its proper design and operation in concert with the environmental conditions present at the site. The North Carolina coastal zone is somewhat different than in other areas of the country, and the southern coast is different from the northern coast. Thus, the critical factor is the proper design with the existing environmental conditions.

Ocean outfall systems must contend with a very complex current and mixing situation off North Carolina. The dilution capacity is most likely adequate, but we must be careful regarding the back transport of sewage to beaches where there is large, potential people contact. Design criteria must be collected to prevent the localization of sludge at the outfall site and the proper use of diffusers to minimize the localization of sewage.

A perhaps more subtle impact of ocean outfalls is the deprivation of estuaries of varying amounts of needed fresh water inputs. The ocean outfall concept includes regional collection with adequate treatment and then disposal of the wastes offshore. This, of course, diverts ordinary inputs of fresh water around the estuaries where it may be of importance to maintenance of productivity.

An important point at the present time is that basic information for the design, construction, and operation of ocean outfalls is lacking in North Carolina. Studies are underway and others are planned to provide this basic information. Regardless of the availability of basic information and the design and monitoring criteria, we must work out a realistic permitting system with a monitoring program that has provisions for remedial action.

From an environmental point of view, it would seem that ocean outfalls is a viable alternative for disposal of wastes in the coastal zone providing the proper design and siting techniques are utilized. A pycnocline apparently exists nearshore off North Carolina with a net onshore drift of surface waters. If this is true, then proper design would have to place the outfall beneath the pycnocline so that the back transport towards the shore would be minimized.

QUESTIONS AND DISCUSSION

QUESTION: (Dr. Donald Francisco) In public hearings you are always confronted with opposing viewpoints by supposed experts. How do we avoid having the public view hearings as a negative response or negative feedback rather than positive?

DR. BENJAMIN C. DYSART: You posed a question there that I sometimes have a problem getting over to my students. There are varying viewpoints; and anything can be proven and supported by expert witnesses who will stand up and state that this is the case in good conscience. They will also have the data and information to prove it. Then, they are followed by someone who may take the same data or different data that's just as good and come to completely different conclusions. This is confusing to the public in case anyone actually came to such a meeting to learn what was going on. This is something which underscores the need for having involvement prior to that point so the public will know more about what is going on. I don't think we are ever going to get to the point where everyone is going to agree, whether we are talking about laymen simply deciding how much development they want in an area or whether we're talking about professionals who look at a situation the same way. We have to start early. If a public meeting or hearing is set up as the forum for hammering out these completely different viewpoints, then I think this is unfortunate. That should not be happening, though. If it is a matter of trying to gain advocates and convince somebody that this side is right, that's the wrong function of the hearing or meeting.

DR. B. J. COPELAND: I don't know how to answer your question, Don, except to say that it's a very sticky one. As Ben says, I think the public hearings are structured somewhat wrong in that we generally wind up in a kind of adversary situation where opposing points of view using the same data base are often given. I've been involved in some of those. So the public goes away saying,"Those guys don't know what they are doing--they're crazy!" I agree with Ben also that when you have a series of interactions with the public about a question in point so that they can begin to see the background they can end up better making their own decision. When I am faced with this kind of situation, I always try to back up and give as much of the background as possible so that the interpretation that we place on the data can get there in the context of the background. When you begin to see how it could take place and how the interpretation was obtained, you can make sense out of it. But that's difficult.

DR. BENJAMIN C. DYSART: In many public meetings and hearings when you come in the back door, some nice young lady is sitting there handing out cards and asking you to sign in and indicate whether you wish to speak in opposition to or in support of. I've had students ask me, "Isn't there another box that should be on there--that you came with an open mind to learn?" It is assumed that you are coming to be an advocate of one side or the other. So we are starting out on the wrong foot. Another problem which we have had in the coastal area is conflicting expert testimony even on one side of an issue. I looked into a situation where the party proposing a course of action had too many consultants and experts presenting testimony in their behalf, and their consultants seemed to draw conflicting conclusions. When that happens, what does some member of the public sitting out in the audience think? Not only are they disagreeing among themselves but outside parties are disagreeing, too. If I were involved with the development interest, I would say, "Let's go through our things in advance," and I thought that always took place. But this seemed not to happen in this case. Maybe that's an extreme situation.

QUESTION: (Mr. William E. Burnett) A question to Dr. Copeland. Would you please comment on studies by the Sea Grant Program or other groups which you are aware of in the Onslow Bay area in North Carolina?

DR. B. J. COPELAND: We have, this past winter, initiated a small project to bring together the existing information concerning the Onslow Bay in particular but also for all of the North Carolina coast. The physical dispersion characteristics of the nearshore environment, along with some analysis of potential for ocean outfalls, will be available in about two to three weeks. The second project has to do with a large physical oceanographic undertaking of trying to nail down some of the localized current and dispersion characteristics of Onslow Bay, which include current arrays, developing physical models, and a mathematical model to be predictive and try to fill in points to make the physical model real with the existing environment. These are the two major studies that are underway at the present time, particularly relating to Onslow Bay. Dr. Ernest Carl, Department of State Planning, is trying to pull together several aspects from their point of view and trying to get a sound base of where we are in that analysis so we can take off with somewhat longer-range studies to get at the problem of where to put outfalls, how to build them, economics of the situation, development and design criteria, etc.

QUESTION: (Mr. William E. Burnett) Do you have any information or conclusions from the first study?

DR. B. J. COPELAND: I have with me an abstract which I'm supposed to present to the North Carolina Marine Science Council this afternoon at a meeting over at the Marine Biomedical Lab. This will give a preliminary view of findings. The major conclusion is that we do have presently off our coast, a pycnocline and it is relatively very shallow. There are net toward-shore currents and so forth so there are problems we have to overcome before we stick a pipe out there.

QUESTION: How can citizens obtain the kind of information needed beforehand and quick enough to have an input into hearings with only a 15-day notice?

DR. BENJAMIN C. DYSART: This, of course, is not a new problem. The usual course of action for environmental groups is to try to get involved as early as possible and identify the problems and indicate that there is controversy. With only a short period of time, you cannot make a thorough review of a technical proposal. As far as solving your particular problem, I don't know what they could do about that, other than try to obtain some expert advice and try to dig into it. It seems there is more and more recognition of the need to have more time, or an appropriate amount of time, for people who have the desire and can obtain the capability to be able to assess and address technical matters. For something that someone or some agency has spent a year and a half and 50 or 100 thousand dollars or took 5 years in developing the plan, it's difficult to address that whether you have 15 days or 30 days or 90 days. It's difficult for state agencies with a lot more capability and manpower than you all have at your disposal to respond to things that seem to be pulled out from under the cover on short notice. I'm afraid I don't have a very good answer in your particular situation. If you look at the legislation and guidelines concerning public participation for EPA and other agencies, I would think that it would be very difficult for someone to justify giving you only 15 days. It is quite possible that something was available or information could have been obtained prior to this. I would suspect if they had been following guidelines that are in effect, something must have been announced and available if people had known about it and had gotten onto it early enough.

WATER SUPPLY AND WASTEWATER IN COASTAL AREAS

Southeastern Conference

April 2-4, 1975

Sponsored by the

Coastal Plains Center for Marine Development Services, Coastal Plains Regional Commission
Water Resources Research Institute of The University of North Carolina
University of North Carolina Sea Grant Program

In cooperation with the

Sea Grant Program, University of Georgia
Environmental Resources Center
Georgia Institute of Technology
Sea Grant Program, South Carolina
Marine Resources Center
Water Resources Research Institute
Clemson University

Conference Host

University of North Carolina at Wilmington

Conference Secretariat

Water Resources Research Institute
124 Riddick Building
North Carolina State University
Raleigh, North Carolina 27607

Edited by James M. Stewart