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WATER RESOURCES

Mr. Irving K. Fox

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Reviewed by: Colonel J. H. M. Smith, USAF

Date: 21 December 1960

INDUSTRIAL COLLEGE OF THE ARMED FORCES
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WATER RESOURCES

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Reporter: Ralph W. Bennett

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WATER RESOURCES

14 November 1960

CAPT. GALLAGHER: General Mundy, Gentlemen: To discuss the supply and demand of water in the present and in the future, we have with us this morning Mr. Irving Fox, of Resources for the Future, Incorporated.

Mr. Fox, it's a pleasure to introduce you to the Class of 1961 of the Industrial College of the Armed Forces.

MR. FOX: Thank you, Captain Gallagher. It's a pleasure for me to be here; and I must say that I'm quite honored by such an illustrious audience. I didn't realize there would be quite so many. I have heard for a number of years about the programs here, but this is the first time I have had an opportunity to visit this group.

I think that I'll take just a minute of your time to tell you a few things about Resources for the Future. I have arranged with Captain Gallagher to distribute some of our literature--a bulletin that we issue--and also permit you to get in touch with us, if you wish, to get on our mailing list and receive some of our information.

Resources for the Future is a non-profit organization, a foundation that was established about seven years ago by the Ford Foundation. All of the financing that Resources for the Future receives comes from the Ford Foundation.

We have an income of about a million dollars a year. Roughly, half of this money is used to finance our central office staff. The other half

is used as grants to colleges and universities over the country.

Our mission is research and education in the field of natural resources. We deal primarily, at least in the period of our history so far, with the social sciences--the application of the social sciences to natural resources. We have been primarily concerned over the last few years with the question of, you might say, the supply-demand outlook for natural resources--minerals, energy, land, water, and so forth. And it's from this sort of background that I speak to you today about water resources, and particularly water resources in the United States.

I'm going to begin this by reading a little note that Abel Wallman, whom I'm sure many of you know or have heard of, brought to the attention of a number of us some years back. It's a quotation from the Philadelphia Monthly Magazine of 1798:

> "Pure water is the best drink for persons of all ages and temperaments. By its fluidity and mildness, it promotes a free and equable circulation of the blood and humors through all the vessels of the body, upon which the due performance of every animal function depends. And hence water drinkers are not only the most active and nimble, but also the most cheerful and springly of all people. But to delicate and cold constitutions, and to persons unaccustomed to it, water without wine is a very unproper drink."

Before beginning, I want to make one other comment here, so that you can take what I say with an appropriate grain of salt; namely, I am not an engineer. I am not in a good position to answer questions in the

field of engineering. My interest and experience have been primarily in what you might call the policy and economic aspects of water development; and it's in that area that I hope, if at all, that I can make a contribution.

I'm going to begin with a quotation from a prominent Government official, whom I will not name; but I think it serves to provide a setting for the comments that I have to make today. This comment is as follows:

> "One of the most serious political and social problems of the next twenty years may be the universal concern of how to get good, fresh water to meet our growing demands. It is estimated that the total average fresh water supply that is usable in the United States is about 515 billion gallons per day. We are now using about 290 billion gallons a day for all purposes, or about 55 percent of the total water available. Picture, if you will, the problems we will face in 1980, which is just 20 years hence, for by that time it is estimated that we will be using about 600 billion gallons per day. It doesn't take much of a mathematician to figure out that we will be short about 85 billion gallons of water unless totally new sources of supply can be developed. The most likely sources, obviously, are the great oceans and the vast reserves of brackish and saline water."

This, I believe, is a very popularly and widely held view of the nature of the water problem in the United States; and, in my judgment, it is a misleading and inaccurate view of the situation that we face in the

water resources field. One of the major objectives of my lecture this morning is to give you what I hope is a more accurate understanding of the water situation in the United States. Specifically I hope to do the following:

First, I would like to provide a general picture of water use in the United States in recent years.

Secondly, I would like to describe to the best of, I think, our current information, as far as our current information will permit, the water supply demand outlook. And in that presentation I hope to contrast the situation in the arid and humid regions.

Thirdly, I hope to outline rather broadly the nature of the water development and management problem confronting us in the next couple of decades.

This is a difficult and a risky task. It is difficult because I am trying to cover a lot of ground when talking about the water situation in the United States as a whole. It's risky because water problems are localized. When I speak in general terms, almost everyone can provide information on specific localities that will demonstrate that I am in error. Also much of the data one would require for the type of analysis I wish to present is deficient.

First, when we talk about water use in the United States, we run into a problem of defining use. When we speak of water use for irrigation, we mean one thing. When we speak of water use for recreation, we mean something quite different. Domestic use is still a different kettle of fish. Navigation is still something else. Hydroelectric power

production is different from any of these.

Although these uses make incompatible demands upon the same supply, how can they be aggregated in a meaningful way? How can we put together a total picture of the water supply and demand situation?

This problem is further complicated by the fact that we have very little historical data on water use in this country. Actually, the estimates that are of any real value begin in 1950. There had been some early estimates, running back to 1900; but these are, I think, of questionable merit.

Because of these problems, it is impracticable to set forth a rigorously defined statement of use, even for recent years. We have hope--and this, I believe, is based upon recent studies that are now in process and well along--that within a few years we will be able to add up water use and relate it to supply in a meaningful way.

For the moment, however, we must content ourselves with what you might call indicators of use. And this, I believe, is one of the errors in the statement that I have read to you. It took indicators of use and considered that as the actual use of water. We were talking about water used when it was really water withdrawn. And, as all of you know, much of the water that is withdrawn is returned to the water course and is subject to reuse.

Now, most of the data on water use relate to withdrawals from underground and surface sources. Such data can be misleading, because most water withdrawn is actually returned and available for re-use, as I suggested. I will give you some indication of what these proportions

are.

For irrigation, roughly half of the water--this will vary from a third to nearly two-thirds--roughly half of the water is return flow, as we use the term in the western states. And, as all of you know, I am sure, at least many of you do, that return flow is always taken into account in calculating the availability of water for western irrigation projects.

When water is used for steam electric power cooling, roughly 98 percent of it is returned to the water course. For most industrial purposes about 90 percent of the water is returned to the stream. For most domestic uses about 90 percent of the water is returned, although this varies from west to east, depending upon how much of it is used for lawn watering, in other words, irrigation purposes by the householder.

Let us turn now briefly to what these quantities are. I want to remind you first that in the United States, average annual runoff runs about 1100 billion gallons a day. Today, or in the most recent data that we have, using 1955 data because these are the most recent estimates that are available--in 1955 it was estimated that irrigation used or withdrew from watercourses about 110 billion gallons a day; for municipal uses about 19 billion gallons a day; fuel electric power 60 billion gallons a day; and for other industrial purposes roughly 32 billion gallons a day.

I have put some of these figures over here (indicating easel), to give you some of these relationships. This is irrigation. Here is fuel power. Here is industrial. Here is municipal. You can see that

irrigation, which is water used in the arid regions of the country, is the heaviest water user if you measure in terms of withdrawal. Fuel power comes next, industrial next, and municipal here.

In other words, in 1955 we were withdrawing from watercourses something over 220 billion gallons per day for all purposes, which, as you can readily see, is about a fifth of the average annual runoff of the United States.

Now, there is another figure that is interesting here. Net consumption, or evaporation and transpiration to the atmosphere, was considerably less. It has been calculated by a former member of this body in an earlier program that about 72 billion gallons of water was the net consumption in 1955, compared with, you might say, an average annual runoff of 1100 billion gallons a day.

There is one other interesting figure here that I think you should have in mind--that of this net consumption of about 70 billion gallons a day, roughly 50 billion gallons were consumed by irrigation. In other words, in terms of both withdrawals and net consumption or evaporation and transpiration to the atmosphere, irrigation, which takes place in the western part of the country where the water supplies are most deficient, uses the most water.

In order to illustrate this geographically, I have set up here a map which shows the average annual runoff by the major basins in a graph form. It shows withdrawals and net consumption. I want to cite a few of those figures here (walking over to map).

Here we take the Southeastern United States. A very large amount of average annual runoff here, in this green line. The orange shows the withdrawals from watercourses in this area. And a little narrow black line down here illustrates net consumption. Even in the industrial Northeast here you find this much runoff, this much withdrawal, and this much net consumption.

Over here in the West I think you begin to see how the picture changes. And I use the Colorado River Basin, the Great Basin area, to illustrate this most sharply. Here you have the green line actually less than the total withdrawal, which illustrates my point about, first, returning flow, and in this particular case there is an over-use or withdrawal from the ground water area down in Arizona that exceeds the rate of recharge. So here you have net consumption nearly, well, roughly two-thirds of average annual runoff in that particular part of the country.

Now, this is only part of the water picture. There are, of course, other kinds of uses. And, as I said earlier, it is extremely difficult to provide data on these uses that can be added to withdrawals or to net consumption data. And to go into this problem I would like to turn to the second major part of my lecture this morning, and that is with regard to the supply-demand outlook.

I think that the best work that has been done on the problem of aggregating use in a meaningful way and comparing it with supply is the work that has been initiated by a number of us, including Resources for the Future, in collaboration with a number of the Federal agencies, for

the Senate Select Committee on National Water Resources. I understand that you are acquainted with the work that the Senate Select Committee has been doing; that you are familiar with the many reports that the committee has sponsored.

I would like to draw your attention in particular to Committee Print No. 32, which is being issued about the middle of December, and which is not yet available. This study was under the leadership of Dr. Nathaniel Wallman, of the University of New Mexico, whom we brought in here to initiate a study of water resources supply-demand outlook in the United States. He had just gotten under way in laying out the study when the Senate Select Committee approached us and asked if we would collaborate with them. By this time we recognized the dimensions of the problem and inquired as to whether the Senate Select Committee would help secure the collaboration of the Federal agencies in what we considered a very large-scale effort. This was done. So what has been produced so far is a report that reflects the effort of a large number of people in the Government agencies, operating generally under the chairmanship or leadership of Dr. Wallman, of the University of New Mexico, whom we brought to Washington for the purpose.

What he has prepared is called "A Preliminary Report" and I would like to emphasize and underscore the word "preliminary," because the work is far from complete. It does begin to portray, I think, a very interesting and worthwhile picture; but there is much work yet to be done, and we have provided a grant to the University of New Mexico now to

continue these studies for two years into the fugure.

Dr. Wallman has classified the water use into three broad categories. These are the withdrawal uses, which we have been discussing here so far this morning; secondly, the on-site uses, which refer to water required for the maintenance of wet land, for the conservation of soils, and things of that kind. In other words, it's where water actually is held and is evaporated or transpired in the process of serving a particular function on the land, for the most part. This may not seem very important to you. Yet, as we look ahead, we can see that soil conservation programs will use somewhat more water as these programs progress. And, secondly, there is a great deal of interest in this country, with the growth of demand for outdoor recreation, that we maintain a certain amount of swamps and wet lands for the preservation of wild life. And, again, it's amazing to see how much water this will require if the programs take on the dimensions now estimated by the agencies interested in those particular programs.

The first group was the withdrawal uses. The second we called the on-site uses. The third are what are called the flow uses. These are navigation, power, waste disposal or waste carrying or pollution, if you will, and recreation. And when I referred to power, I was referring to hydroelectric power.

Now, what Dr. Wallman and his associates finally did here was to say that the total water demand for a region can be expressed in terms of the minimum flow of a stream or streams required by the flow use

that has to have the largest flow, plus evaporation and transpiration losses for the on-site uses and the withdrawal uses. Let me explain this a little further, because I think this concept is rather complicated.

In other words, let's take just two or three of these. You take a basin like the Ohio. You have to have water for, let's say, navigation and the pollution abatement. The one of those that requires the most gives you a certain figure, a certain number of second-feet, or billion gallons a day, however you wish to express it. Take the largest of those two and add it to the evaporation and transpiration losses for the withdrawal uses, which we have described earlier, and the on-site uses--the conservation, wet lands, and so forth--and this will provide you with the estimate of the demand--the combined estimate of demand upon the water resources of the region.

Now, in proceeding with this study, he immediately ran up against the question as to what is the appropriate amount of water required for pollution abatement or waste dilution or whatever you wish to call it. Here they made a quite fundamental assumption that colors and determines much of the rest of the output of the study.

They assumed that reasonably clean water, with adequate oxygen to maintain aquatic life, is an objective of national policy. And, to be more specific, they assumed that water should be maintained to average a minimum oxygen content of four parts per million. That is on the average. They assumed that some places will be less, and therefore probably cannot maintain aquatic life; but that on the average over the

region there would be some areas that would maintain better supplies than this.

Now, the study indicated that to accomplish this objective, even with a high degree of treatment, but assuming no change in present waste treatment technology, a fairly substantial quantity of dilution water would be required in all regions.

On the basis of a procedure devised by Professor George Reed, of Oklahoma, it was possible to calculate dilution water requirements by regions for various levels of organic pollution. The studies indicate--and this is a crucial point--that in practically all regions in the future, waste dilution demand, based upon this assumed desirability of four parts per million of oxygen, would be very large.

Further, if this demand for waste dilution water is met, the other few flow uses--navigation, etc.--would be, for the most part, satisfied. In other words, waste dilution requirements became one crucial part of this formula.

Well, so much for the general procedure of estimating the requirements. I want to go back just a little further.

They were talking about 1980 and 2000, as I think most of you know from looking at the Senate Select Committee document. We had made projections of economic growth at Resources for the Future for another large-scale study that we have under way. These were basic to the projections of water requirements, and the projections of national growth for the various components of the national economy were broken down

by regions, by water resources regions over the country. Against these were applied coefficients of water use, and from these, figures were derived indicating the amount of water that would be required generally in each region.

In other words, they projected the amount of water that would be required by the steel industry for cooling purposes within such-and-such a region, the amount required for fuel electric power purposes, and so on. And, based upon the total composition of the population and industry within the region, they derived estimates of waste water dilution requirements within that region.

I want to emphasize again that these estimates that come out--and I'm going to give you some of these in just a moment--are still, you might say, of limited value, because they are fairly early in the stage of the research effort.

I think there are two basic limitations of the study at the present stage, and these are limitations that we would hope to remedy in the years ahead.

First of all, it assumes , the estimates assume, no change in waste treatment technology. And this, of course, as I think all of us will agree, is an unlikely assumption. In other words, we should expect improvements in waste treatment technology in the years ahead in view of its significance.

Secondly, there is not built into this an estimate of the effect of price or cost of water upon demand. We all know that as the price of

water increases, the demand for water declines. But these estimates assume that prices and costs of water will be roughly the same over the next forty years; and this also seems to be an unlikely assumption. Nevertheless, I think the estimates, even in preliminary form, are indicative and helpful in understanding what we are up against in the years ahead.

Let me give you first some figures on the national aggregate. I am going to keep these to a minimum, because you can get these data out of the Senate Select Committee report as soon as it is available. We will duplicate some of the material from these statistics, and I will arrange with Captain Gallagher to make this available to each of you. First, the national aggregate. We look to 1980. Let me show you what the composition of this demand is in 1980.

The losses from withdrawals are expected to be roughly 120 billion gallons a day in 1980. This is the evaporation-transpiration losses from irrigation and so forth. The on-site losses--this is the conservation, wet lands, and so on--will be about 70 billion gallons a day. But the waste dilution flows required in 1980 will be 332 billion gallons a day. In other words, the water required for waste dilution will be roughly 60 percent of the total water requirement for all purposes in 1980.

Looking to 2000, you get figures like this: This is again national aggregates. You get 156 billion gallons a day as the evaporation and transpiration losses for withdrawal in 2000, 97 billion gallons a day for losses from the on-site uses, waste dilution flows 447 billion gallons a

day. Again, all of this is looking toward the maintenance of a quality of water of four parts per million.

To trouble you--and I hesitate to do this--I would like to contrast what we run into in the West in comparison with the East.

Let us take New England--and I will limit these figures to 1980 because I don't want to give you too many. I know how they just become a bunch of figures and lose all their meaning. In 1980, to meet the withdrawal requirements, we will need about 7/10th of a billion gallons a day--this is New England; for the on-site uses--conservation etc.--1.4 billion gallons a day; waste dilution 12.7.

Now, here this totals about 14 billion gallons a day in New England; and the average flow that is available, if it is controlled and regulated through the construction of reservoirs, amounts to about 65. In other words, in this area you have about 65 billion gallons a day, with a projected demand in 1980 of less than 15 billion gallons a day. Or, in other words, the demand will be less than 25 percent of the flow, even though we are considering a very large demand for waste dilution purposes.

This is New England, and I think this reflects the kind of situation that we have in much of the eastern part of the United States, varying somewhat from the highly industrialized areas to the less industrialized areas. We have plenty of water, and there is not, that we can foresee, any serious problem provided either the regulation is supplied through the construction of reservoirs, or we find a waste treatment technology that reduces this demand upon the water.

Incidentally, we figure that to supply this water for New England, it would require the addition of about 3 1/2 million acre-feet of storage above what is available at the present, to provide the flow that I mentioned here earlier.

We find a quite different situation when we look at the West; and this I think is essential--that a contrast be made. Here I will use as my example the Colorado River Basin.

The Colorado has a flow that people argue about--and I hope I will not be quoted on this, because someone will certainly tell me from their own experience that I am absolutely wrong. But it's from the report, and I'm sure it will cause a great deal of argument. But it is estimated that the maximum sustained flow of the Colorado is about 10.4 billion gallons a day.

Looking to 1980, and projecting the growth in uses that the various Federal agencies anticipate, you find that there just won't be enough water. Losses from withdrawals are estimated to be about 15 billion gallons a day. The losses from the on-site uses are about 2.1 billion gallons a day. The waste dilution loss requirement about 2.2 billion gallons a day. And that shows a total estimated demand, if we proceed the way we have been proceeding, of about 19 billion gallons a day, in comparison with an available supply of about 10 billion gallons a day.

In other words, the available supply will not meet the projected demand in this arid region if we try to maintain the type of economy and the pattern of water use which are being anticipated, particularly by the

public agencies responsible for water development and management in that region.

I think it is appropriate at this point to outline rather briefly the nature, then, of the supply-demand problem, and in particular to begin with the West.

In many areas of the West, not only the Colorado Basin, net consumption approaches average flow. I think any of you, or many of you, that are acquainted with the West are well aware that water is what they call over-appropriated in many val leys. In other words, the water rights exceed the amou nt of water that will be available in a dry year.

What do we do in the West? And assuming the continued pressure for economic growth, it seems to me that there are three alternatives, or some combination of alternatives, open to the people of that part of the country.

First, you can provide additional supplies to maintain the traditional patterns of water use. This means desalinization, weather modification, practices for conserving and using water more efficiently, trans-basin diversion. We have talked of bringing the Columbia water down into the Southwest--and things of this nature.

The second alternative is to limit economic growth in order to maintain the present patterns of water use without resorting to these other procedures that I have talked to earlier.

The third possibility is to reduce irrigation and transfer water to other uses. In other words, take land out of irrigation, as is being done

in many areas of the West today, and use this water for purposes that will support more population and income than can be supported by an irrigation economy.

Now, I think we will probably resort to at least two of these. We will try to increase supply whatever way we can. I think it will be essential to transfer land or take land out of irrigation and use the water that has been applied to irrigation for municipal and industrial purposes.

And I say this for two reasons. One of them is that until we get a major technological breakthrough, desalinization offers little promise of meeting a problem of the magnitude of the one confronting the western States. Weather modification may help some if it's gotten down, since it is not a costly way of providing additional supplies. But when you talk about increasing rainfall by 20 percent in an area that has six inches a year, you are not really talking about very much of an increase in runoff.

The trans-basin diversions that have been discussed will be very, very costly. In other words the outlook today is that, unless we are ready to make investments in the West in water development much larger than we have made heretofore, we are going to be unable to maintain the pattern of irrigation water use in the West and at the same time support the economic growth that now seems destined to occur in the West. Yet I think that if we will use the water of the West more efficiently--and there are many opportunities for so doing--and gear that to some adjustment from irrigation water use to municipal and industrial use, a very high rate of economic growth can be continued in most areas of the west-

ern States. You may have more questions about that later. I think it's an issue that will be argued and debated a great deal in the years ahead.

Now, over the country as a whole, if we assume that the demand for clean water is realistic--and I believe it is--and if we assume further that Professor Reed's estimates of the dilution water requirement for the maintenance of clean water are roughly right, then pollution abatement really moves to the center of the stage in water resources management in the United States.

We really have, then, two serious problems. One is an adjustment in water use in the arid West; and this could be painful and costly, depending upon how we go about it. And the second problem is that of meeting the pollution problem that is emerging in the United States and which threatens to be of very serious consequence.

I would like to emphasize that in the national economic sense the quantitiative shortages of water are not serious. It's the quality problem that becomes the most serious one.

Now, for just a minute or so I'd like to just outline briefly what seems to me the broad outline of the water managment problem.

We have the pollution problem that I have just been mentioning and I think all of you realize that it has many, many ramifications and aspects. There is silt pollution, there is heat pollution, there are caustic wastes, there are synthetic organics, there are natural organics; and they all create different types of pollution problems.

Supposedly the heat pollution can be regulated. I think that this

is demonstrated as practicable. Toxic wastes must be dealt with in some way. The synthetic organics, such as the detergents, create a special problem; and probably they can only be met successfully through some sort of research development. The natural organics are the ones that require the large amount of dilution water.

Now, many of you have heard of the story of the experience at Canute, Kansas. I won't go into any details on that if you recognize or are aware that in that particular instance the sewage effluent was turned through the water treatment plant when they had a shortage out there, and the water was re-used. They treated the water very carefully. There were no illnesses attributable to water-borne disease as a consequence.

In other words, water treatment can be successful in meeting the health problem. This is not the nature, you might say, of the demand for clean water.

The demand for clean water, as I understand it and see it in the United States, is based upon the demand for recreation opportunities in the United States--the demand for clean rivers for esthetic and recreation use, including boating, fishing, swimming, and the like. If this demand did not exist, the pollution problem would not be a serious one.

The indicators all suggest that recreation use of water will mount rapidly in the years ahead, as it has over recent years. I think you can just cite a good many statistics to illustrate this point.

In the Tennessee Valley reservoirs you had a 400 percent increase of water areas between 1947 and 1956. The Corps of Engineers data are

equally dramatic.

In other words, when you get down to it, these recreation demands that require clean water mean regulated flow if you assume present technology to be as it is..

You turn to navigation. You find that navigation has increased in demand rather markedly over the last decade. It was 35 billion ton-miles, according to the Corps of Engineers, in 1946. In 1957 it was 115 billion ton-miles. To maintain navigation, regulated flows are required.

For hydroelectric power: I want to remind you, as many of you know, that hydroelectric power is increasing in value per kilowatt hour because of the use of hydro and its value for heating purposes. There is no indication that this demand will decline. We had 27.9 million kilowatts of hydro in 1958, and that could go to 60 or 70 million kilowatts by 1975.

Flood control. The potential damages are increasing because of the increased intensity of flood plain use. The Weather Bureau data indicate that average annual losses from 1936 to 1955 were three times as great as the period from 1903 to 1935. Again, regulated flows are desired, at least, to reduce these damages.

Because of these factors that I have just cited here, there is mounting pressure for reservoir storage to provide regulated flows for these several purposes. And it has been suggested that our Federal Government policy should be directed to the end of making more regulation. In fact, it has been suggested that we make the creation of completion of

an integrated, nationwide water-regulation system a primary objective of Federal activity. This policy would have the premise that full regulation of nearly all the nation's streams is inescapable over the long run, and that substantial progress toward this end will have to be made during this century. We may now do best to begin our planning in terms of progress toward full regulation, making it the basic Federal program.

There is one idea, and yet it comes face to face with other demands upon reservoir land. I think any of you who have lived in the Washington area, or almost any other area, know the controversies that were encountered when it came to the construction of a new reservoir and the elimination or the inundation of the activities or the uses of the land that have been there.

What do we need, then? I think we can foresee in the years ahead a sharpening of conflict--on the one hand the demand for regulated flows, on the other hand a strong demand to maintain the use of the reservoir areas for the purposes for which they are now dedicated.

And what's the answer? I think it requires a more imaginative approach to water resources management than we have generally used in the past. I think we urgently need alternatives to stream regulation as the main answer to some water demands, so that these alternatives can be adopted when circumstances warrant.

For pollution I think we urgently need a technological breakthrough to minimize the requirements for regulation.

For flood management I think we need to place more emphasis on

the regulation of flood plain use, upon flood insurance, and other means of minimizing flood damages.

For power and navigation, I think we should carefully appraise the values to be realized through these developments against the cost of inundating the land area.

In think, in short, that water management should no longer be equated with a construction program. It involves an integrated effort by engineers, by biologists, by economists, and by many others.

Well, I think I'll end this now, and on this little note, that I think probably goes with the first one that I read from what Dr. Wallman has quoted. It goes something like this:

> "Water is the best of drinks. But who am I that I should have the best of everything? Let princes revel at the pump, let peers at the pond make free; but whiskey, beer, or even wine is good enough for me."

CAPT. GALLAGHER: Mr. Fox is ready for your questions.

QUESTION: Mr. Fox, you mentioned that clean water seemed to be a problem for recreational purposes. I understand that there are certain industrial applications, such as paper making and the textile industry, that demand water that is pretty low in mineral content. Is this going to be a problem for us in the future?

MR. FOX: Yes. That's my problem, you see, in generalizing that I talked about at the outset.

Certainly many industries require water of very high quality.

Usually for many of them the quantities of high-quality water required are not so large. The point that I am making is that that problem is, important as it is, dwarfed by what I consider to be, you might say, the larger problem of meeting this demand for recreational purposes.

I think that there are many aspects of this pollution problem that I have failed to probably cover adequately and place in proper dimension. For instance, there is this question of the pesticides that flow into the stream, which might cause toxic wastes to be in the stream. People drink the water. They are not taken out always by treatment processes, and they cause a very serious problem. There are many ramifications of this, and I would say that what you are speaking of is one of them. But I think that in terms of the total national investment that will be required in water development, just providing clean water for recreation purposes dwarfs the rest of them, the rest of the uses.

QUESTION: Mr. Fox, on your figure of 1100 billion gallons flow per day now, is that the usable runoff?

MR. FOX: I'm sure it is not. I don't know just what it is. I don't know that anybody can tell us what the usable flow or the regulated flow can be. We have frequently said that you can provide a regulated flow of roughly half of the total average annual runoff.

I think that this is probably too low a figure, from the other estimates that I have seen. We have estimates of regulated flow by major basins, that is, the amount that could conceivably could be provided if it were required; and this would total somewhat less than the 1100 billion

gallons a day. But it would still approach that figure. I have forgotten just what it adds up to, but I think it is 900 or something of this order of magnitude.

This varies a great deal from west to east. When you try to provide a high degree of regulation in the West, evaporation losses cut into the availability of water--cut into the regulation, so to speak, and reduce the average that will actually be available, because these are so great.

In New England, for example, on the other hand, the average annual flow is roughly 67 billion gallons per day, and it has been estimated that this could be regulated to nearly 65 billion gallons per day.

That's about the best that I can do on that question.

QUESTION: Will you comment just a little bit on the economics involved; on, say, the pollution costs versus the other demands?

MR. FOX: I don't know that I have those figures right at my fingertips here. You are probably better acquainted with them than I at the present time. But I would suggest--at least, the reason that I did not go into costs today--I'll make two observations.

First of all, I think it's extremely difficult to make reliable long-range estimates, because, in part, I think these costs, or the cost outlook, will change over time as technology changes. And, secondly, that when we talk about providing reservoirs, the cost of acquiring the land and developing the reservoirs is only going to be part of the problem. There will be other types of cost, you might say, that people are going to be

concerned about that create a very large problem in trying to provide the storage at a given reservoir site.

Again, I remind you what we are up against in this question of the River Bend Dam right here on the river. It's not the dollars and the cost of the program that cause problems there. It's the values that people, at least some people, attach to having that land available for other purposes, including recreation along the Canal, the development of residential areas on the lands that would be inundated, and so forth. So I'm not sure that the dollars give you any real indication of the magnitude of the problem.

But let me go just beyond that to say this: We now invest, as I remember, roughly, at the Federal level, close to a billion dollars a year in water resources. I would not foresee, on the basis of the estimates that we have so far--and these are very crude estimates--that this would anticipate, you might say, a great increase in the rate of public investment in the years ahead. In other words, sure; it will require some increase in investment; but the data that we have developed here do not indicate any doubling or tripling of the rate of the public investment in water resources and in water treatment facilities.

Would that agree with your estimate of the situation?

COMMENT: May I make one point: I think it's important here. It's important to recognize that the cost of water itself is governed strictly by the facilities that are constructed to manage it. The water itself is free. The basic cost of water refers only to the cost of treatment

and the cost of managing the water, of constructing the dams and the hydroelectric facilities; and it's important to understand that when dealing with this problem.

QUESTION: Mr. Fox, about a year ago there was an article in the Scientific American about the water resources development in Israel. I always thought in my own mind that their situation over there was probably worse than what we have in the Colorado River Basin. As I recall the figures, they have increased the amount of land to be irrigated something between 30 and 50 percent. You have suggested to us that we would have to decrease the amount of land in irrigation. Have you studied that problem versus the Colorado River Basin enough to say why they are increasing it when we have to decrease it?

MR. FOX: No, I haven't. And I know relatively little about the situation in Israel.

My inclination offhand would be this, namely, that we have highly developed the available supply. The supply is limited in Israel. It's limited in the Colorado. Over the years we have highly developed the water supply in the Colorado; and I think, as you know, when you go down to Arizona, we have been using water that has accumulated over a fairly long period of time, to support the irrigation in the Salt River Valley. In other words, we are not just depending there for the current irrigation upon the supplies that run off each year,--the average annual recharge. We are mining the water supply at the present.

Now, if you assume that you are going to expand your economy,

this is going to catch up with you, you see. And in may areas, as I think many of you are aware, it has already caught up with us, because the costs of pumping have come to exceed the value of the water for certain purposes.

Now, I just assume that we're just farther along in our development in this country, at least in particular locations.

Incidentally, while we're on this point: This is a situation that varies a great deal from locality to locality. When you say that land will have to probably come out of irrigation, you have got to carry with it a number of "if's" and assumptions. And one of those assumptions is that we are going to anticipate a very high rate of growth, at least we anticipate, a high rate of growth for the Southwest. We have had a high rate of growth there, and we are looking toward a continued high rate of growth in that part of the country.

Now, if this occurs, it's pretty difficult to see that you can have enough water to support your irrigation and support the cities and the industries unless you bring water from other sources.

There is much to be done, in fact, we've only scratched the surface, when it comes to preserving and conserving flows in some of that country in the West. We are quite wasteful in the use of water. And I think, incidentally, this is in part attributable to the kind of water law that we have in much of the West.

But, even after we have done that, if we have the population and industrial development that is now contemplated for the Southwest, it

seems very, very difficult to meet this without finding more water or taking land out of irrigation.

Now, what I said earlier was that that I am very doubtful that this can be done at a price we can afford to pay, at an economic price. I think it would involve bringing water out of the Northwest, for example, or desalinizing large supplies, large quantities.

We know today that, at least we can't really see today beyond reducing the desalization cost below 50 cents, say, a thousand gallons, or 40 cents, or something like that, for seawater. We know that for irrigation you have got to have water that is, say, under a nickel a thousand gallons. Unless we get a major technological breakthrough in the desalinization field, we don't see that this will be the answer.

So, barring some major unforeseen development, and assuming that you continue to have the rate of growth that we have been experiencing there, and which we now foresee, then it looks as if the only answer will be to take land out of irrigation. And our task is to do this in a way that we cause a minimum of hardship and problems to the communities that tackle it.

QUESTION: What type of problem do we face on our borders with, say, Canada, on the Great Lakes, the Columbia River, or with Mexico, or in the Southwest?

MR. FOX: I would need another hour to answer that to my own satisfaction; but I will just make a few very brief observations on that score.

It's a very interesting thing that such a large proportion of our water resources are international in character. You see, this is the Columbia (indicating on map). All of this along here, you have international water. You also have international water, as you suggested, down here and over here in the Colorado.

Now, I'll mention just two interesting problems that General Cassidy can speak much better about than I on the border here. The Columbia and the St. Johns.

In the Columbia--to develop the Columbia and get the most out of it economically, we need storage in Canada to regulate flows through these dams, through the power equipment, the generators, that already exist on the Columbia in the United States. And I think it is very interesting to see that there is an agreement well along between Canada and the United States on that score, which will provide roughly, as I recall, 21 1/2 or 22 1/2 million acre-feet of storage in Canada to regulate the flows on the Columbia River in the United States.

And this can only be done this way. That is, the water must be developed in Canada, and the power comes off generators, at least for the most part, in the United States. And to work out such a development, we have to either pay Canada for this development in dollars or return some of the power to Canada for its use. And, as I understand the agreement, about 35 percent of the power produced as a consequence of this regulation up in Canada will be returned to Canada in payment of them for building those structures. I think this is a great advance. I doubt whether

there are many places in the world where this sort of an arrangement has been worked out between two countries.

When you come to the St. Johns, you have the reverse situation. Here in the lower St. Johns, at the Canadian Dam, they need some regulation in the United States in order to get the most out of those facilities.

This, incidentally, brings up another kind of problem that we face in the water field, and an extremely important one. The dam that has been proposed here, at Rankin Rapids, will inundate part of the Allegash River; and the Allegash River is one of the foremost and most popular canoe streams in the United States, and there is a great deal of opposition by canoists who go down that stream. Incidentally, this is where I spent my vacation this year--canoeing down the Allegash River. So you see the kind of problem that we get up against.

But regulation in the U. S. would be very beneficial to Canada and Canadian power output, and would provide a very desirable type of arrangement; and I think it's to the credit of the two countries that they have made such excellent progress here in the Northwest in dealing with this.

Now, of course you know the story or have been hearing about the Great Lakes situation. I don't think I have time to go into that.

Here in the Southwest you have a different situation, where the interest is in making water available for both irrigation and municipal and industrial uses. And again I think the Canadian and Mexican governments