ENERGY, ENVIRONMENT AND WATER RESOURCES

Proceedings UCOWR Annual Meeting

Held

July 28-31, 1974
Logan, Utah

Universities Council on Water Resources

"Old Main" Building

Constructed about 1890 as first campus building. Still houses administrative and business offices of university along with some academic departments.

F O R E W O R D

The 1974 Annual Meeting of the Universities Council on Water Resources was devoted to a critical review of energy issues with particular emphasis on their relationships to water and the environment. Regional workshops on energy-water relationships were conducted to discuss: (1) energy production and water supply; (2) management-conservation; (3) pollution-environment; and (4) institution-policy.

The Proceedings include papers presented, questions and answers, and resolutions passed by the delegates. Papers and reports of discussions represent personal opinions of their respective authors. The resolutions reflect the view of the Universities Council on Water Resources.

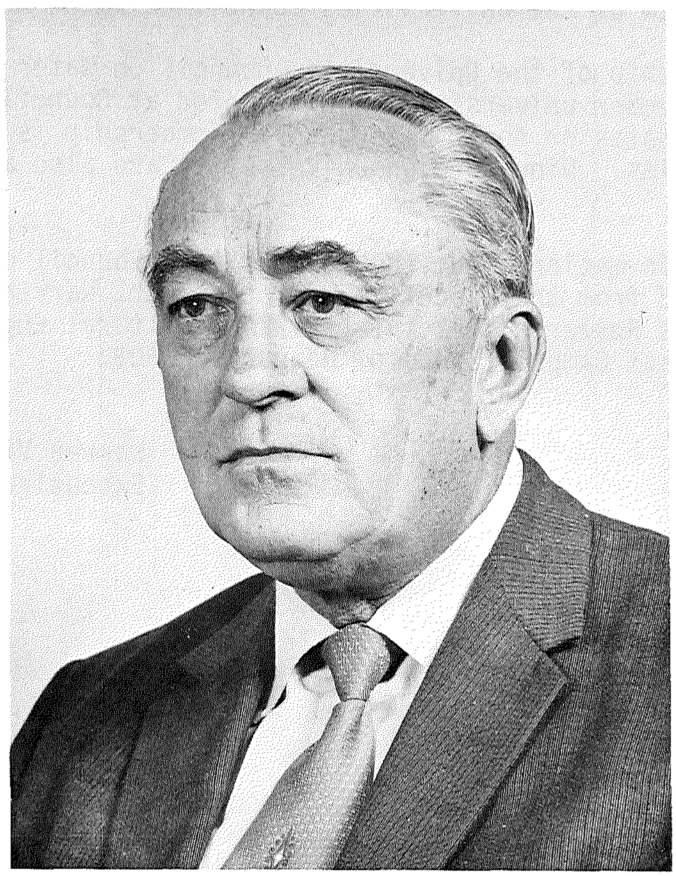
The membership of the Universities Council on Water Resources stands at 79. Each member university is represented at Council Meetings by officially appointed delegates or their alternates. Membership is open to all qualified U.S. universities. Nine foreign universities are also affiliated with the organization.

Further information about the Universities Council on Water Resources may be obtained from the Executive Secretary, Dr. Warren Viessman, Jr., Water Resources Research Institute, 212 Agricultural Engineering, University of Nebraska--East Campus, Lincoln, Nebraska 68503.

Warren Viessman, Jr.
Executive Secretary

A C K N O W L E D G M E N T

The Universities Council on Water Resources expresses its appreciation to Dr. George E. Smith, Director, Water Resources Research Center, University of Missouri, Columbia for providing photographs for the Proceedings. A vote of thanks is extended to him.



Dr. George E. Smith
UCOWR Photographer

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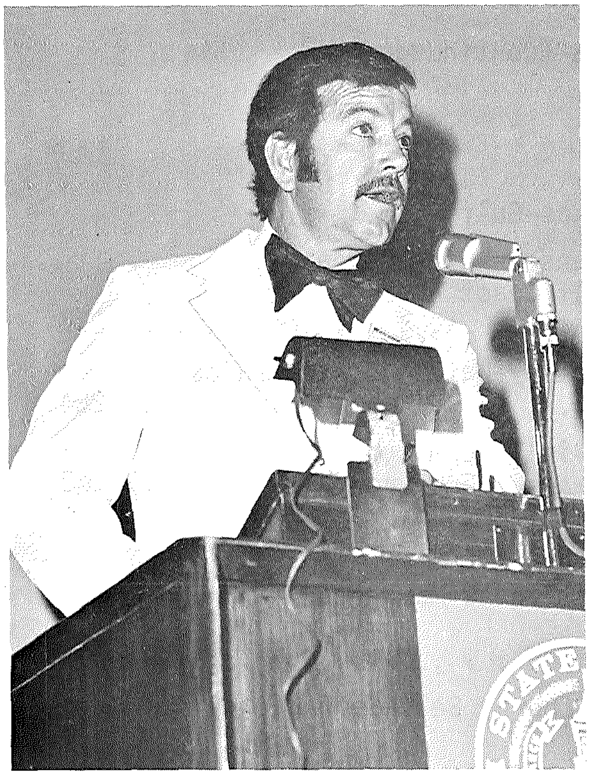
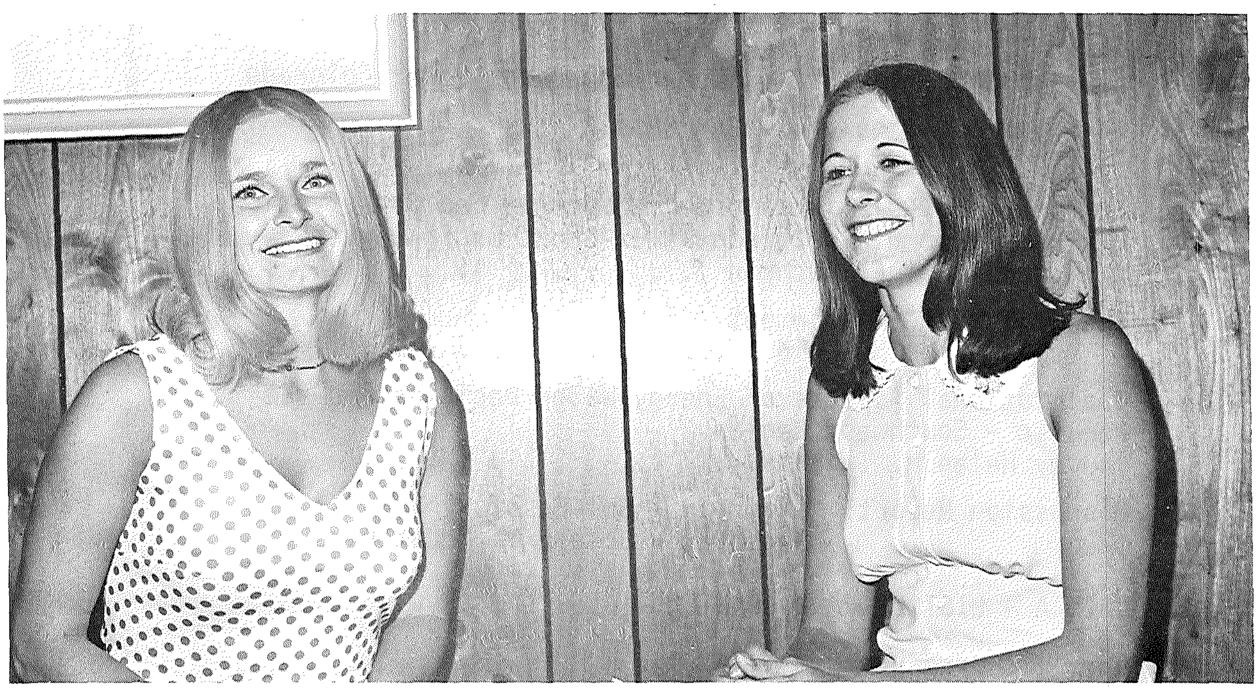


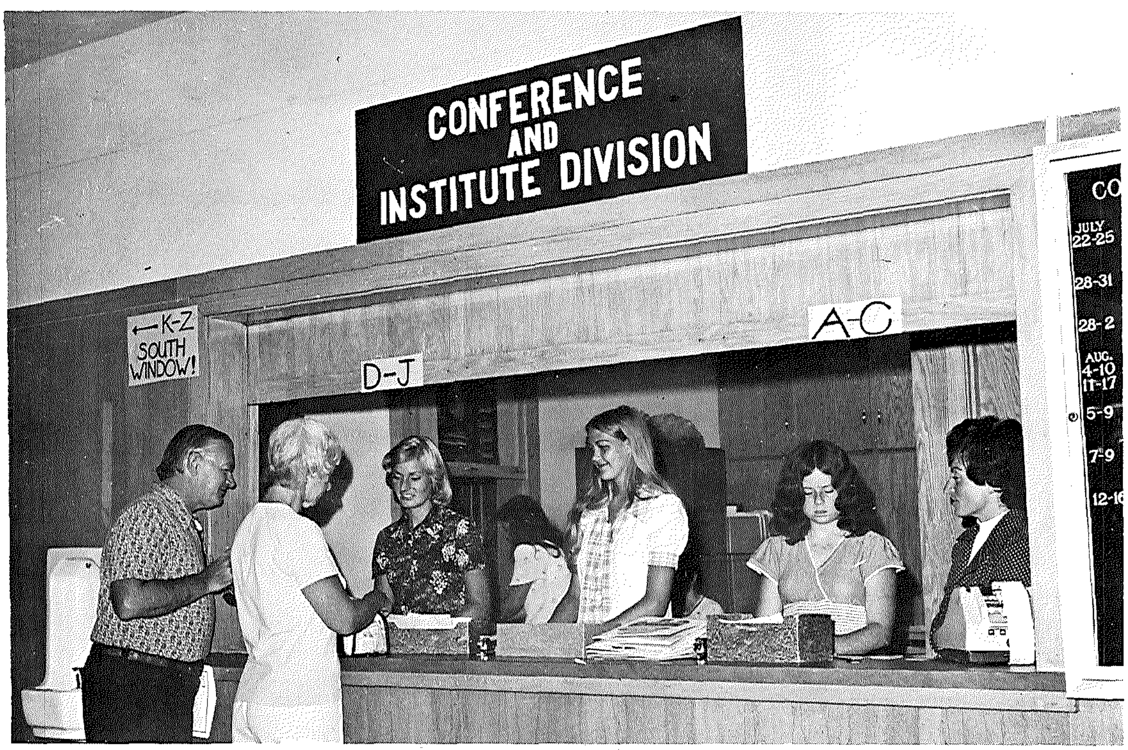
Dr. Ernest T. Smerdon
Chairman UCOWR Executive Board

Dr. Warren Viessman, Jr.
Executive Secretary

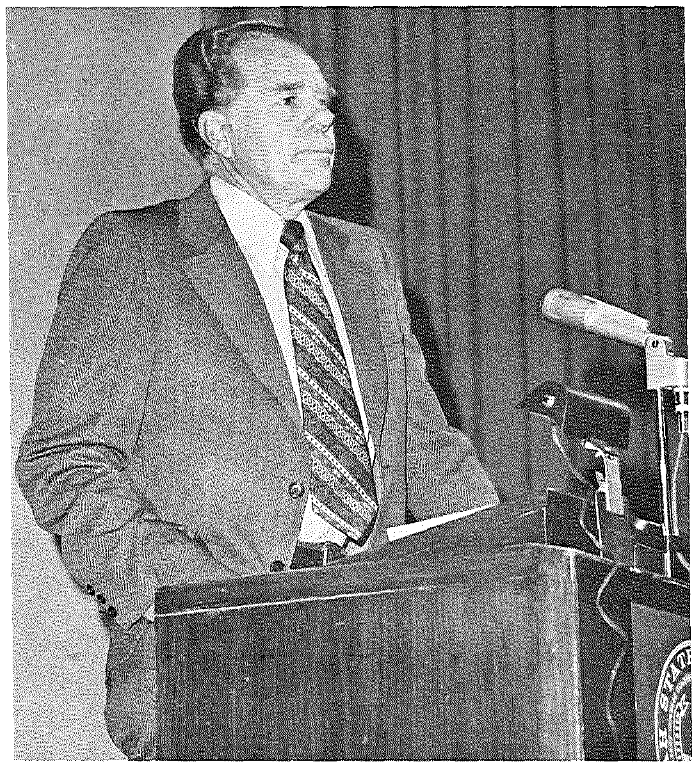


Jeanne Enevoldsen, Nebraska Institute Secretary
Nyla R. Thomsen, UCOWR Secretary

Dr. Jay M. Bagley, Utah State University, discusses the Annual Meeting with his assistant Anne Humble



Registration



Welcome

by

Richard M. Swenson
Vice Provost
Utah State University

AN ENERGY OUTLOOK

by

Dudley E. Faver
Regional Administrator
Federal Energy Administration
Lakewood, Colorado

A quotation from a semi-classical source in English literature reads: "It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, it was the epoch of belief, it was the epoch of incredulity, it was the season of light, it was the season of darkness, it was the spring of hope, it was the winter of despair."

It is well recognized, of course, that I am quoting the opening paragraph of Charles Dickens' A Tale of Two Cities. Dickens was describing the times of the French Revolution. Others saw the times differently. William Wordsworth, then a young poet filled with Romantic longings, could enthusiastically write, "Bliss was it - in that dawn - to be alive," while Edmund Burke, spokesman of British Conservatism, railed in stentorian tones against "an infinite number of acts of violence and folly."

Revolutionary times have always bred optimism and pessimism, hope and despair. They characterize not only the French Revolution but our own revolutionary era. Technology is transforming our world, and a new society is struggling to emerge.

We find that because technological advances are altering the very fabric of our daily existence, we are overtaxing the organic fuel sources upon which we depend so heavily. A world-wide hunt goes on for new fuel resources and our scientists are looking for new technology including new ways to get more use from the fuels we now have. Additionally, one of the greatest challenges of our times is the search for different sources of energy - sources other than coal, petroleum, wood, or agricultural waste - sources of energy to sustain our expanding population and the ever more complex technology of tomorrow.

Before I discuss our energy future and our present overdependence on petroleum products, let me hypothesize with you that one of our most important ingredients for energy production is water, both its quantity and its quality. This audience is particularly well aware of the huge amounts of water needed for hydropower, oil shale processing, coal gasification, coal slurry and similar activities.

Just one brief illustration: Coal gasification plants require approximately 14 million gallons of water daily to produce 250 million cubic feet of gas a day; oil shale development requires about 15 million gallons of water to produce 100,000 barrels of oil within that same period.

Along with developing our nation's water and energy sources, an equally great challenge is presented us in both safeguarding and preserving the environmental quality of our natural resources for the benefit of future generations. Water problems and environmental problems are monumental. It is clear to all that the wisest course can only be forged by the careful deliberations of all of us working together to minimize energy shortages, yet maximize our efforts to conserve and protect our natural resources. The Federal Energy Administration is committed to such a concept.

Water and environment must be kept in mind as I discuss energy alternatives for our future. I want to lead into this discussion of our energy future by reviewing those forces which have led us into a shortage. I want to show that the shortage is, by present trends, just at the threshold of becoming tremendous in magnitude.

A good beginning point is with petroleum. Until 1973, demand and supply were about equal. It is well to examine how our total demand has been met and how we had, by pre-embargo forces, planned to continue to meet our demands and seek a balance in supply and demand.

As you know, this nation imports a very substantial quantity of refined products. Many of our domestic oil companies have invested heavily in overseas refining facilities. A part of that foreign production is imported into the United States.

Economic forces, legislation, and controls on petroleum required that, in order to survive, oil companies had to cut back on expensive exploration at home. Domestic exploration, in fact, peaked about 1956. Over two decades ago, circumstances became such that major U.S. oil interests moved their action to foreign shores.

Along with imported refined products, we meet our demand for petroleum through imports of "Other Foreign Crude," as distinguished from "Canadian Crude." No one any longer doubts that foreign crude oil is very sensitive to the actions of foreign governments.

Once, we considered our Canadian petroleum a reliable supply. This may no longer be true. Representatives of the Canadian government announced to the press a few months ago that the United States should count upon zero imports from that country a decade from now. It is a reasonable conclusion that imported refined products, foreign crude, and Canadian crude can all disappear overnight without warning to the United States. The significance of these sources can be graphically shown from Figure 1 showing United States oil consumption beginning in 1955.

Synthetic crude, as you know, is a liquid petroleum product obtained from shale oil and from the liquefaction of coal and from tar sands. Tar sands oil is a Canadian source that could also dry up.

1. Product Imports
2. Other Foreign Crude
3. Canadian Crude
4. Synthetic Crude
5. North Slope
6. Lower 48 & S. Alaska

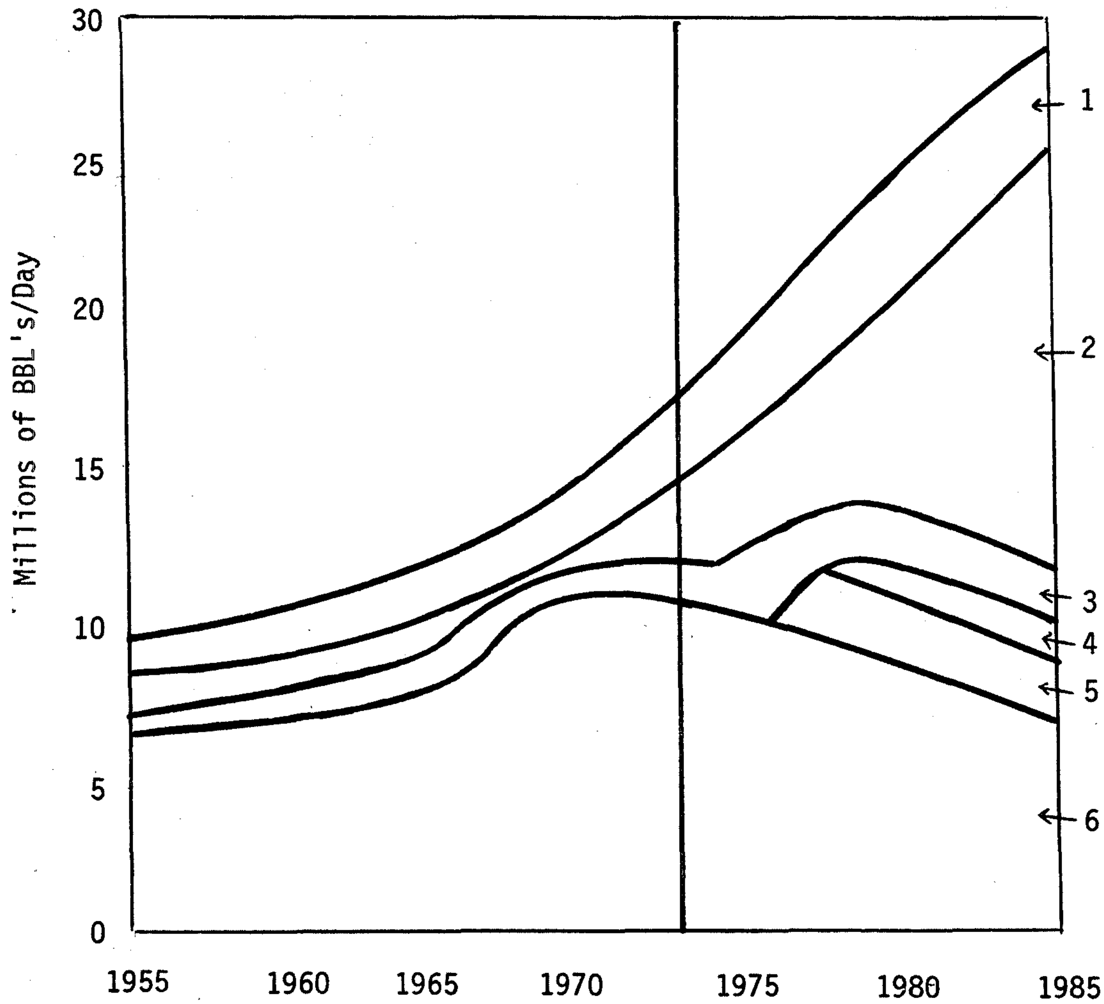


Figure 1 - U.S. OIL CONSUMPTION

Important to our balancing of supply and demand of petroleum is oil from both the southern and northern slopes of Alaska. Only after completion of the Alaskan pipeline (scheduled as I understand it for mid-1977) can we expect much product from the North. In the meantime, there are tanker facilities for transporting some crude oil from southern Alaska.

Domestic production of oil peaked at 11.3 million barrels per day (BBL/d) in 1970 but it has declined since then. (Figure 2) Natural gas production has leveled in the last four years and production now amounts to about 63 billion cubic feet per day (CFD). (Figure 3)

For the short range, we must not only arrest the decline in our domestic oil production, but our government must provide industries with the opportunities and incentives to accelerate their growth.

We must encourage and accelerate the exploration of the untested or lightly explored areas in our country that offer potential reserves, and, in particular, we probably should consider making our public lands more readily available for such exploration. FEA is now working with the Department of the Interior to increase the acreage leased on the Outer Continental Shelf to 10 million acres per year beginning in 1975.

The coal industry experts believe that the output of coal will increase by 50 percent by 1980 and another 50 percent by 1985.[1]

This forecast is based on four assumptions:

(1) Total cooperation from both industry and labor;
(2) Waiving of some environmental restraints;
(3) Faster leasing of federal coal lands; and
(4) Guaranteed sales and other incentives for capital investment.

The labor force would have to increase from 35,000 (1973) to 46,000 (1980) for strip mining, and from 100,000 to 150,000 in underground mining.

The addition of one ton of annual strip mining capacity costs $10 in capital while underground mining capacity increase costs $20. Thus, an $18 billion investment would be required by 1985 to achieve this goal by strip mine expansion alone. There is also currently much discussion of guarantees on coal investment with a production goal in mind of 2 billion tons a year by 1990.

There is also consideration being given to operating a few demonstration mines in cooperation with industry that reflect a variety of the conditions found in mining. The mines would be used as sites to test new technology and equipment without interfering with the operation of a commercial mine. They could also be used as training sites for new mine labor.

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[1]U.S. Energy Outlook, A Report of the National Petroleum Council's Committee on U.S. Energy Outlook, December 1972.

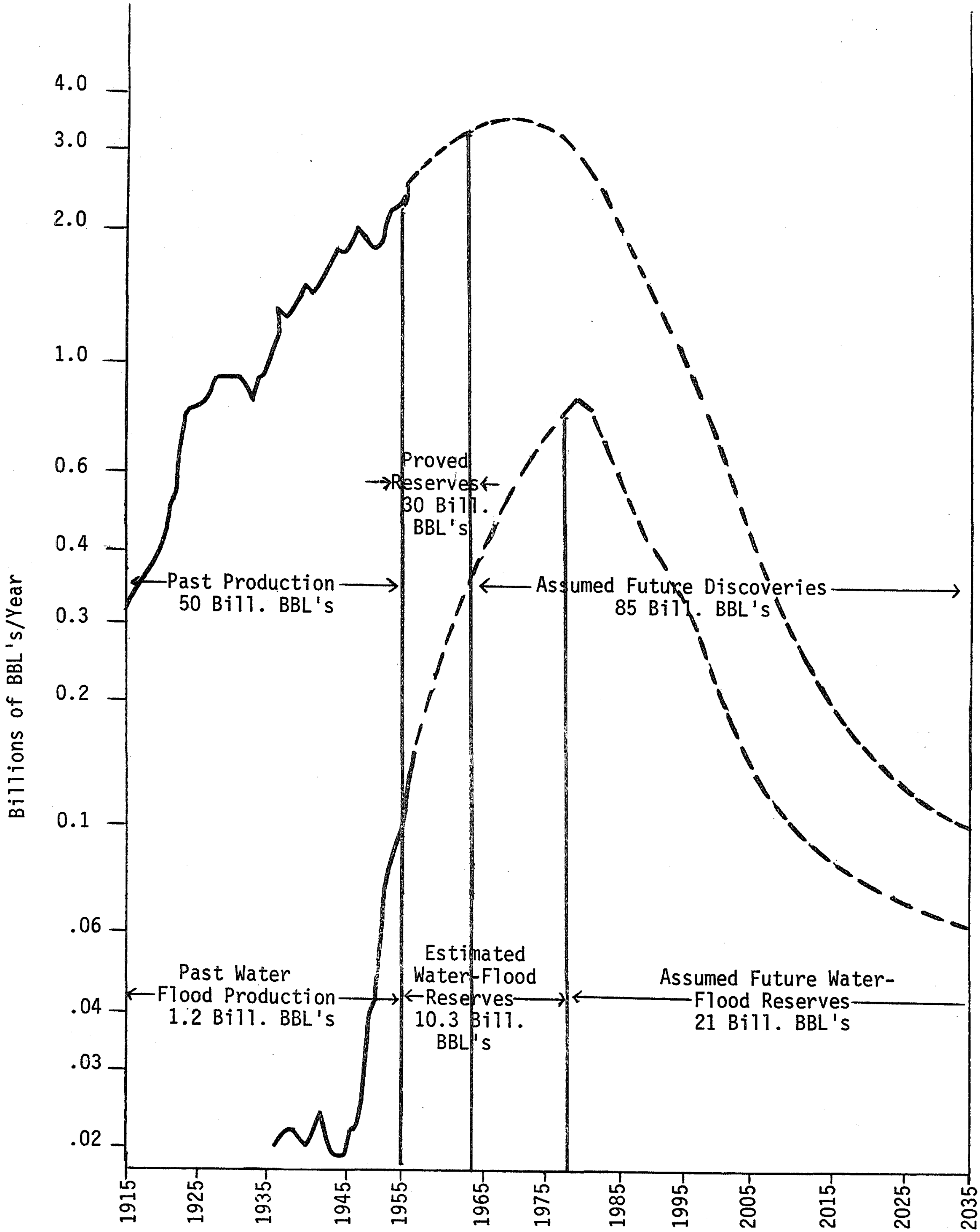

Figure 2 - COMPUTED PATTERN OF CRUDE OIL PRODUCTION IN THE UNITED STATES

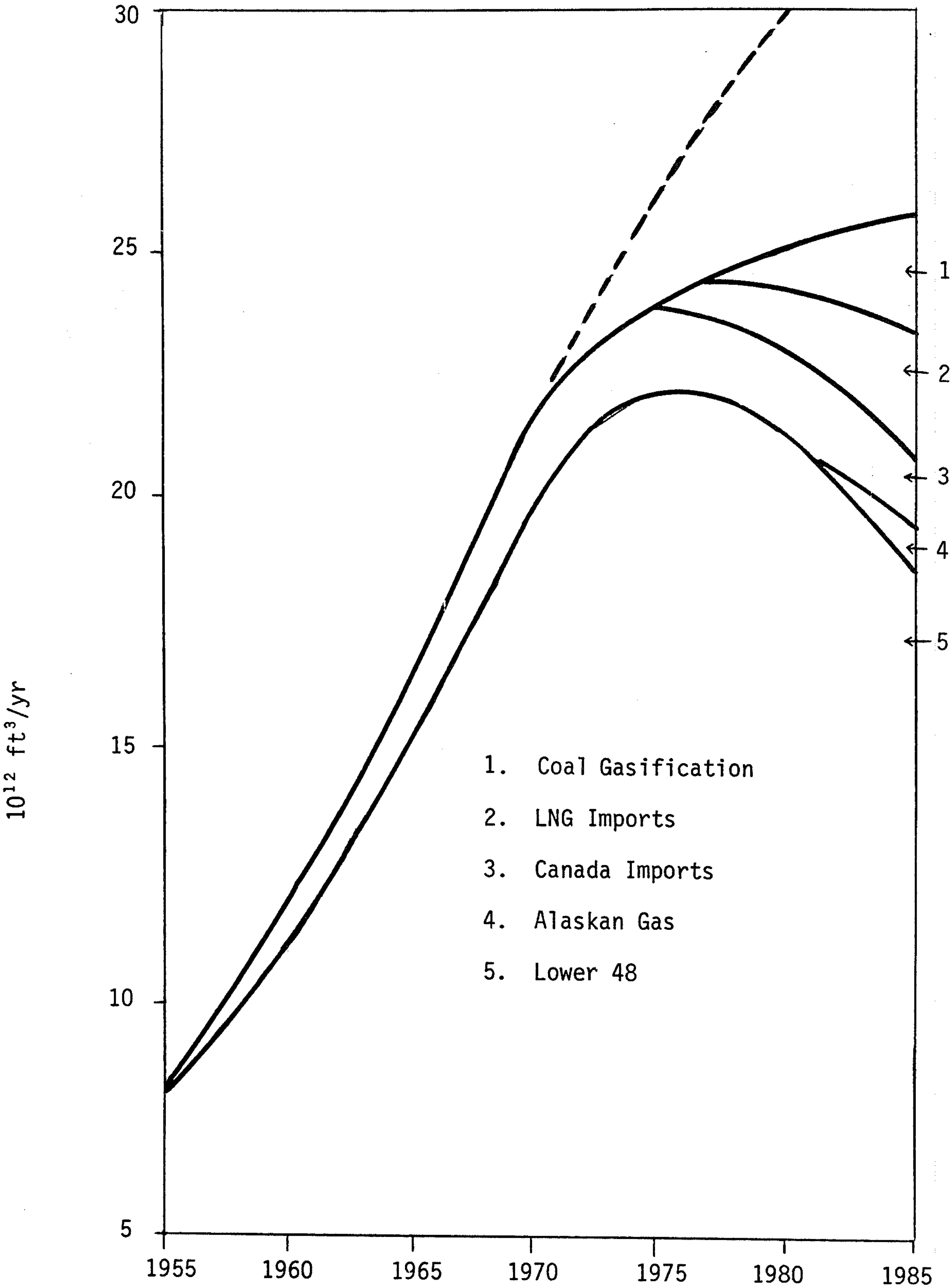

Figure 3 - U.S. GAS SUPPLY

In designing training programs, management should not be ignored. They need the opportunity to update their thinking concerning human relations and management practices. Labor leadership should have a similar opportunity. Also, communications between these groups should be further developed in order to maximize the cooperation needed to achieve coal output goals.

Two approaches to nuclear energy must be considered -- one with fission reactors and the second with fusion reactors.

Nuclear fission uses uranium for fuel. At a price of $10 per pound, 340,000 to 940,000 tons may be mined economically. At $15 per pound another 160,000 tons might be mined. The expected cumulative consumption by 1990 is 700,000 tons.

The capital cost of fission nuclear plants is rising above the $600 million cost of a recently completed plant ($170 per kilowatt of installed capacity). It may be as high as $340 per kilowatt of installed capacity during the seventies. There are 47 generating units in place now, another 60 under construction, and 126 planned.[2]

The AEC forecast that nuclear capacity would be at least 825 million kilowatts by the year 2000, enough to supply 22 percent of the energy consumption of that year, is questionable, owing to a slowing of the nuclear program. A number of proposed constructions have recently been canceled.

Major technical obstacles to first generation controlled fusion plants utilizing deuterium/tritium have been overcome precisely as forecast from theory. A prototype could be built as early as 1985. With increased funding and commercial power, output could be achieved as early as 2000.

Oil shale is one of America's largest undeveloped energy resources and is one with great potential for becoming productive in the next few decades. Although its contribution to the total U.S. energy production will be small, it will be in the vital form of petroleum. (Figure 4)

The majority of America's oil shale resources lies in publicly owned lands. There has been little incentive for full-scale commercial development. This was alleviated somewhat when, beginning January 1974, the government opened six tracts of federal land, about 5,120 acres each, via public lease sales, to private industry for prototype commercial development -- two tracts in Colorado, two in Utah and two in Wyoming. However, other problems remain.

Oil shale plants are big water users, and water is scarce in the region as indicated earlier. Some predict that oil shale water use will dry up local ranch and farm land. On the other hand, industry spokesmen say the industry will minimize its use of agricultural water rights. A third group points out that oil shale will not be the area's only big water user and calls for an integrated water use plan.

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[2] Energy Information, July 24, 1974, Denver, Colorado.

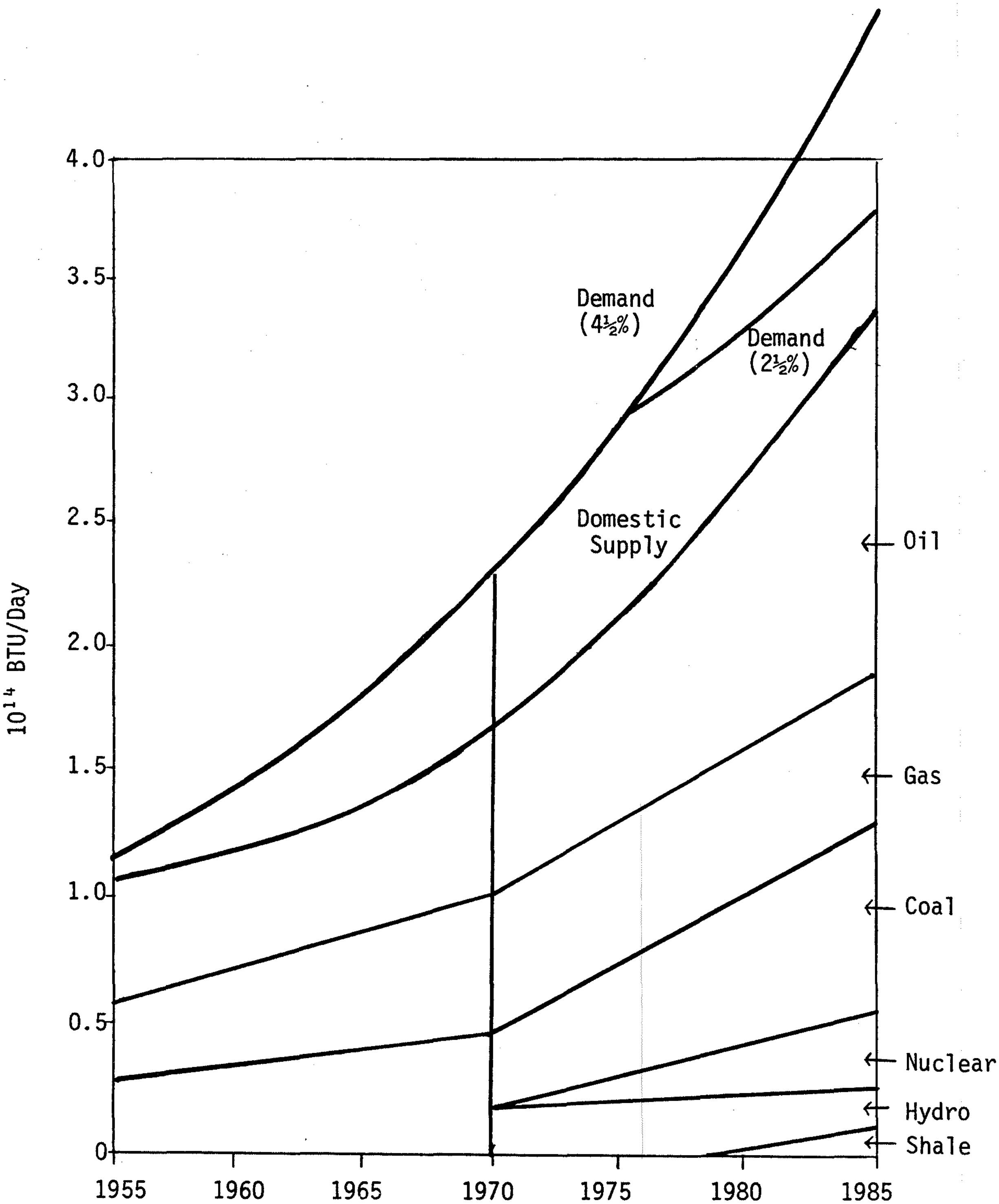

Figure 4 - U.S. DOMESTIC SUPPLY

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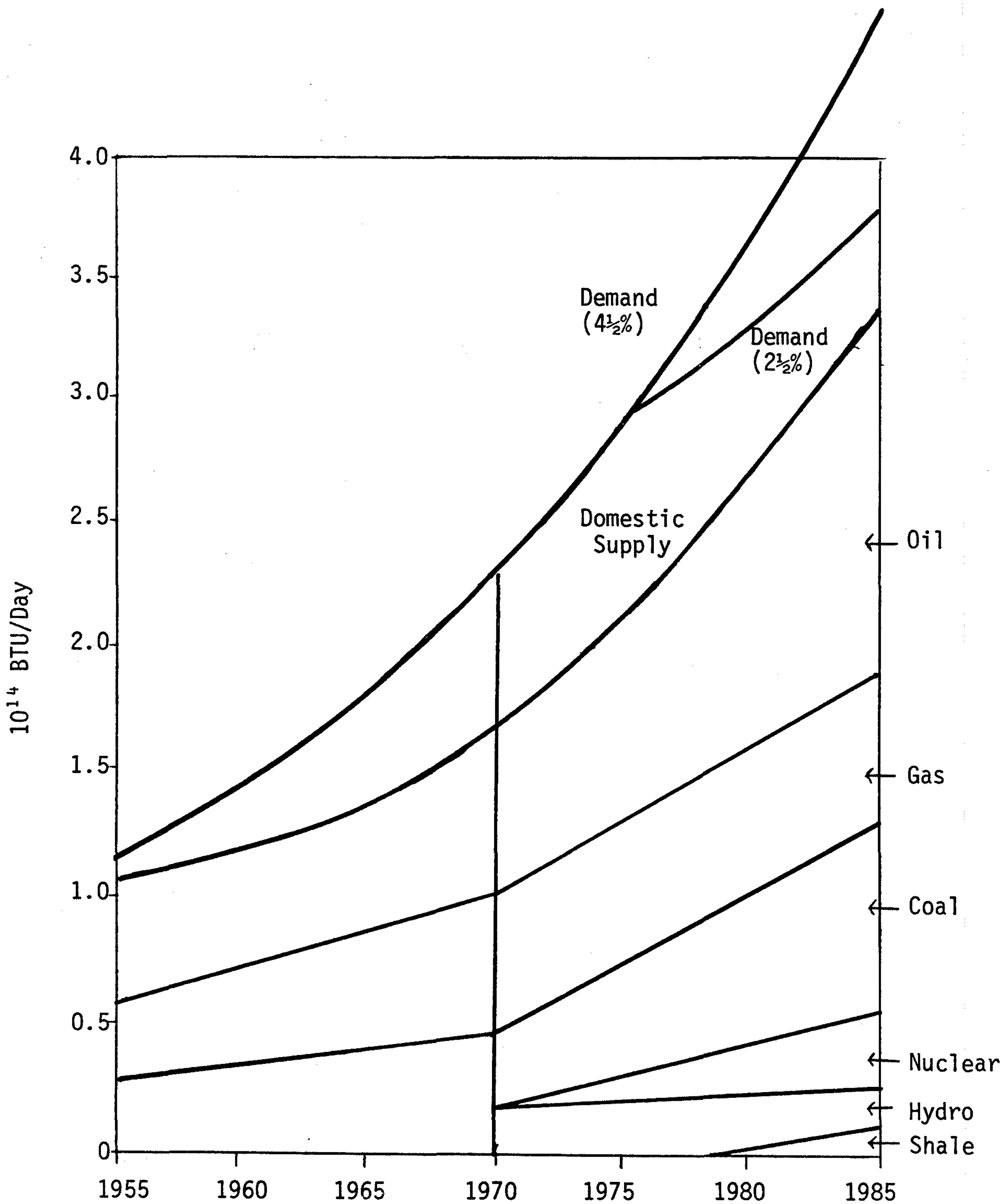

Figure 4 - U.S. DOMESTIC SUPPLY

The salinity problem, so often debated, has many facets -- the most discussed again is water consumption. Oil shale plants will draw relatively fresh water out of the Colorado River and not return any, thus increasing the river's salinity. Proposed salinity solutions include lining irrigation ditches with concrete, building expensive desalting plants or diverting some natural salinity sources.

Transportation raises the major air pollution problem expected from oil shale development. The Colorado oil shale region, like Denver, suffers from air inversions — which are air pollution compounders. Most believe the region will need careful land use planning and good mass transit systems to prevent population growth from causing hazardous air pollution. Air pollution from oil shale plants themselves is still an unknown, though much discussed, quantity.

Oil shale development, and its related urbanization, will unavoidably take large amounts of land away from the agricultural and open range areas of the Rocky Mountain region. Many sources fear the effects on wildlife, for the region is known as a wildlife area and boasts of the largest herd of migratory deer in the world. As a result, many observers, including industrial and environmental groups, favor the creation of wildlife preserves in the area.

The world's largest reserves of oil shale are found in the Green River formation in Colorado, Utah and Wyoming, over an area of about 17,000 square miles. The Piceance Creek Basin, which ranges over 1,250 square miles in Garfield and Rio Blanco Counties in western Colorado, is the richest single area of recoverable oil shale in the United States. The Piceance Basin of Colorado, alone, contains some 120 to 150 billion barrels of shale oil recoverable by modern methods in reserves more than 30 feet thick and containing at least 30 gallons of oil per ton. Interior Department's Geological Survey has estimated that the total shale oil reserves of the Green River formation in Colorado, Utah and Wyoming is more than 600 billion barrels of oil in deposits containing at least 25 gallons per ton of oil shale.[3] Because of these interesting possibilities, seminars have been developed around the subject of oil shale alone.

The Federal Energy Administration has a number of task forces working on data collection and analysis in assessing our present and future sources of energy. None has any more of a challenge than the Synthetic Fuels Task Force. The objective of this task force is to determine the basic need for each type of synthetic fuel, its present and projected availability by 1980 and beyond.

The task force will determine the probable use of each type of synthetic fuel, and then determine what the projected consumption will be for 1980 and for even more future years. The key factors which may affect substitution are domestic prices and a priority of use for the most abundant fuels. The two basic areas of use for synthetic fuels will be for heating and as

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[3]Colony Development Operation Bulletin, 1974.

a substitute for petrochemical feedstock. The task force is assuming that the basic feedstock for the synthetic fuels, which is coal, will be available to meet demand. (Figure 5) Projections are being developed for each type of synthetic fuel based on such key factors as labor costs, capital costs, lead time to building facilities and the technological constraints which presently affect plant size.[4]

The first geothermal power plant in the United States was built in 1960 by Pacific Gas and Electric (PG&E) at the Geysers, 90 miles north of San Francisco. This dry steam field has been developed by Union Oil, Magma Power and Thermal Power which sell steam to PG&E. From the first 12.5 megawatts (MW) unit installed, the operation has grown to about 400 MW. Two major problems have been experienced at the Geysers. The condensate is highly corrosive because of oxidation of hydrogen sulfide (H_2S); and there is a buildup of a dust-like material which causes loss of efficiency, plugging of nozzles and unbalancing and loosening of shrouds on turbine blades.

The most extensive exploration work in the U.S. has been at the Imperial Valley in southern California. The Bureau of Reclamation has had an exploration and testing program in the Imperial Valley at Mesa Anomaly. The purpose of the program is to determine technical and economic feasibility of desalting geothermal waters for augmentation of the Colorado River.

Hydroelectric energy is one of the forms of energy alternatives receiving increased attention. Most of the usable sites for significant development of hydroelectric energy have already been utilized. Some growth will occur from 1971 through 1985 but will probably average only about 1.6 percent annually. Thus, hdyroelectric energy may not maintain its increasing share of electric power generation in this period.

Most of the expansion of hydroelectric power will occur in the western areas of the United States -- about 84 percent of it in the central and midwest states. The available hydroelectric energy will barely affect requirements for coal, oil, gas and nuclear power east of the Mississippi. If planned expansions occur, about 60 percent of the potential hydroelectric energy in the United States will be harnessed by 1985. Necessarily, the undeveloped potential will be most widely scattered small sites in the 50- to 150-megawatt range that may never be developed for economic reasons.[5]

As long as fossil fuels remain available, even though not abundant worldwide, the utilization of solar energy will perhaps be confined to small experimental installations and unique situations. Because it is so diffuse and intermittent when it reaches the earth, solar energy can be put to no foreseeable large-scale use over the next 15 years, even with appreciable improvements in technology. The silicon cell, developed about 15 years ago, has proved to be a reliable means for direct conversion of solar radiation to electricity for applications in outer space. The generation of significant

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[4]FEA Task Force.

[5]Summary of New Energy Forms Task Group Reports.

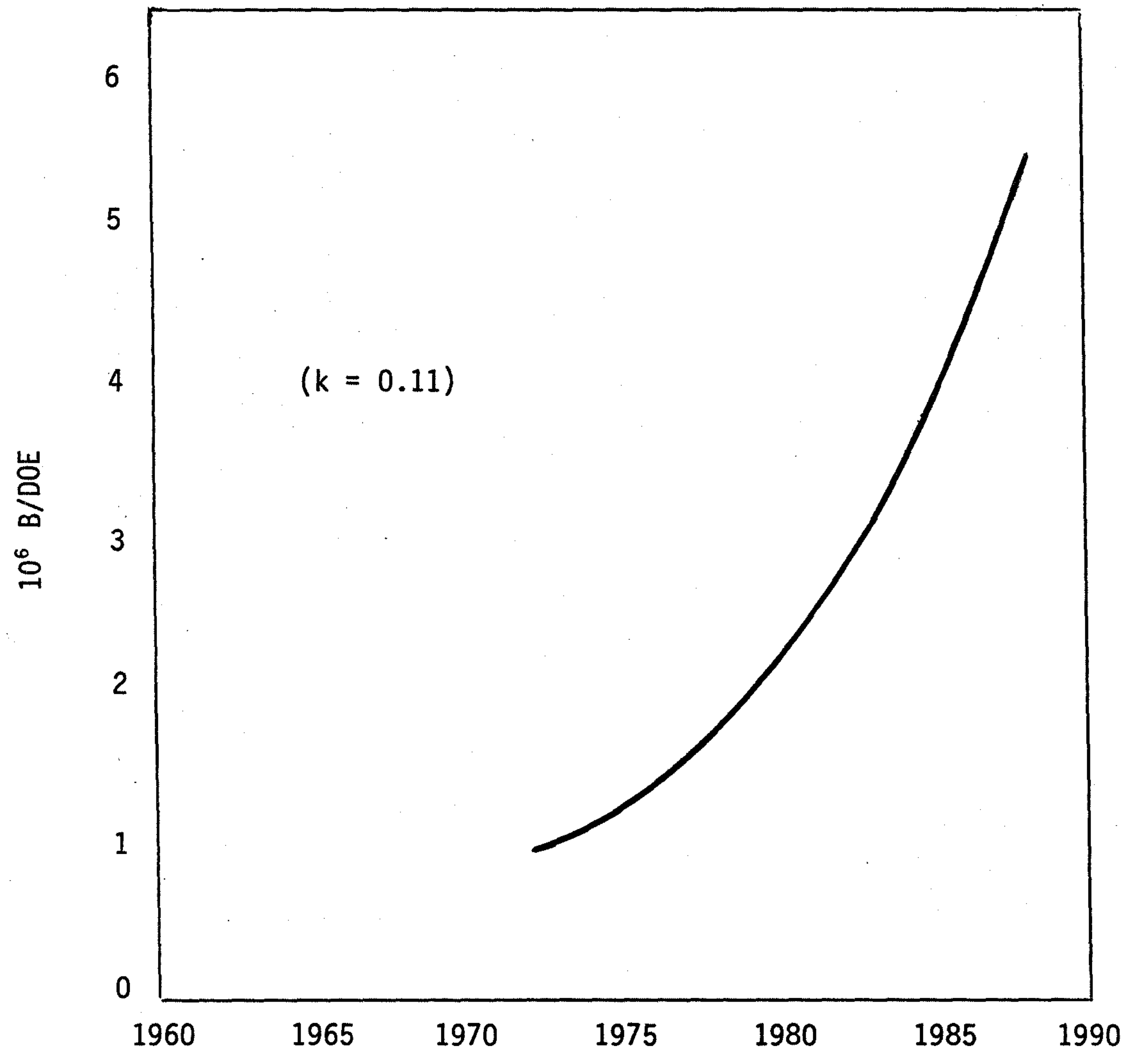

Figure 5 - PETROCHEMICAL FEEDSTOCKS

amounts of power, however, requires the connection of an extremely large number of cells. The high capital cost of silicon cell arrays results in power costs on the order of $2.00 to $5.00 per kilowatt hour. Thus, the cost is roughly about 1,000 times that of conventional power sources.

Based on current research levels on solar energy cells, no major breakthrough is anticipated before 1985. The time when this ultimate source of energy will have to be used to supplement the dwindling supplies of other sources remains indefinite but could be as soon as the year 2000. If the use of solar energy utilization is ever to achieve any prominence in the United States, it would appear that its development must be supported by the government just as atomic energy was.[6]

Let's put all this discussion into our perspective and look just at Region VIII, which I represent -- Colorado, Montana, North Dakota, South Dakota, Utah and Wyoming.

Region VIII contains nearly 50 percent of the nation's coal reserves. By 1980, estimated production in Montana, Wyoming and North Dakota is 160 million tons. The states of Colorado, Utah and Wyoming possess all of the economically recoverable oil shale in the United States. Sources of geothermal energy presently are being explored in the region. Our "tight" gas sources are believed to exceed the known amounts of conventional natural gas by nearly two times. Uranium requirements by the year 2000 are forecast at a 50-70 percent increase with 45 percent of the processing capacity in Region VIII.

Additional sources of energy in this area involve about 5 percent of the nation's crude oil and gas reserves and substantial amounts of geothermal energy and solar energy for development of hydroelectric power. The estimate of crude oil reserves is 1.9 billion barrels or 5 percent of the U.S. reserves. Addition of the four corners state of New Mexico to the Region VIII output increases the area production to almost 11 percent of the total U.S. production.

The recoverable natural gas reserves in Region VIII have been estimated to be 10 trillion standard cubic feet (SCF) or 3.5 percent of the total U.S. reserves. This region, along with New Mexico, contains significant reserves of so-called "tight" natural gas. Tight gas refers to natural gas trapped in rock strata of low permeability. Extensive conventional fracturing techniques, as well as the more controversial nuclear stimulation (fracturing), have been proposed to free these gas reserves. Recent estimates of potentially recoverable trapped gas in areas of Wyoming, Colorado and Utah amount to 600 trillion standard cubic feet.

Geothermal activity in the region is rapidly increasing and has great potential. The National Science Foundation has a geothermal exploration experiment, consisting of drilling a deep well in an area of high heat flow, underway in Montana. Considerable interest in federal leasing has been expressed in Utah, Montana, Colorado and Wyoming.

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[6]Summary of New Energy Forms Task Group Reports.

As of January 1, 1972, it was estimated that the mountain states had about 21 percent of the total undeveloped hydroelectric capacity of the United States. Estimates by major drainages show the combined total "undeveloped" capacity of the Colorado River and Missouri River Basins to be about 11 percent of the total undeveloped hydroelectric capacity of the United States.

All of this is to say we have keen and deep interests in this country's major energy program, identified as "Project Independence." During the week of August 6 through 9, we will initiate the first of some ten public hearings on "Project Independence."

The first hearing will be in Denver. We are pleased that Region VIII was selected to demonstrate what a model public hearing can be. So I invite you to participate and to encourage all citizens to participate as representatives of organizations -- most important of all -- as a representative of their individual concern.

The hearings will begin at 9:00 a.m. on August 6, run all day and into the evening -- 7:00-9:00 p.m. for the four days and nights -- August 6 through 9. They will be held in the Denver Post Office Building auditorium. If you want to testify, you should let us know. If a personal appearance is not possible, we have made arrangements so that you can submit your written testimony as part of the official record and proceedings. You may want to include written testimony in addition to your verbal comments. We very much want to hear from all segments of society.

The input from the ten public hearings -- particularly this first one -- will become a part of the Blueprint for Project Independence, represented by a document to be placed on the desk of the President by our FEA Administrator, Dr. John C. Sawhill, by November 1, 1974. The Blueprint will contain:

(1) An historical perspective of the energy situation - How did the problem arise?
(2) A definition of energy independence.
(3) An analysis of alternative energy supply and demand under a variety of assumptions, including an evaluation of cost, environmental effects and ability to reduce our vulnerability.
(4) An analysis of the manpower, financial, material, transportation and other constraints we face in achieving these goals.
(5) Recommended administrative, economic, budgetary and legislative policy actions to achieve our objectives.

American consumers and taxpayers, corporations and investors will have the final word. Some degree of self-sufficiency probably can be attained in the next six years, but the question remains whether or not the nation is prepared to make the necessary commitment.

The early FEA Action Program in Conservation and other current FEA programs are only a start, pending completion of our more comprehensive program -- as set forth in the Project Independence Blueprint. It is a job that neither the federal government nor FEA nor any other federal agency can accomplish by itself. It requires the cooperation of state and local governments, the business community and the commitment of this fine organization -- every one of us!

QUESTIONS AND ANSWERS

Dudley E. Faver

Q: You mentioned that "Project Independence" would require the cooperation and input of various groups and state agencies, including the academic community. I wonder if you could give any specific ideas as to what the academic community might be able to do in making an input to "Project Independence?"

A: We need all the studies we can get to improve determinations relating the availability of water to requirements of various activities associated with energy production or use. These are needed for determining trade-offs that would best suit our future requirements.

Q: Did you mention wind as an alternative source of energy? Particularly in Region VIII, is wind considered a possibility with subsequent development of a secondary fuel source from, for example, electrolysis of water?

A: I must say I did not devote any time to this subject. However, some very extensive surveys selected the one area in the United States that could be depended upon to have the most reliable source of wind. As I remember, this was an area in Wyoming.

Q: I remain unconvinced that sufficient effort is being made to work out means for more efficient use of energy. True, our prices are increasing very drastically, but the pricing mechanisms themselves (the structure of pricing mechanisms) isn't changing. We are still utilizing the use-inducement price structures where unit cost decreases as amount consumed increases. It seems obvious that sooner or later we are going to run out of easily accessible sources of energy. We have all grown used to a pattern of consumption that is extremely wasteful. Why isn't there more serious consideration of that alternative (more efficient use of energy) along with the development of new sources of energy?

A: I agree with every word you say. There is no question that the better utilization of what we have is the first payoff. I recently read an article which mentioned that in addition to the savings we have made in consumption of gasoline, by reducing speed (a by-product in this area) there was a reduction in fatalities over the first five months of this year of 27 percent. So this conservation element not only covers fuel but also human life. We can go further with that in the construction of our houses where there is an extremely fertile field for the reduction of energy use through the proper application of insulation.

Q: We've been talking about information transfer or technology transfer. Recently, I read an interesting article on a home designed specifically to conserve energy and other resources. It was claimed that energy consumption in this home was reduced by 50 percent. There are a number of building codes which must be considered in taking advantage of energy savings. Given the acuteness of the situation, we may have to look for an incentive to let us take advantage of a 50 percent reduction in some fraction of new domestic construction.

A: May I go just a little further with that comment and state that within the past two weeks, I read some data that indicated some states were considering giving a tax break on energy-saving considerations that people put in new houses, and one in particular that I found interesting related to the utilization of solar energy to heat houses. This was offered as an incentive to cause people to give greater consideration to this alternative.

Q: An item in the Washington Star said that PEPCO (Potomac Edison Power Company) by conserving its own utilization of energy had reduced its in-house consumption by 30 percent. That's a comment; now a question relating to oil shale. My arithmetic, following your statement that 30 gallons of oil were produced per ton of shale, says this is approximately 10 percent by weight. Does that mean there are 1,800 pounds of tailings for every 30 gallons of oil produced?

A: It sounds like your arithmetic is right. I recently visited the model mine installed in Colony, not too far from Grand Junction, Colorado, and there is quite a bit of tailing. That's one of the problems that environmentalists are concerned about, along with the rest of us. On the subject of conservation, I can plug that just a little further. I read a report that during the third quarter of this last fiscal year, all agencies of the federal government had stressed conservation to a degree. Their savings for that quarter exceeded the amount of energy expended, and I think this is part of the message we are trying to convey.

Q: You said that in order to meet the energy goals, we may have to relax environmental standards. What did you have in mind?

A: I really didn't have anything specific in mind, and that's probably the safest route to take. But I do know that, for example, in the area of the Colony oil shale development they were very careful in testing the effects of inversions in the valleys, and after considerable study they elected to place the mine plant on the plateau, out of the inversion area. Now exactly what standard they're going to be able to meet by having the plant on the plateau, I don't know. But we do know that by putting the plant up there, the pollution will be less than in the valley, so there may have to be some adjustment in the standard to let them continue in their operation in the new area, knowing full well that it's better than it might have been but it may be below some of the standards that we have currently dictated.

ENERGY SELF-SUFFICIENCY: THE IMPACT ON ENVIRONMENTAL RESOURCES

by

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INTRODUCTION

The title of my presentation is "Energy Self-Sufficiency: The Impact on Environmental Resources." My purpose is not to address specific technical aspects of particular environmental problems -- after all, the members of this association are more experienced and knowledgeable in these matters than I. Moreover, my purpose is not to evaluate specific federal and state legislative initiatives that are designed to rationalize the dilemma between increased energy consumption and production, on the one hand, with the desire for improved environmental quality on the other hand. Instead, my purpose is to provide an overview of the potential conflict between the major energy issue of the decade (and perhaps the remainder of the century) -- namely, energy self-sufficiency by 1980 -- and our desire to preserve the quality of the environment. In this sense, my sole task is to outline the potential environmental impacts that surround "Project Independence", and identify the implications for energy research and development. However, because of current data and modeling limitations, the environmental impacts are limited to land-use requirements and air pollutants.

"PROJECT INDEPENDENCE"

The events of the past year have made it abundantly clear that the U.S. economy is highly energy intensive. It has become common knowledge that much of our past economic growth, and most of the imporvement in the quality of life, has been related to the rapid increase in energy consumption per capita. Moreover, it has become clear that our current rate of energy consumption cannot be sustained by the current level of domestic production alone, and, at the same time, cannot be supported by a guaranteed source of foreign imports.

The point is simple. It is now clear that the U.S. economy must develop its domestic energy resources more rapidly and more intensively than in the past. It must design and implement an energy program that will satisfy the near-, medium-, and long-term needs of the domestic economy. Since it must do so by relying more heavily on domestic resources, it must also do so in a manner that balances the desire for increased energy against the desire for improved environmental quality.

However, it is important to understand that there is more to a rational domestic energy program than protecting the environment alone. In fact, there are five essential criteria for a rational domestic energy program. They are:

(1) More efficient methods of converting and consuming energy must be developed and utilized;
(2) A potentially limitless source, or combination of sources, of primary energy, which can be converted into secondary fuels, must be discovered and rendered commercially feasible;
(3) The primary sources of energy, and their by-products, must be developed by environmentally clean and safe methods;
(4) The primary energy sources must be within the reach of present technology and within the capital and manpower constraints existing in the economy; and
(5) The primary energy sources must be domestically available in order to insulate the economy from the vagaries of international politics.

Obviously, these are not mutually exclusive criteria; rather, they are interrelated and, in some cases, inconsistent. Yet, they represent the issues that will dominate energy research and development as well as energy policy for a long time. In short, it is my opinion that the major energy issues center on the following topics:

(1) Reducing per capita consumption of primary energy resources at the least cost to economic performance; and
(2) Increasing the domestic production of primary and secondary energy in the least environmentally degrading manner.

As a reaction to the need for a new domestic energy program, the federal government has embarked on an initiative called "Project Independence" whose stated objective is to free the economy and society from dependence on insecure foreign sources of energy. Although "Project Independence" has implication for each of the criteria listed above, the most relevant for my present task is the relationship between "Project Independence's" rapid development of domestic energy resources and society's desire to preserve environmental quality -- i.e., the integrity of the land and the quality of ambient air.

In order to gain a perspective on the intensity of this relationship, a statistical summary of the projected energy demands and supplies, as envisioned by "Project Independence", is shown in Table 1. The columns under the heading "minimum development and conservation" represent forecasted demands and supplies under a set of assumptions that permit present (i.e., pre-1974) consumption and production trends to continue unaltered. The columns under the heading "maximum potential development and conservation" represent forecasted demands and supplies under "Project Independence." (Roughly, the "Project Indendence" forecasts are based on the

Table 1

PATTERNS OF U.S. ENERGY PRODUCTION AND CONSUMPTION

1975

	Minimum Development & Conservation			Maximum Potential Development & Conservation[b/]		
	Demand	Supply[a/]	Deficit	Demand	Supply[a/]	Deficit
Petrolum:						
million bbl/day	18.5	10.3	8.2	15.7	10.7	5
trillion Btu	37,310	20,800	16,510	31,714	21,540	10,174
Natural Gas:						
billion cu.ft.	23,909	21,681	2,228	21,518	22,188	(670)
trillion Btu	24,650	22,350	2,300	22,185	22,880	(695)
Coal:						
million short tons	584	636	(52)	537	754	(217)
trillion Btu	14,260	15,450	(1,190)	13,119	18,320	(5,201)
Hydropower:						
million kwh	290	285	5	290	285	5
trillion Btu	2,930	2,910	20	2,930	2,910	20
Nuclear Power:						
billion kwh	296	245	51	296	274	22
trillion Btu	3,150	2,610	540	3,150	2,920	230
Geothermal:						
billion kwh	5	4	1	5	4	1
trillion Btu	110	90	20	110	90	20
Solar:						
trillion Btu						
Total						
trillion Btu	82,410	64,210	18,200	73,208	68,660	4,548

a/ Includes shale oil

b/ Assumes conservation equal to 15 percent in petroleum, 10 percent in natural gas and 8 percent in coal.

Source: Compiled by F. J. Alessio from documents supplied by the Federal Energy Administration.

Table 1 (cont'd)

PATTERNS OF U.S. ENERGY PRODUCTION
AND CONSUMPTION

1980

	Minimum Development & Conservation			Maximum Potential Development & Conservation[b/]		
	Demand	Supply[a/]	Deficit	Demand	Supply[a/]	Deficit
Petroleum:						
million bbl/day	21.6	11.4	10.2	18.4	14.2	4.2
trillion Btu	43,530	22,950	20,580	37,001	28,530	8,471
Natural Gas:						
billion cu.ft.	24,869	19,480	5,389	22,382	23,586	(1,204)
trillion Btu	25,640	20,080	5,560	23,076	24,320	(1,244)
Coal:						
million short tons	665	740	(75)	612	1,023	(411)
trillion Btu	16,140	17,980	(1,840)	14,848	24,860	(10,012)
Hydropower:						
million kwh	313	313	--	313	313	--
trillion Btu	2,970	2,970	--	2,970	2,970	--
Nuclear Power:						
billion kwh	651	651	--	757	757	--
trillion Btu	6,940	6,940	--	8,070	8,070	--
Geothermal:						
billion kwh	14	14	--	63	63	--
trillion Btu	300	300	--	1,370	1,370	--
Solar:						
trillion Btu				120	120	--
Total						
trillion Btu	95,520	71,220	24,300	87,455	90,240	(2,785)

a/ Includes shale oil

b/ Assumes conservation equal to 15 percent in petroleum, 1[illegible] percent in natural gas and 8 percent coal.

Source: Compiled by F. J. Alessio from documents supplied by the Federal Energy Administration.

Table 1 (cont'd)

PATTERNS OF U.S. ENERGY PRODUCTION
AND CONSUMPTION

1985

	Minimum Development & Conservation			Maximum Potential Development & Conservation[b]		
	Demand	Supply[a]	Deficit	Demand	Supply[a]	Deficit
Petroleum:						
million bbl/day	25.6	11.0	14.6	21.8	18.5	3.3
trillion Btu	51,840	22,080	29,760	44,064	37,210	6,854
Natural Gas:						
billion cu.ft.	26,437	18,155	8,282	23,793	23,981	(188)
trillion Btu	27,250	18,720	8,530	24,252	24,720	(468)
Coal:						
million short tons	893	980	(87)	822	1,570	(748)
trillion Btu	21,470	23,810	(2,340)	19,752	38,150	(18,398)
Hydropower:						
million kwh	339	339	--	362	362	--
trillion Btu	3,120	3,120	--	3,360	3,360	--
Nuclear Power:						
billion kwh	1,130	1,130	--	1,745	1,745	--
trillion Btu	11,750	11,750	--	18,150	18,150	--
Geothermal:						
billion kwh	28	28	--	210	210	--
trillion Btu	610	610	--	4,560	4,560	--
Solar:						
trillion Btu				4,100	4,100	--
Total						
trillion Btu	116,040	80,090	35,950	118,238	130,250	(12,012)

a/ Includes shale oil

b/ Assumes conservation equal to 15 percent in petroleum, 10 percent in natural gas and 8 percent in coal.

Source: Compiled by F. J. Alessio from documents supplied by the Federal Energy Administration.

following assumptions: (1) all resource availability, including water, and capitol development constraints will be eliminated by appropriate governmental policies; (2) the only binding constraint is the development of energy technologies; and, (3) the level of consumption of the major primary energy sources is reduced by 15 percent for petroleum, 10 percent for natural gas and 8 percent for coal -- or, a 9.5 percent reduction in total BTU's consumed.)

An examination of the data is worthwhile. By 1980, the domestic economy is expected to move from a deficit in total energy consumption of slightly more than 24 quads (quad = 10^{12} BTU's) to a surplus of slightly more than 2.75 quads. However, it is interesting to note that there remains a deficit in petroleum consumption offset by a small surplus in natural gas and a large surplus in coal. In fact, the maximum potential production of coal exceeds the forecasted level of consumption by more than 70 percent. In addition, the surplus in total energy hides the fact that in order to achieve total independence by 1980 the domestic economy would have to substitute coal consumption for nearly 19 percent of the forecasted level of petroleum demand -- a seemingly improbable task in the short time available.

More revealing are the data presented in Table 2 which represent the rates of growth in the output of the various domestic energy sectors. Petroleum production would have to increase by 32 percent over the five-year period of 1975 to 1980 (i.e., approximately 6 percent per annum), while coal production would have to increase by 35 percent over the same five-year period (i.e., approximately 7 percent per annum). These rates of expansion are beyond the recent historical growth patterns in both industries, although the petroleum increase is feasible when the north slope begins to produce. Finally, nuclear power production is expected to more than double at most five-year intervals.

Tables 1 and 2 represent nothing more than an overview of the magnitude of the development of domestic energy resources that could occur under the initiative of "Project Independence" and the drive to energy self-sufficiency in the near term.

ENVIRONMENTAL IMPACTS

The data presented in Table 1 indicate clearly that a massive development of domestic coal resources as well as a rapid introduction of nuclear power and solar energy are prerequisites to achieving energy self-sufficiency. Needless to say, coal is the least desirable primary energy source from an envrionmental point of view, and nuclear power is the most controversial secondary source from a societal point of view.

With this in mind, Table 3 illustrates the potential land use and air pollution impacts associated with "Project Independence" as outlined in Table 1. The data reported in these tables are preliminary. The degree of error cannot be determined until more work has been done to refine the existing model. Therefore, these numbers are nothing more than preliminary estimates and should be viewed as such. Nevertheless, the results are somewhat surprising. All oil fixed electric power plants would have to be converted to coal by 1980. If these conversions are accomplished, and if nuclear power is able to

Table 2

FIVE-YEAR GROWTH RATES FOR U.S. ENERGY SUPPLY & DEMAND

	1980 Demand	1980 Supply	1985 Demand	1985 Supply
MINIMUM DEVELOPMENT & CONSERVATION				
Petroleum	14.2	10.3	16.0	-3.8
Natural Gas	4.0	-10.2	6.3	-6.8
Coal	13.1	16.4	33.0	32.4
Nuclear Power	120.3	165.9	69.3	69.3
Hydropower	2.0	2.0	5.1	5.1
TOTAL ENERGY	15.9	11.1	21.5	12.9
MAXIMUM DEVELOPMENT & CONSERVATION				
Petroleum	14.2	32.5		30.4
Natural Gas		6.3		1.6
Coal		35.7		53.5
Nuclear Power		176.4		124.9
Hydropower		2.7		13.1
Solar		--		--
TOTAL ENERGY		31.4		44.3

Source: Calculated from Table 1.

Table 3

PERCENTAGE CHANGE IN ENVIRONMENTAL DEGRADATION
RESULTING FROM PROJECT INDEPENDENCE
(Assuming an Adequate Coal Cleaning Technology)

	1975	1980	1985
ENVIRONMENTAL EFFECTS:			
Land Use (sq.mi.)			
Coal strip mine (annual)	32.754	49.749	77.690
Coal steam electric plants	18.357	-3.998	-26.059
Oil fired electric plants	-100.000	-100.000	-100.000
Gas fired electric plants	-32.579	-40.048	-90.515
Nuclear electric plants	11.877	16.282	54.468
Electric power transmission	-8.050	-9.570	1.880
Air Pollutant Emission (million lbs.)			
Carbon dioxide	-8.212	-15.099	-13.108
Carbon monoxide	-7.978	-9.555	1.524
Sulfur oxides	-4.948	-17.097	-21.673
Nitrous oxides	-7.642	-14.583	-15.636
Particulates	0.829	-8.544	-9.028
Hydrocarbons	-8.201	-9.864	-0.128
Aldehydes	-12.517	-15.444	-5.346

supply 8.0 quads (i.e., approximately 10 percent of the total energy requirement) by 1980, and if sufficient quantities of low sulfur coal can be mined, there is the potential for substantial improvements in air quality -- the volume of air pollution emmissions decline in all categories. However, the volume of land strip mined to recover the coal increased by nearly 50 percent per annum by the end of 1980.

If nuclear power does not grow as planned, the environmental degradations are quite severe, even if there are adequate supplies of low sulfur coal. (Table 4) (On the other hand, if the level of demand is reduced by 10 percent through conservation, the environmental improvements are significant. Table 5) Finally, it should be noted that if a technology which permits power plants to burn high sulfur coal, and still meet the air pollution standards established in NEPA, is not developed, the volume of air pollutants would rise dramatically -- sulfur oxides would increase by 25 percent, nitrous oxides would rise by 15 percent and particulates would rise by 400 percent above the level power plant emissions implied in Table 3.

This very limited environmental assessment points to two interesting conclusions:

(1) A coal cleaning technology must be developed and rendered commercially feasible. However, none appears to be on the horizon before 1985. Consequently, the environmental impacts are likely to be less pleasant than those shown in Table 3.

(2) From the viewpoint of preserving the quality of the ambient air, the nuclear power portion of "Project Independence" is critical. Without nuclear power, the potential environmental damage is large, given the existing technology of energy conversion and utilization. However, it has to be emphasized that the improved air quality associated with the growth of nuclear power comes at the expense of large volumes of radioactive wastes.

SUMMARY

The conclusions are simple. If the conflicting desires for energy self-sufficiency and improved environmental quality are to be met simultaneously, the direction of energy research and development is clear-cut; namely, we must develop a commercially feasible technology for cleaning coal, we must develop a system to manage radioactive wastes safely, and we must develop a regulatory mechanism to insure adequate reclamation of strip mined land. In my opinion, these are the major environmental problems that must be solved if "Project Independence" is to be a rational energy program.

Table 4

PERCENTAGE CHANGE IN ENVIRONMENTAL DEGRADATION
RESULTING FROM PROJECT INDEPENDENCE
MINUS NUCLEAR POWER
(Assuming an Adequate Coal Cleaning Technology)

	1975	1980	1985
ENVIRONMENTAL EFFECTS:			
Air Pollutant Emission (million lbs.)			
Carbon dioxide	9.938	17.516	15.248
Carbon monoxide	10.074	9.686	2.047
Sulfur oxides	10.848	25.284	28.531
Nitrous oxides	9.882	17.576	20.740
Particulates	12.839	25.584	21.119
Hydrocarbons	8.162	9.801	0.026
Aldehydes	8.117	9.434	0.465

Table 5

PERCENTAGE CHANGE IN ENVIRONMENTAL DEGRADATION
RESULTING FROM A TEN PERCENT ACROSS THE
BOARD REDUCTION IN TOTAL ENERGY DEMAND

ENVIRONMENTAL EFFECTS:	1975	1980	1985
Land Use (sq.mi.)			
Coal strip mine (annual)	-11.182	-13.025	-16.566
Coal steam electric plants	-13.398	-14.585	-18.550
Oil fired electric plants	-15.569	-17.551	-22.747
Gas fired electric plants	-15.569	-17.551	-22.747
Nuclear electric plants	0.0	0.0	0.0
Electric power transmission	-9.340	-9.588	-11.399
Air Pollutant Emission (million lbs.)			
Carbon dioxide	-8.415	-8.996	-9.265
Carbon monoxide	-0.073	-0.080	-0.448
Sulfur oxides	-10.683	-12.314	-14.941
Nitrous oxides	-5.575	-6.327	-9.759
Particulates	-8.377	-10.586	-13.643
Hydrocarbons	-0.490	-0.502	-1.136
Aldehydes	-7.287	-7.051	-5.610

QUESTIONS AND ANSWERS

Frank J. Alessio

Q: Will "Project Independence" include an environmental impact statement? It is a major federal action, I take it, to prepare this report and as such it would seem to be covered by Section 102.

A: There are environmental standards connected with each of the major development phases in "Project Independence." For example, there are environmental impact statements associated with oil shale development, with the development on the outer Continental shelf, and with nuclear power production as envisioned by the Atomic Energy Commission. However, the data on which these environmental impact statements are based, the analytical methods used and their quality are somewhat questionable. It seems to me they serve no useful purpose as presently structured. Perhaps a better procedure would be to prepare a much more detailed technology assessment as it relates to the environment. Most environmental impact statements tend to dwell very heavily on economic benefits associated with a particular resource development. The important aspect to be covered is simply what the technology is and how the technology itself changes the environment.

Q: From your remarks, could one infer that you're really looking in the near term or relative near term for either or both coal and nuclear power development? Given the consequences associated with either energy source, do we need to look to some other primary and secondary source of energy in the long-term future -- the year 2000 and beyond?

A: Coal development will be largely a near-term project. We cannot go on developing coal forever the way it's envisioned simply because there is not enough coal. With respect to nuclear power, however, it is possible that nuclear development through 1980 is not necessarily consistent with long-term nuclear development through the year 2000 or 2050, and that's an important point for enery research. There are different kinds of nuclear reactors and nuclear power. The real technological fear is that we may be so determined to achieve energy self-sufficiency by 1980 that we may begin to develop both coal and nuclear power in such a way as to bias all future energy research and development. I fear that "Project Independence" and the kind of development it implies will move us very quickly toward technologies like the breeder reactor which are not socially or economically rational. We should be investigating alternative sources of energy.

Q: Since you're an economist, and I happen to share that profession, I find I am almost forced to ask this question. I have great faith in projections, as all economists do. However, there's a great emphasis on the supply side with very little concern about demand. Recently, the

Salt Lake City Tribune published an article about refineries across the country which are running at 7 to 9 percent below capacity at the height of the recreation season, which is the high demand season for gasoline. How do you reconcile this with your concern that conservation won't work? Is the demand for gasoline and the increase in price actually reducing consumption or isn't it?

A: The projections I discussed were only orders of magnitude. There has been a significant level of conservation on the demand side--about 10 percent per year which is much more than we've ever experienced in the United States. However, conservation, in terms of what it does to land use requirements and ambient air standards, does not take us nearly as far as alternative supply patterns would. With respect to the refining industry, it is only recently that they began to operate anywhere near 95-98 percent capacity. The historical pattern for this industry is about 85 to 88 percent of capacity. One of the reasons they generally operate 15 percent below actual physical maximum productive capacity is due to the significant amount of down time in a refinery. When production increases to 95 percent, however, refineries are merely postponing down time which could be disastrous at some later point. It is very important that the mechanics of the refining industry be restructured so that 95 percent of capacity utilization is a good performance.

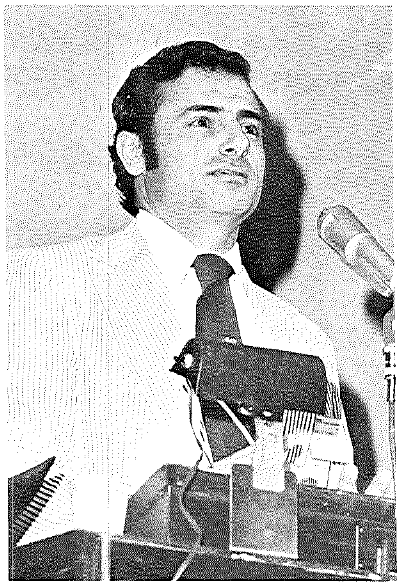
Q: You indicated we know a great deal more about the supply side of the economy because of the projections available on coal, oil, etc. However, totally ignoring the demand side, particularly by the industry representatives and government, is unrealistic in view of the performance of the economy over the last two years. I believe the public has responded in its consumption of energy and will probably further reduce consumption as prices escalate. However, economists need to spend a little time and attention looking at the demand side of the economy to determine if the demand curve is valid and to find out how people do respond.

A: There has been a great deal of work on demand and conservation both. By the middle of next year we will have spent $1.6 million alone on conservation studies--understanding the technical limits of conservation in electrical power. Conservation is very difficult to deal with. The traditional techniques of demand analysis are no longer appropriate in a time when trends in energy prices have been reversed.

Conservation by electric power consumers has been very large. Most of the major utilities are reporting base loads down 7 to 15 percent. That's not necessarily because people are turning off their switches, but mainly because large industrial users of electrical power are managing their consumption better and have reached a 1 to 1 relationship with the utilities for designated periods of uninterupted service. Additional data indicates that the pulp and paper industry (the second largest consumer of power in the U.S.) has reduced its consumption of electricity by 30 percent since the beginning of the year. However, this is mainly a one-time saving. The 30 percent savings has not eliminated the problem in energy self-sufficiency but merely given it a new time frame. Conservation is important not because it makes the drive for energy self-sufficiency less important but because it gives us more time to reach our goal of energy self-sufficiency, more time to develop new technologies.

Q: The major coal reserves have been identified as those in Colorado, Wyoming and Utah. This is also an area with a limited water supply. Efforts made in coal gasification and coal liquefaction require large amounts of water, and unless we are willing to pay the price of massive water imports to this area of development, many of the things being suggested will be impossible.

A: I agree that we know very little about water requirements for coal and oil shale development. For example, even if there were enought water to develop oil shale and bring the resource out of the ground, there still would not be enough water to utilize at the electric power plant. We will be faced with a water constraint in coal and oil shale development not merely in the production of the primary resource but also with conversion to a secondary form of energy. The water constraints are very severe and the electric utility industry is very concerned about this.



WATER SUPPLIES FOR "ENERGY SELF-SUFFICIENCY"

by

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WATER AND "ENERGY SELF-SUFFICIENCY"

At the outset of the current "energy crisis," or perhaps more properly at the time it came to the attention of national policymakers, the most critical issue was defined to be our dependence upon an unreliable fuel source -- Middle Eastern Oil -- for a substantial portion of our projected energy needs. Most of the policy initiatives taken thus far have been for the purposes of dealing with the shortages precipitated by the Arab oil embargo and reducing the prospects of even greater future dependence. These initiatives and purposes have come to be referred to under the loosely defined rubric "Project Independence."

Quite naturally, policymakers pursuing independence began to focus their attention upon the well-known Rocky Mountain oil shale deposits and the vast domestic coal resources as obvious sources of British Thermal Units which could be substituted for imported crude oil. These resources are "conventional" in the sense that they can provide hydrocarbons suitable to feed the kinds of thermal energy cycles which we understand and to fuel the kinds of electric generators and prime movers which we already own and can replicate.

Coal and oil shale, therefore, would have to be mined in great quantities and converted to electricity and to gaseous and liquid fuels within reasonable economic terms. Initially, the major problems were seen to be the development of efficient and economical conversion technologies and the solution of the environmental problems associated with mining and electrical generation.

Water supply at first was seldom mentioned. The technical advice was coming from energy experts who were preoccupied with energy sources and processes. Because relatively little energy development has taken place in arid regions, water has not historically been an important factor and was not assigned much prominence in their calculations.

Primarily as a result of the attention to environmental impacts of potential development, however, water resource questions began to be raised.

--In the Southwest, coal-fired power plant proposals were challenged as preempting other important water uses and accused of conflicting with Indian water rights.

--The limitations upon water availability in the oil shale regions became more widely recognized.

--The need for water to irrigate reclaimed mined lands in arid regions was highlighted.

These and similar fragmentary concerns began to come to the attention of policymakers. Following on the heels of an almost total lack of consideration for water resources, a cliché evolved that water might well be the "limiting factor" in domestic energy development.

Thus far, however, the discussion of water for energy development has consisted largely of generalizations from very specific examples. Water resource experts who know the data base and understand its limitations have only begun to participate in the discussions within the past few months.

ANALYSIS OF THE PROBLEM

There is no doubt that water supply, at least in some regions, will be an important consideration in energy development. How important it is nationally, or even regionally, we cannot conclusively say, because the necessary data has not been compiled and the appropriate analyses have not been done.

As in most policy issues, it will be necessary to continue to make decisions about energy based upon available information, however inadequate it may be. Therefore, an analysis of water needs should include two phases.

First, experts in water and in energy should begin immediately with the information at hand to make judgments about the water supply problem. The objective of such judgments should be to put the water constraints into proper perspective and to define the critical needs for data collection, R & D, and management. It should not be to use the energy crisis as an opportunity to gain priority consideration for water resource development at the risk of distorting energy policy decisions.

Second, but in parallel, a competent analysis of the water resource needs for energy development should be designed and carried out. It should be done expeditiously, but it should not involve so many short cuts that it is reduced to only a more detailed version of the first effort.

In my view, the first effort can be accomplished by the right people in a few months. The second will take a year or more.

STATUS OF INFORMATION

Analyses of the water for energy problems will involve three distinct data bases:

(1) water resource use and availability;

(2) energy resource availability and demand; and

(3) parameters of the energy development, conversion and transportation systems with special emphasis on water use.

For planning purposes, of course, each of these data bases must involve both historical (present situation) data and projections of future situations.

Water Data

Historical data on water resource use and availability are relatively good. In terms of gross amounts, the first National Assessment made by the Water Resources Council which was completed in 1968[1] is the most recent comprehensive compilation, but a second assessment is presently in preparation and could become a useful input to energy analyses. At the regional level, more detailed data of more or less recent vintages exist for nearly all major river basins. The validity of measurable physical quantities is very good considering the complexity of the systems.

These sources also include projections of future situations. The more recent projections of water resource needs are quite sophisticated. Their principal shortcoming is that they do not recognize the impacts of recent energy policy decisions and proposals. Various future energy options will be the independent variables in these kinds of analyses, however, so the available water resource data base would seem to be entirely adequate.

Energy Resources

The energy resource data base is nearly as adequate in an historical sense. There is abundant information about the occurrence (and, of course, use) of coal and oil shale resources, and it is sufficiently accurate for planning purposes. Historical energy consumption data also are adequate.

The greatest shortcoming in the historic energy resource data base probably is the uncertainty regarding the availability of undiscovered oil on the Outer Continental Shelf and in Alaska. Major new domestic oil discoveries, of course, would greatly change projections of development of all energy resources. They would, however, tend to relieve the most critical water demands for energy.

Projections of future energy demand and of energy resource development are not good. Gross demand projections cover a wide range. The recent aberrations in costs of basic energy resources, along with potential changes in demand patterns resulting from new social values, conservation efforts and high energy costs, furthermore, have made the allocation of future demands among various energy sources very uncertain.

For the present, the only way to deal with projections of energy resource development appears to be in terms of alternative futures. A range of gross energy demands must be used and for each of several levels of demand several potential mixes of energy resource development must be postulated.

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[1]U.S. Water Resources Council, The Nation's Water Resources, Washington, D.C., Government Printing Office, 1968.

System Data

The data base which is most deficient, even in terms of historical factors, is the data concerning energy development, conversion, and transportation systems.

Presumably somebody, somewhere, knows with precision what the capability of each petroleum refinery, terminal, or transportation facility is. There must be statistics on the ability of individual railroads to haul coal, and the existence of most mining equipment must have been noted. In a collective sense, however, as recent efforts to allocate fuels revealed, we do not have a good evaluation of the limitations and capabilities of the complex physical and management systems which obtain, process and deliver our energy resources.

Projections of future energy systems are infinitely more obscure. They depend upon the unknown mixes of various resources which will be used. Furthermore, they will be molded by the impact of the massive R & D programs in energy technologies which we are presently initiating.

SOME PRELIMINARY OBSERVATIONS

Recognizing the shortcomings of the data, there are a few observations which can be made and which are sufficiently important to be examined.

Assumptions

Some general simplifying assumptions are necessary at the outset.

(1) Water is substantially a renewable resource. Because of water quality regulations, a trend toward more efficient agricultural and industrial water use can be expected. Therefore, the existing level of water consumption can be considered adequate to meet all existing water uses including existing levels of energy production.

(2) Incremental energy demands will impose incremental water needs which must be met either from presently unused water resources or by reductions in present uses of water.

(3) Incremental energy demands until 1985 will be met from:
(a) expanded coal development,
(b) new domestic oil discoveries,
(c) development of oil shale,
(d) other unconventional sources such as solar and geothermal, and
(e) expanded oil imports.

(4) The "Project Independence" concept primarily implies substituting coal or oil shale products for expanded oil imports.

Gross Water Needs

In order to gain some appreciation of the magnitude of energy water supply problems, it is useful to estimate the gross incremental needs for water. The first requirement is to postulate an energy development program for "Project Independence." A useful model has recently been set forth by the Task Force on

Energy of the National Academy of Engineering.[2] The Task Force examined the possibility of meeting 1985 energy demand with domestic energy supplies. It projected an unrestrained "business as usual" demand of 58 million barrels per day (MBPD) equivalent of crude oil and then assumed a reduction, through conservation means, to 51 MBPD. A vigorous conservation effort appears to be a reasonable assumption, because the energy conditions which would give rise to a sustained effort to achieve self-sufficiency by 1985 almost certainly also would provide strong incentives for conservation.

Of those activities which the Task Force set forth as probable means of providing domestic energy, those which appear to involve significant water requirements have been abstracted in Table 1. Water requirements for each activity have been estimated using conversion factors from several sources.

Table 1 shows that total requirement for incremental water supplies to support such a "Project Independence" concept would amount to 10,245,000 acre-feet annually by 1985. This estimate does not include any water for the development of coal mining in Eastern (non-arid) states, for increased domestic oil and gas production, or for small projected increases in hydroelectric and geothermal energy. These activities were considered to be provided for as part of generally anticipated municipal and industrial water demand growth.

The major portion of the water demand would be cooling water for new fossil and nuclear power plants. In this regard, the estimate is undoubtedly excessively high. It is entirely based upon cooling-tower consumption. To the extent that sea coast plants or other sites permitting once-through cooling are utilized, these figures would be greatly reduced.

Gross Water Supplies

Total streamflow in the conterminous United States is estimated to be 1,345.1 million acre-feet annually. According to the National Water Commission,[3] national water withdrawals in 1970 amounted to 414.4 million acre-feet/year of which 98.6 million were consumed.

Therefore, the estimated water for this "Project Independence" concept amounts to less than 0.8 percent of streamflow, 2.5 percent of current withdrawals, or about 10 percent of current consumptive use. In gross terms, the development of this amount of water is clearly well within the bounds of feasibility.

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[2]National Academy of Engineering, U.S. Energy Prospects, An Engineering Viewpoint, A report prepared by the Task Force on Energy, Washington, D.C., National Academy of Engineering, 1974.

[3]National Water Commission, Water Policies for the Future, Final Report to the President and the Congress of the United States, Washington, D.C., Government Printing Office, 1973.

Table 1

INCREMENTAL WATER SUPPLIES REQUIRED TO MEET MINIMUM 1985 ENERGY DEMANDS FROM DOMESTIC RESOURCES

Resource Development[1]	Amount of water[2] (acre-ft/year)
Increased coal production in the arid West (surface mining reclamation for 500 million additional tons per year)	24,000
Coal slurry pipelines to convey western coal (100 million tons of coal conveyed per year)	64,000[3]
New coal/libnite power plant capacity (167,000 megawatts)	3,200,000[4]
New nuclear power plant capacity (325,000 megawatts)	6,500,000[4]
Oil from shale (0.5 million bbls. per day)	87,000
Synthetic gas from coal (1.1 million bbls. per day equivalent)	200,000
Synthetic liquids from coal (0.6 million bbls. per day equivalent)	180,000
TOTAL	10,245,000

[1]These estimates of resource development are based upon U.S. Energy Prospects: An Engineering Viewpoint, a report of the Energy Task Force of the National Academy of Engineering, 1974. Other forms of domestic energy development which are not water intensive have been omitted.

[2]Estimates of water requirements are based on factors derived from several sources.

[3]This water might be usable at the point of delivery as process or cooling water supply.

[4]This is a conservative figure which would be reduced greatly by siting plants on the seacoast or using other sources of once-through cooling water.

Water resource planners have been contemplating projected increases of 25 million acre-feet in annual consumptive use by 1985 without much consternation. This projection of annual consumption includes about 2.6 million acre-feet for new thermal power plants, which is much less than the "Project Independence" requirement. The projection also includes 12 million acre-feet for new irrigated agriculture, however, which is more than the incremental amount needed for the energy development.

In gross figures, provision of adequate water supplies for energy self-sufficiency would imply an increase of about 30 percent in the incremental water requirements for 1985 which have been previously anticipated. Alternatively, it could imply a reduction of about 60 percent in the new irrigation water supplies which have been projected. In national terms, therefore, water for energy does not appear to present a particularly forbidding challenge.

Critical Regions

To view the water for energy problem in terms of gross national water supply and demand, of course, is to grasp only its most general dimensions. The essential problem of water resource management in the United States has never been a matter of gross deficiencies; it is a matter of discrepancies between the geography and timing of water demands and resource occurrence. A better estimate of the water for energy problem can be obtained by examining the situation in the regions where it will be most intense.

Two major geographical regions are critical in such an analysis: the Colorado River Basin and the Northern Great Plains. These regions are both rich in domestic energy resources which have only begun to be exploited and are arid regions in which water resources may one day present a real limit to further socio-economic development.

The Colorado River Basin includes over 100 billion tons of coal in thick accessible beds which could fuel several hundred major coal-fired power plants or synthetic fuel plants throughout a useful economic life. The northern portion of the region contains substantially all of the national reserves of oil shale. Over 100 billion barrels of oil might be economically recoverable from the resource with present technologies and the total resource is much larger.

The Northern Great Plains states are estimated to contain 1.5 trillion tons or 40 percent of the national coal resource. Of this amount, perhaps 35 billion tons are in readily surface-minable proven reserves. The low sulfur content of this coal has created great pressures for its development.

In order to consider the demands which would be imposed upon water resources by the aggressive development of these energy sources, it is necessary to postulate some reasonable developmental pattern. Table 2 presents such a speculative scenario. The table allocates incremental energy development for 1985 among the states of the two regions. It has been prepared to be consistent with the national energy future shown in Table 1, with due regard for established trends and the resource base in each state and the views of knowledgable prognosticators. As in Table 1, the water requirements of the developmental pattern are estimated.

Table 2

INCREMENTAL ENERGY DEVELOPMENT IN MAJOR WESTERN REGIONS (CONSISTENT WITH NATIONAL DEVELOPMENT SHOWN IN TABLE 1)

	1,000 MW Nuclear power plants	1,000 MW Coal-fired power plants	250 million cu.ft./day syngas from coal plants	50,000 bbl/day synthetic liquids from coal	50,000 bbl/day oil shale	Coal slurry pipeline MM ton capacity per year[1]	Surface mined coal million tons per year[1]	Water requirements (acre-feet per year)
Upper G.P.						90	220	68,000
Montana	-	7	4	4	-			240,000
Wyoming	-	8	3	4	-			250,000
N. Dakota	-	5	2	-	-			120,000
S. Dakota	-	1	-	-	-			20,000
Subtotal	-	21	9	8	-	90	220	698,000
Colorado Basin						10	280	20,000
Colorado	1	8	-	-	8			250,000
New Mexico	1	6	4	-	-			180,000
Utah	1	5	5	-	2			187,000
Wyoming	-	8	-	-	-			160,000
Arizona	3	-	-	-	-			60,000
Nevada	1	2	-	-	-			60,000
California[2]	2	-	-	-	-			40,000
Subtotal	9	29	9	-	10	10	280	957,000
TOTAL	9	50	18	8	10	100	500	1,655,000
National[3]	325	167	20	12	10	100	500	10,245,000

[1]Allocation by States not meaningful

[2]Using Colorado River Basin water supplies

[3]See Table 1

Colorado River Basin

The table indicates that development of this magnitude would result in incremental water demands of about 957,000 acre-feet annually in the Colorado Basin. In a region which is widely thought to be experiencing current water shortages, such an additional burden might seen an impossibility.

Upon closer inspection, however, regional water shortage, even in the Colorado Basin, is more prospective than real. The Colorado River system, through a complexity of compacts and water rights, is indeed overcommitted in a legal sense. Furthermore, each new consumptive use or degraded return flow adds to the spectre of an ultimate moratorium on any new uses in order to preserve a usable quality for furthest downstream existing rights. The severity of the water resource planning and management problems of the region are undeniable, but the problem is not yet one of physical limitation.

California, which currently diverts more than its ultimate legal entitlement, is presently contemplating the use of Colorado River aqueduct water for a new nuclear power plant. New Mexico, through formal borrowing, has water allotments until the year 2005 sufficient to support several coal-fueled electric or synthetic fuel plants. Several upstream states have not yet fully developed their allotments of the basin's water supply. Utah, Wyoming and Colorado have undeveloped water entitlements and contemplate their dedication, in part, to energy uses.

Colorado, because of its dominance in oil shale, requires special examination. Table 2 estimates a water requirement of 250,000 acre-feet annually. Recent estimates by state officials indicate that "there is at least 800,000 acre-feet of water available to Colorado on an annual basis which is not now being uses. . ."[4] This water, like most Colorado River Basin water, is variously under conditional water decrees and other legal commitments, and the use of a large part of it for energy would entail the preemption of some other potential application, in most instances agricultural.

In the Colorado Basin, about 90 percent of all existing water uses are for agriculture, much of it inefficiently applied and producing low value crops. Water for new energy uses quite probably will come, in part, from purchases of existing agricultural rights rather than the development of new supplies. There also exist in the Basin aquifers of considerable size, particularly saline aquifers with little current utility. In some energy applications, such as materials handling, saline groundwater could be used if runoff to surface streams can be prevented.

Northern Great Plains Region

The Northern Great Plains Region derives most of its water supplies from the Upper Missouri River and its tributaries, although the state of Wyoming, which lies partly within each of the basins, has considered diversions of

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[4]Felix L. Sparks, Water Prospects for the Emerging Oil Shale Industry, remarks of the Director of the Colorado Water Conservation Board before the 7th Oil Shale Symposium, Colorado School of Mines, April 18, 1974.

undeveloped waters of the Green River (Colorado Basin) into coal fields lying in the Missouri River Basin drainage in the northeast portion of the state.

The water resources of the Northern Great Plains Region are less critical than those of the Colorado Basin. There are fewer legal constraints, particularly in terms of interstate compacts, and only about 30 percent of the region's annual natural water supply is being consumed. On the other hand, the streams are not as fully controlled as those of the Colorado Basin and major new regulatory reservoirs would be necessary to develop their ultimate possible yields.

There is available uncommitted water in each of the states of the region to supply several times the amounts shown in Table 2 if appropriate regulatory works were provided. Existing storage capacity alone is probably adequate for the requirements shown in the table.

Despite the lack of legal constraints upon the depletion of the Missouri River by the states of the Northern Great Plains Region, however, there probably are political inhibitions which restrict the potential ultimate uses. The flows of the Upper Missouri are major contributors to hydroelectric generation throughout the Missouri River and to navigation operations downstream to the Mississippi delta. Excessive depletions which would adversely affect these uses would probably be politically opposed, particularly where federal financing of water development works were involved.

As in the Colorado Basin, over 90 percent of existing water consumption is by irrigated agriculture. Agriculture would also be the principal competitor with energy uses for uncommitted supplies.

THE NATURE OF THE PROBLEM

Overview

This cursory evaluation of water supply for energy self-sufficiency can provide some preliminary but useful judgments about the nature of the problem. Foremost among these is that there is no physical shortage of water to develop a reasonable domestically supplied energy future.

Certainly, detailed examination will reveal specific instances where proposed energy facilities will be deprived of water because of local unavailability or legal constraints. The geographic availability of energy resources, particularly coal, are so extensive, however, that alternative siting proposals should easily overcome such situations on the regional or national scale.

A more significant concern is the potential competition between energy development and other water uses, particularly irrigated agriculture. Such competition will be manifested in economic competition for existing, developed water supplies and in political as well as economic competition for new development. It may present a serious problem, primarily because energy uses will usually have a clear advantage in both instances.

The value of water to sustain an agricultural economy in the arid West is not entirely reflected in its economic terms (which are limited by values of agricultural production over reasonable decision making periods). The rapid preemption of irrigation water in predominantly agricultural, rural communities will have profound social and cultural impacts upon the inhabitants. It will also have important secondary economic impacts upon processing and service industries. Pockets of "Appalachian-type" dislocations could be created by unplanned conversion of water to energy uses on the basis of strictly economic considerations.

Technological Options

In addition to site-selection alternatives, there are several technological options which could reduce the impact of energy development upon water supplies. Power plants which are cooled by once-through circulation consume less than half as much water as cooling towers evaporate. Reexamination of thermal pollution standards with regard to the environmental tradeoff in this factor might enable more plant siting on large bodies of water and less total consumption. Air-cooled power plants, at some cost in efficiency, might prove practicable in critically water-short areas. Nuclear power plants located near major load areas might take advantage of sewage water as a cooling source.

In situ oil shale technologies offer a possibility for major savings in water. Extensive use of *in situ* methods with most refining done outside of water-short regions could reduce oil shale water needs to half those shown in the tables.

Transportation of coal also can greatly extend the flexibility of the planning options for domestic energy production. Coal could be transported away from water-short localities, or even regions, to be processed where water is available. Coal to serve a 1,500 megawatt power plant is presently being transported by slurry pipeline using 3,200 acre-feet of slurry water annually, in contrast to the cooling water consumption of the power plant which is 30,000 acre-feet annually. In this regard, it is interesting to note that such a plant consumes about 5 million tons of coal annually. The cooling water it requires weighs 40 million tons. The advantage lies clearly in transporting fuel rather than water in most instances.

PLANNING METHODOLOGY

The approach to a sophisticated analysis of the water supply needs for energy self-sufficiency can now be set forth:

(1) The projected incremental needs for energy must first be determined. Because of the uncertainties caused by present transitions, particularly in prices, several alternative energy futures should be used.

(2) Energy demands should be disaggregated to regional geographic demand centers.

(3) Domestic energy resources available for meeting these incremental demands should be cataloged on a regional basis.

(4) For each geographic energy resource center, the options for conversion and transportation of energy should be described and associated water requirements estimated.

(5) A network or inventory model should be developed which will permit sensitivity analyses using varying energy demands and differing resource development mixes.

(6) Potential situations which appear to pose serious water resource problems when other water needs are also considered should be identified along with the available options for avoiding or minimizing the conflict.

Of course, an analysis such as this can be accomplished with varying levels of sophistication. A rudimentary example is set forth in this paper. In a year's time, however, and with the expenditure of about two million dollars, a study could be completed with sufficient detail to greatly increase awareness of the water resource factor in energy policy and to enhance the competence of policy decisions. Existing data are generally adequate for such a study, but the greatest technical effort would be required in evaluating the capabilities of existing and potential systems for conversion and transportation of energy forms.

CONCLUSIONS

Despite the fact that very little effort has been devoted to the water supply problems of energy development, there is no reason to suggest that water would be a limiting factor upon the achievement of a "Project Independence" concept. The provision of adequate water to develop domestic energy resources is simply a planning problem. It is true that continued disregard for the water resource dimensions of energy proposals may result in economic and social dislocations in some localities; but it is equally true that there are abundant opportunities to avoid such dislocations through responsible analysis and management.

The federal government, of course, does not have control over each of the major decisions which will dictate the future of energy development. It does, however, have important influences over many of them. To the extent that a "Project Independence" program is established, federal influence through incentives and direct participation in energy development may be expected to increase.

The federal role in planning for water supplies to accommodate energy self-sufficiency would not appear to involve any drastic policy changes. Neither would it seem to require dramatic increases in investments for water resources development projects.

Major intrusions into existing institutional constraints upon water use, however desirable they may otherwise be, are unlikely to be justified by the energy requirement for water supply. Major long-distance transfers of water, similarly, are exceedingly unlikely solutions for relatively minor and highly localized shortages. There simply are too many potential alternatives for the development of domestic energy resources to permit water needs to give rise to expedient and drastic actions.

There should be a strengthening of federal activities in river basin planning with a new emphasis on the emerging energy outlook. A national assessment of water for energy, such as hs been described, should be initiated immediately and given adequate funding and the highest priority.

On the energy side of the problem, a realistic awareness of water needs should be nurtured in energy planners, both public and private. Energy planners should not be given license to bid away scarce resources from other economic sectors, leaving the long-rage dislocations for solution at public expense. The true cost of water -- to the general public -- should be reflected in energy decisions.

Finally, federally sponsored energy research and development programs should assign a high priority to water conservation technologies. Opportunities to increase the efficiency of water use at some additional cost in fuel or investment should be explored. They may not appear inviting on a national scale but, in particular situations in the arid states, the may be invaluable.

QUESTIONS AND ANSWERS

Edward G. Altouney

Q: It would seem to me that this paper is directly contrary to the conclusions of much of what we've been hearing. I don't see how it's conceivable that there are large excesses of water available in the western regions, and I question the conclusions of this paper when you consider the inevitable demands for water in the future.

A: Circular 703 of the U.S. Geological Survey -- "Water Demands for Expanding Energy Developments" -- states that findings indicate that in the East, South, Midwest and along the seacoast, water supplies are generally adequate for energy production. West of the 100th meridian, however, runoff is generally less than potential diversion and energy producing industries must compete with other users for the limited water supply. This circular goes on to say that for converting coal to synthetic gas and producing liquid hydrocarbon from oil shale or coal in the Rocky Mountains of the Great Plains, the problems may be of great magnitude. I discussed this with Dan Dreyfus, and his position did not change as a result of the USGS findings. He told me made two major assumptions in his paper: (1) If we are to pursue "Project Independence," we will have to strengthen our conservation efforts and not expand previous trends. (2) The second assumption is that water availability for energy uses is given the highest priority. It is predicated on shifting future uses from one potential use to another -- from agriculture to energy production. At the present time Mr. Dreyfus cannot foresee any major impediment to "Project Independence" based strictly on water availability. There are enough margins of flexibility in energy sources so that this problem can be alleviated without additional water projects.

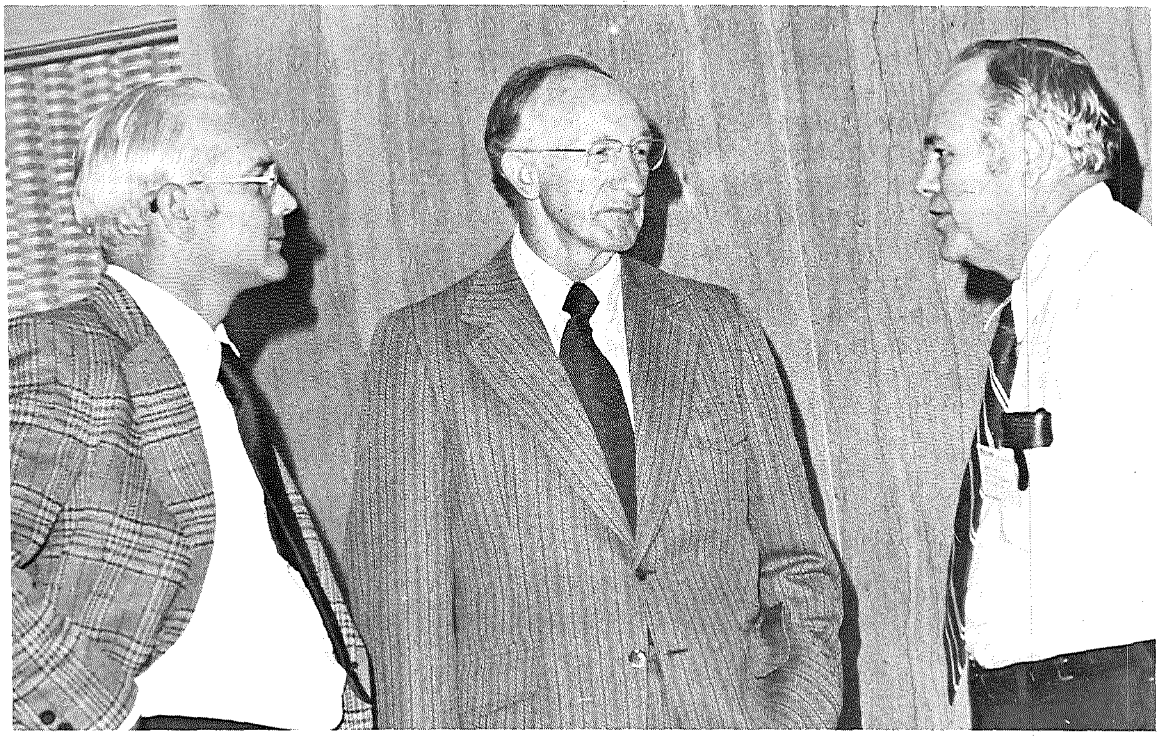
Q: I cannot agree with the statement in Mr. Dreyfus' paper that present institutions appear adequate for the future. He seems to play down the need for considering institutionalization or anything else other than what we already have. This seems to be a premature decision, and I would hope this particular phrase would not be given much credibility.

A: I will be glad to relay this information to Mr. Dreyfus. I'm sure he will take it into consideration.

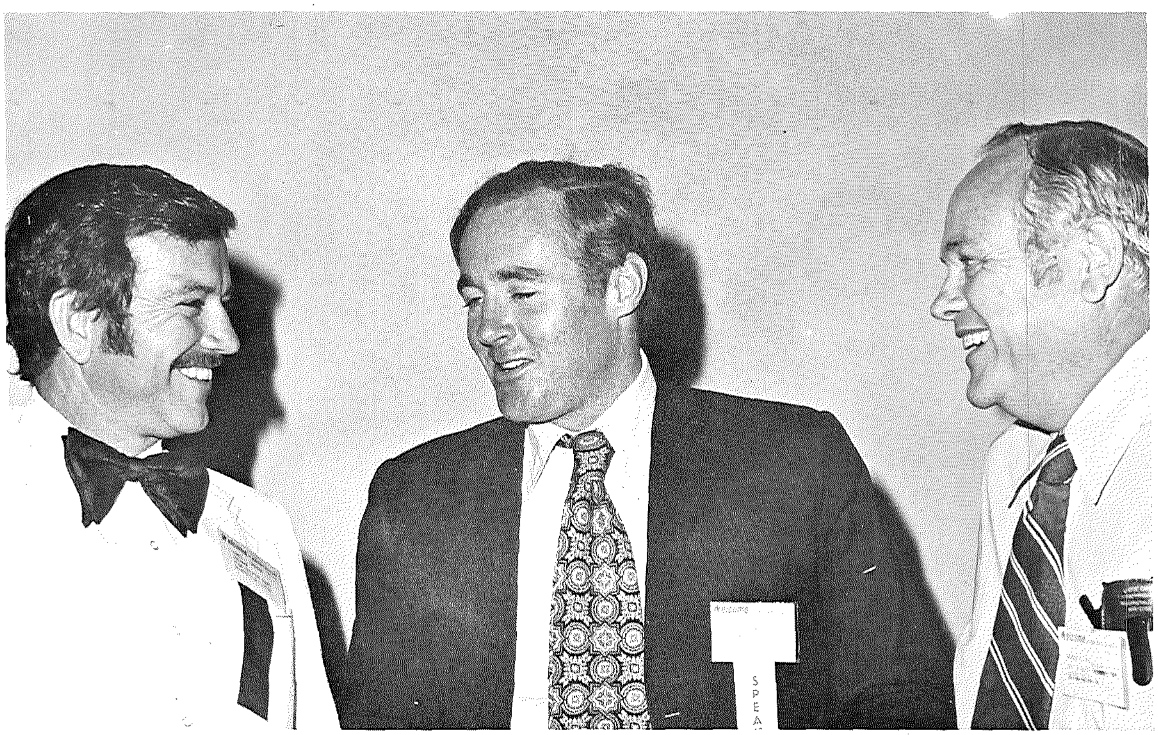
Q: The figures quoted in Mr. Dreyfus' paper are not clear to me. Were the figures indicated strictly for generating power or did they include anything for reclamation of strip mined lands?

A: I believe his figures covered the whole spectrum of energy sources.

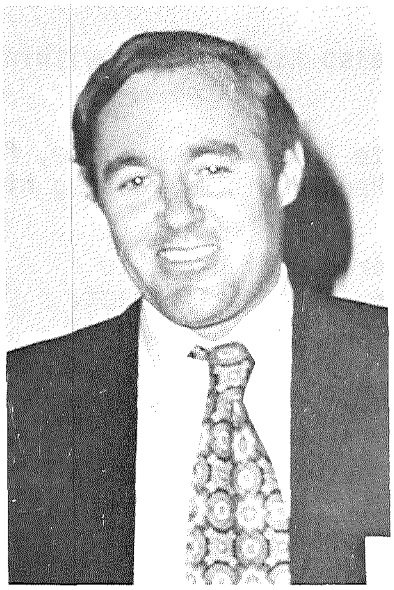
Comment: Knowing Dan very well, in his discussion of institutions, I believe he was really addressing himself to the peculiarities of the Colorado Basin, more often than not. In that sense I believe he was saying that the Colorado Basin has a very peculiar set of institutions with respect to compacts, administration of compacts, etc. At the same time, he noted later in his paper an increased need for institutions or some mechanism for broad range basin planning and stated that we should be developing long-range plans for the future. In that sense he is looking toward some new type of institution to perform this task. Compact commissions which have a long-standing legal right to manipulate compacts, etc. should not be tampered with, but a new mechanism should be developed to plan the future.



Dr. Jay M. Bagley, President Glen L. Taggart,
Utah State University, and Dr. Warren A. Hall



Ernest T. Smerdon, Jack O. Horton, and Warren A. Hall



WATER RESOURCES RESEARCH IN THE INTERIOR DEPARTMENT

by

Jack O. Horton
Assistant Secretary of the Interior
Office of Interior for Land and Water Resources
Department of the Interior

I had the opportunity, several months ago, to meet with some of the officers and representatives of the Universities Council on Water Resources. On April 10, a talk I had expected to give at OWRR's Ninth Annual Water Resources Research Conference on the subject, "What the Department Expects of the Program," was kindly presented on my behalf by Interior's Assistant Secretary, Program Development and Budget, Royston Hughes. Most of you were in attendance at that conference and thus have some idea of how I view land and water resources problems and the role of research in planning and mangement. Let me hasten to say, however, that it is a great pleasure for me to be here in person to participate in this Annual Meeting of UCOWR and to share some additional thoughts with you.

At my meeting with your representatives, they assured me that their primary concern was to assist the Department of the Interior in fulfilling the special missions assigned to OWRR under Public Law 88-379. As I indicated then, we fully share that concern. Also, we are pleased to cooperate with you and we sincerely seek your advice and counsel in the conduct of this and related programs.

Eighteen months ago a major reorganization took place within the Department of the Interior. Two major bureaus, Reclamation and Land Mangement, were brought together under a single appointed official. Fifteen months ago I was sworn in as the first Assistant Secretary for Land and Water Resources. In addition to the two bureaus, the Office of Saline Water, the Office of Water Resources Research, and the Office of Land Use and Water Planning report directly to me.

This was not a game of political musical chairs. The reorganization came about; it flowed directly from a developing philosphy and policy of total resource management. This policy position acknowledges the essential interdependence of <u>all</u> the resources of a region. It recognizes that decisions about water affect the use of land, that decisions about land bear upon the water available in a basin, and that commitments of either resource must take into account the present and potential values of the other.

This same kind of synthesizing movement is also taking place within the water resources field.

At his confirmation hearing before the Senate Interior Committee, former Under Secretary of the Interior, Dr. William T. Pecora, in expressing his philosophy, stated:

> "One must look at the role of man on this earth. If he is to survive as a species, and a thriving species, he does, in fact, need more resources, but, on the other hand, he must adopt good housekeeping.
>
> "Therefore, all of his attention must be not only to the science and technology for seeking and developing earth resources, but at the same time maintaining a careful balance with the environment so that his tradeoffs and judgment values do not destroy the very environment upon which he calls for subsistence."
>
> "In the final analysis," Dr. Pecora wrote in 1971, "we must settle for conservation with controlled preservation rather than for whole preservation, and for a system which provides the best alternatives when no solution is a perfect one."

This is the type of philosophy or rationale to which we look in Interior for the protection of our land and water resources. The national challenge to water requires a precise sense of balancing between preservation and use and the realization that new policies must reflect changing national priorities.

You probably know better than I the dispersion of authority and responsibility in water resources research.

The Office of Water Resources Research has been one of 20 or more federal agencies involved with water resources research. It, along with the Office of Saline Water and the Bureau of Reclamation in my area of responsibility in Interior, participates extensively in water resources research and the other units under me -- the Bureau of Land Management and the Office of Land Use and Water Planning -- are concerned with water resources research. Other agencies in Interior, especially the U.S. Geological Survey, engage in water resources research and, of course, the Fish and Wildlife Service, the National Park Service, the Bureau of Outdoor Recreation, and the Bureau of Indian Affairs have responsibilities relating to land and water resources planning, management and research.

Among agencies in Interior, the Bureau of Reclamation is concerned with research related to multipurpose dams, irrigation efficiency and weather modification. The Office of Saline Water has pioneered in the development of saline water desalting facilities and is still concerned with improved techniques. The Bureau of Land Management has a multitude of land and water resources problems but relies on other agencies for most of its research. With the recent urgency for increased production of energy and expected appropriations for energy-related research, it will be looking to other agencies for some of the research needed to solve problems in connection with oil and gas leasing programs, construction of the Alaska Pipeline and other energy-related activities in addition to its other responsibilities for managing the Nation's public lands.

With the possible exception of the National Science Foundation, OWRR probably has the broadest authorization for water and related resources research of any government agency. In one sense, OWRR is not mission-oriented, except for the primary mission stated in the basic Act -- that of "assuring the Nation at all times of a supply of water sufficient in quantity and quality to meet the requirements of its expanding population;" and, under Title II, where the research is required to be consonant with the mission of the Department of the Interior.

OWRR has continued to have a high mission or responsibility for sponsoring needed water resources research at local, state and regional levels under Title I of the Act and for disseminating research findings through the Water Resources Scientific Information Center.

The valuable contribution of the P.L. 88-379 Program to the training of personnel for water resources and related positions has been well recognized. The students who serve as research assistants on approved OWRR projects under the supervision of well-qualified principal investigators learn to do by doing. I understand that many of these former students at your universities now hold jobs in federal and state agencies as well as in universities and other organizations concerned with water resources.

We are also aware of the synergistic effects of some of the annual allotment projects. Some of these projects, with very modest funding, have enabled the initiation of effective lines of research and have attracted money from other sources, thus having beneficial seeding effects.

Finally, I have been impressed with the fact that the State Water Resources Research Institutes, many of them in existence only about 10 years, have become recognized centers where the public and state governments can obtain water-related information and guidance.

During the past year I have gained valuable insight into the OWRR program and have become appreciative of both the direct and indirect results of the State Institutes and other universities cooperating with OWRR. There have been solid accomplishments in research and we have received independent testimony of the good faith and effectiveness with which most of you have carried out consultation and collaboration with water officials in your states. You have made gains in clearing the communication channels to assure that research results go to those who can use them rather than becoming lost in the Archives.

From our vantage we look at OWRR as a research arm for the Interior Department, recognizing, of course, that OWRR has other responsibilities and missions. It is apparent, I think, that perhaps more clearly than in previous administrations, the program priorities of the department and of the administration have been set forth. With respect to Title II of the Act, therefore, I would hope that more emphasis will continue to be placed on these water-related priorities or objectives. From the standpoint of research, these address investigations which will help solve problems related to energy production, environmental protection, improved land and water use, preservation of rate and endangered species, outdoor recreation, irrigation efficiency, water reuse, and self-determination for the Indians.

I am sure that all of you are interested in knowing what will be the Administration's posture on the future funding of the state institutes. I, of course, cannot predict at this time what the budget decision will be for next year, but all indications are that the overall monetary policy for federal spending in 1976 will be one of severe constraint as the President indicated in his economic speech last Thursday night. I would have to say that the justification for funding the institutes at a higher level is overwhelming based on the reduction that was proposed in 1975.

As far as the current budget situation, you probably know that the House Committee has reported out an allotment of $110 thousand per institute. If the Congress appropriates this higher level of funding ($21 thousand above budget proposal) and the President signs the bill, it is reasonable to expect that these funds will be made available because of the restrictions placed on impoundments by the new Budget Reform Act.

In my opinion, the State Water Resources Research Institutes are essential to the optimum administration of the P.L. 88-379 program. The formal linkages of these institutes and the universities which cooperate with them through OWRR provide an outstanding opportunity for the coordination and focusing of water-related research in the university research community. The channels are available for communication of the Interior Department's priority problems and related research needs to the universities and for the return of the research results. We have a challenge to learn to use these channels more effectively.

As I have noted, some important redirection of water policy has occurred in the Department. This redirection will continue, consistent with the framework of legislative authority and guided by the new demands of a complex technological society. For example, in terms of planning for water projects, we consider both national economic development and environmental quality as parameters basic to the planning process.

In terms of research, I think it is highly desirable that emphasis be given to water-related problems of critical national and regional importance such as water reuse, improved irrigation efficiency, and total water management programs designed to more effectively conserve and utilize land and water resources. Obviously new water programs will be essential for a growing population, for expanding cities, and for maintenance of industry; and water will be <u>the</u> controlling factor in the production of America's future energy resources.

In my area of the Interior Department, I am interested in developing more effective total resource management. A logical organization to do this will require a departure from the linear concept of individual resource management to a process respecting the cause/effect or interdependent relationships between resources. It will require, also, an understanding on the part of researchers of what current planning and management problems are and how they can be approached most effectively.

There were two milestones in the water research area to which particularly I draw your attention. They are the Research Advisory Group in the Department and the Regional Analysis System in the field.

In an effort to coordinate research activities within my own end of DOI we organized a Research Advisory Group (RAG) composed of research administrators and program development officers from the bureaus and offices. This will assure that each unit knows what the other is doing and what research it can sponsor which will be of most use to the action-oriented agencies of Interior. Representatives of other Interior Department bureaus and offices serve as consultants in this coordination effort. This approach assures not only more relevance of OWRR-sponsored research to the Interior Department's program priority areas but will acquaint the Interior agencies with the competence existing within the OWRR program for sponsoring research of interest to them. I feel confident that the water research position in the Department will be enhanced through these and related efforts, including coordination with other government departments.

We are optimistic that the regional problem analysis system which OWRR Director Hall is encouraging with your cooperation will result in a program addressed to more important problems. Instead of supporting several hundred seemingly independent projects on dozens of widely varying problems, this approach will lead to the development of research programs focused on such regional or national problems as have been identified for the Northern Great Plains, or in the areas of water for energy and agriculture or with respect to Colorado River salinity. Instead of being regarded as 53 separate state institutes going their separate ways, the institutes will be viewed as integral parts of a national program engaged in pioneering, yet relevant, research.

In sum, as we have viewed the OWRR program we are quite satisfied with the excellent progress that is being made in research directed toward a better understanding of the cause and effect relationships involved in the many complex biological, physical, and sociological sub-systems which constitute our water resource system. The contribution made to this progress by the universities, including that provided by the State Water Resources Research Institutes, has been most important.

We are rather less satisfied with our ability to interpret and convert those innovative research results into practical applications. For a time it appeared to many of us that this shortcoming was due to poorly written research reports and to failure to transmit the results to the user. On closer examination it became clear that, while these deficiencies often exist, a more fundamental deficiency was the lack of any organization or agency with a specific assignment to assure that the interpretation and conversion of research to practical use is actually accomplished.

There is an excellent analogy between the situation that existed in the early sixties with respect to getting the research done and that which exists now in the early seventies with respect to putting that research to work. Then there was no agency with a responsibility for water resources research *per se* even though there was quite a bit of *ad hoc* research directed toward specific agency missions. Today there is no agency with a responsibility for converting water resources research results into viable action programs even though again there is important development work being done on an *ad hoc* basis.

To assure that this is done without reducing the emphasis on research, the Secretary of the Interior has approved the establishment of an Office of Water Research and Technology under the Assistant Secretary -- Land and Water Resources. The new office will combine the present functions now assigned to the Office of Water Resources Research and the Office of Saline Water. More important, however, it will add a new dimension of water resources development to assure the systematic and orderly application of research to our serious water problems.

We believe this will prove to be a step just as important for solving our water and water-related problems as was the creation of the Office of Water Resources Research and the State Water Resources Research Institutes for producing effective water research. We believe we have an opportunity to turn around an admittedly difficult funding problem for water research by providing the missing links needed to assure that it will be effective in practical applications.

You will note that both the words "Research" and "Technology" are in the title. This represents our recognition that basic and applied research must more closely underwrite technological development. Both must be innovative. The nature of the serious water and water-related problems and their relative importance must determine the priorities for both research and development.

We have also combined these functions under a single head, Dr. Warren Hall, to assure that they are integrated and balanced both between analysis and synthesis and between problems and priorities.

The objectives of the present offices, OWRR and OSW, are not changed by this reorganization. We will continue to rely heavily on the university community, especially the water research institutes and their cooperating university parties for the basic research program under the presently authorized allotment, matching grant and Title II programs. We will continue to carry out our responsibilities for desalination research and development. We will add to these, however, a broader spectrum of development initiatives directed toward the more critical water-related problems.

In our view, this action will have a synergistic effect. The value and importance of OWRT will be greater than the sum of its parts. The orientation of the Office of Water Resources Research toward basic research on high priority problems will be strengthened by a more stable funding situation. By the same token, the Office of Saline Water's mission to develop desalting research and technology can be expanded to encompass the critical area of wastewater reclamation.

The creation of the Office of Water Research and Technology will, we think, arrest the downward curve of water research. With its establishment we can expect a new momentum, a new sense of optimum and expectation.

I know that you of UCOWR join me in the excitement and challenge of this new opportunity. Under Warren Hall's leadership, OWRT and the 53 institutes are in a position to make tremendous contributions to the preservation and enhancement of our nation's water resources.

QUESTIONS AND ANSWERS

Jack O. Horton

Q: My question relates to the reorganization of OWRR and particularly how the Universities Council on Water Resources might be more effective in working with your office in developing operational regulations. We want to make an input to strengthen the two-way communication between the university community interested in research and the Department of the Interior.

A: That's an excellent question, but we've not thought out all the details. We have a plan of action that must be taken in the next two or three months. If Dr. Hall agrees with me, we will ask the university community through UCOWR to analyze the proposal in writing. I will leave a copy of the secretarial order,which appoints Dr. Hall in his acting capacity and outlines the objectives and the organizational framework of the program,with Dr. Smerdon. We have made no further personnel decisions. The secretarial order includes a chart showing executive positions, responsibilities and functions we hope will be fielded in this organization. We'll leave the basic documentation with Dr. Smerdon, and then you may be in a position to recommend some formal mechanism whereby we can ask for the advice of the university community.

Q: The Secretary's proposal of a mechanism through which this communication could be channeled would be very useful. As a member of the UCOWR Board, we have had, during the last few years, problems of getting appropriate information, not because of anything within UCOWR or OWRR, but because of the nature of things. I think your suggestion would be very much welcome and I'm going to urge my colleagues to follow-up this proposal with OWRR and the new organization to get it worked out. This is a system that works in agriculture, between universities and the department, and I think we could make it work here.

A: I'm glad for your support. I think perhaps the next step would be a letter from Warren and myself to UCOWR officially asking for advice, but allowing you sufficient flexibility to address both the functional areas and the organizational areas of this new office. I think we can set up a more or less formal mechanism in the next week.

Q: Secretary Horton, we certainly appreciate your time and interest here. I can speak on behalf of the UCOWR Board over the past year, we've been very impressed with your openness and support of the research programs of the university community and your willingness now to open up further. I'm sure this reorganization will be a great thing for both your department and the university community and we look forward to it.

A: Thank you Dr. Scott. I wanted to mention semi-off-the-record because I have no written assurances, but it's my personal guess that if funds are written into the OWRR budget they will of course be transferred into the OWRT budget and expended for exactly the same purposes that were originally appropriated. If there is a congressional write-in, and if the President signs the bill, and I know of no reason he won't, I think (and this is a personal opinion and not a decision of the administration) that it will be supported by OMB. It is my almost certain expectation that it will be much more than the attempts that were made in F.Y. 1975. Financial flexibility and support to a greater degree than we've seen in the last year is expected, and I'm personally very enthusiastic about it. That's not a promise however.

WATER RESOURCES RESEARCH - A REVIEW AND CRITIQUE

by

David H. Howells
Director
Water Resources Research Institute
The University of North Carolina

The present effort to program, analyze and coordinate federal water resources research has its roots in the recommendations of the Senate Select Committee on National Water Resources in the early 1960's. This was closely followed by enactment of the Water Resources Research Act of 1964 and the Task Group on Coordinated Water Resources Research which recommended that responsibility for encouraging interagency planning and coordination should be placed in the hands of the Office of Science and Technology (OST) and the Federal Council for Science and Technology (FCST) through a Committee on Water Resources Research (COWRR). The Committee was formed in 1963 with members representing the federal agencies having major responsibilities for water resources research. While the Office of Science and Technology has been abolished, the Committee continues its work from its new home in the National Science Foundation.

Until recently, the COWRR Chairman has been appointed from outside the government on an annual or biannual basis. Starting with Bill Ackermann of the Illinois State Water Survey, the list of chairmen reads like a "Who's Who" in water resources. OWRR Director Warren Hall has been holding down the post during the past year and action is underway to appoint a new full-time chairman.

Soon after its formation, COWRR dealt with the task of identifying, classifying and reviewing research performed by the various federal agencies. From 1965 through 1971. the Committee published annual reports which describe and summarize federal water research programs. Its principal accomplishment during these early years, however, was its systematic appraisal of long-range research needs published in 1966.[1] The discussion of major problem areas and research classification system, alone, represented a major advance toward better planning and coordination. While COWRR was supported in its efforts

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[1]COWRR, FCST, OST, "A Ten-Year Program of Federal Water Resources Research," February 1966.

by a Panel on Water Resources drawn from the university community, there has been little subsequent opportunity for review by non-agency groups. As reported by UCOWR in 1972,[2]

> "The utility of these documents, representing a coordinated inter-agency research program, would be increased if the Committee or the Council (FCST) were to arrange for their annual review by appropriate congressional committees or subcommittees instead of leaving such review solely to each individual agency."

While the committee reports have been very useful, they would seem to reflect the same institutional limitations as Federal Interagency Committees or the Federal Water Resources Council wherein agency membership might be expected to preclude any review or actions which could be construed as detrimental to agency programs, leaving only a relatively narrow range of influence to the Committee as a whole.

While the "Ten-Year Program" outlined a program of research for the decade 1967 to 1976, it included projections for a five-year period ending in 1971. This recommended an approximate doubling of the 1967 fiscal year level of spending. This assumed a stable dollar. As will be shown later, the goal was never attained. In terms of constant dollars, spending for water resources research changed little during this period.

In 1972, UCOWR undertook a cooperative study with OWRR in preparation for a possible sequel to the "Ten-Year Program." It concluded that the many changes since 1960 indicated a major shift in social goals and the need for more research with respect to ecological impact of water resources development, social considerations and public awareness.[3] This reflected information solicited by questionnaire from the heads of state water agencies and from the direct contacts of the UCOWR consultants with representatives of state and federal agencies. The six major problem areas cited for attention were technical assessments, institutional changes, water quality, ecological responses, urban water resources, and water and land use. A balanced research capability between in-house and extramural research was emphasized as important to the success of water resources research effort. More will be said about this later. A number of observations in the UCOWR report deserve emphasis in view of the present difficulty with the energy crisis:[4]

> "Water resources research, in common with total water use and development program, lacks clear direction because social, economic, engineering and other goals have not been clearly or adequately established.

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[2]UCOWR, "National Water Research Opportunities," A Report to OWRR-Interior, June 1972, p. i-4.

[3]Ibid, p. i-4.

[4]Ibid, p. iv-8.

"If there is any theory that guides this nation's problem-solving techniques, the element of 'action through crisis' must be given a high rating. If experience yields wisdom, surely crisis-induced action, which is expensive in money and in social costs, must give way to preventive action at some time.

"The energy crisis ...has been developing for many years. ...the lack of critical concern, except during recent years, by the industry and the responsible state and federal agencies has not helped the nation to meet the power shortage.

"There is an analogy between the nation's water problem and the energy problem. Neither resource is being priced to indicate that oil and gas are being rapidly depleted or that water of good quality is in short supply. The consumption of both water and energy is increasing at a rate in excess of four percent annually. Quality water supplies are on a collision course with disaster, just as are energy supplies."

With this as background, it might be appropriate to comment that while the rush to energy research at the cost of essential and related water resources research is foolhardy, at least it's consistent.

While the UCOWR report recognizes the immense value of the "Ten-Year Program" and makes a substantial contribution of its own, it acknowledges that "A suitable methodology by which the necessary analysis (water resource problems) can be made does not exist at present, except for basically straightforward single disciplinary systems with limited objectives." It calls attention to an analytical procedure undertaken by COWRR during 1970 and discussed at the Front Royal Conference. Fiscal and personnel limitations, it notes, have prevented implementation.[5] This method is presented in some detail in the 1971 report of COWRR[6] under the heading, "A Problem-Oriented Structure for the Analysis of Water Resources Research Requirements." This has been further developed by Dr. Warren Hall for use by OWRR and the State Institutes. Additional attention will be given to this later.

The National Water Commission did not attempt a detailed review of the performance of research agencies or to outline a total federal research program in water resources. The Commission focused principally on organization aspects of federal water research activity. It was concerned primarily with the need to develop closer ties between research and planning and a more broadly-based and intensive research and development effort to increase usable water supplies and to handle growing volumes of wastes.

The Commission chose to look upon water resources research as an important aid to the achievement of particular objectives in solving water problems

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[5]UCOWR, "National Water Research Opportunities," A Report to OWRR-Interior, June 1972, p. i-5.

[6]COWRR-FCST, "Federal Water Resources Research Program for 1971," p. 117-125.

and concluded that the success of a research program can be assessed in light of its contributions in assisting planners, designers, managers, and decision- and policy-makers. The existing reliance on agency R&D programs to support agency missions with an Office of Water Resources Research filling the gaps was viewed as sound. Three aspects of the present situation concerned the Commission:

(1) whether fragmented research efforts of individual agencies will provide the needed capability to meet the Nation's needs;

(2) whether planning and management line agencies are reaping the most benefit from R&D efforts and whether R&D agencies are receiving worthwhile counsel and advice from those planners and managers on the "people-problem" end of the water resources spectrum; and

(3) the tendency of mission-oriented departments having jurisdiction over a research agency to require the agency to devote its resources wholly, or largely, to solving the problems of that department, i.e., the strong tendency of the Department of the Interior to look upon the Office of Water Resources Research as its research arm.

Another concern was that water resource agency policy makers appear to take little advantage of agency researchers for scientific counseling on alternative policy positions. A much closer tie between the decision makers and the researchers is needed, said the Commission, to accelerate application of research results.

The interagency Committee on Water Resources Research (COWRR) was viewed as having provided a mechanism for the coordination of federal water resources research activities. The Commission believed, however, that the effectiveness of COWRR could be improved if it were established as an arm of the Water Resources Council and given the strong role in water resources research contemplated for the Council in water resources planning.[7]

The identification of research needs was recognized by the National Water Commission as a never-ending job and a responsibility to some degree of all those involved in water resources.[8] The major areas of needed research which appear to hold the greatest promise for payoff include:

(1) the ecological, environmental and socio-economic impacts of water resources project development and management strategies;

(2) the economic, social and environmental costs and benefits of various levels of wastewater treatment, including the no-discharge alternative, and changes in water-using processes to research alternative levels of water quality;

(3) relationships between energy production and water use and the effects of heat and consumptive use on local water resources;

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[7]NWC, "Water Policies For the Future," Final report of the National Water Commission, June 1973, p. 532-535.

[8]Ibid, p. 535.

(4) the effects on water quality of nonpoint sources of pollution, including investigations of alternative means of control and study of urban storm water control in relation to water quality;

(5) means of more efficient water use and extending the utility of existing supplies; and

(6) new and developing technologies in water, including such things as desalting, weather modification, wastewater reuse, and geothermal resources.

The National Water Commission's recommendations with respect to water resources research were:

(1) The Water Resources Council should direct that water resources planning studies include an assessment of research needed to support planning objectives and a recommended research program to develop the scientific and technological base necessary to cope with future problems. It should review planning reports for needed research as part of the customary WRC review to aid the Council in preparing periodic assessments of needed research with priority recommendations to support objectives of the Water Resources Planning Act. The council should also develop guidelines for field planning entities to assist in reflecting technological impacts in both short- and long-range water resources planning.

(2) The research program of the Office of Saline Water, the weather modification activities of the National Oceanic and Atmospheric Administration, the weather modification and geothermal resources program of the Bureau of Reclamation, and research on wastewater reuse technology of the Environmental Protection Agency should be transferred to a new Office of Water Technology in the Department of the Interior. Additionally, the new office would also absorb the functions of the Office of Water Resources Research and maintain an up-to-date state-of-the-art assessment of new technologies to assist planners and decision makers in the development and evaluation of water management alternatives.

(3) The Committee on Water Resources Research should be reconstituted as a committee of the Water Resources Council.

The most recent study of water resources research was a report to the Congress by the General Accounting Office in early 1974 on research and demonstration to attain water quality goals.[9] As will be noted later on in this presentation, water quality research currently represents 45 percent of the total federal water resources research effort and is certainly deserving of special attention.

In the GAO study the Comptroller was asked to determine conflicts, coordination and effectiveness of the various federal progrmas dealing with

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[9]General Accounting Office, "Research and Demonstration Programs to Achieve Water Quality Goals; What the Federal Government Needs to Do," January 16, 1974.

water quality research. Looking primarily at the Environmental Protection Agency, GAO found that EPA has not had an agency R&D plan setting forth goals, objectives and priorities since it was formed in 1970. EPA responded to the recommendation that it develop a national plan in cooperation with federal and non-federal organizations by saying that it did not have the resources or the authority for the development of a truly effective plan and was reluctant to undertake one without legislatively defined authority.[10]

The General Accounting Office also noted that the Congress and the President have expressed concern over the limited use of the results of R&D programs sponsored or supported by federal funds. To maximize use of federal R&D accomplishments, results - said GAO - must not only be available to potential users, but also must be presented in a form that encourages use of the information.[11] It recognized WRSIC as the major federal center for water resources information, including water pollution.[12]

The review of dissemination of water pollution research information revealed a lack of:

(1) a central organization in the federal government to identify and coordinate available information;

(2) technical analyses of research data to apply research results to water pollution problems;

(3) effort by those groups responsible for gathering information to identify the users of research data and their needs; and

(4) an accepted common language of the program and technical levels for categorizing, indexing, and otherwise managing and transferring technical information to users.[13]

Trends in federal spending for water resources research are shown in Figure 1. When the level of spending is adjusted to account for inflation there has been little change since 1967. Related data are presented in Tables 1 and 2.

When federal investment in research is compared to water resources development, it is clear that there has been a steady drop in emphasis of research in recent years. Starting from 4.6 percent in 1965, federal spending for water research as a percent of spending for water resources development rose to 6.9 percent in 1967. From there it decreased steadily to settle at 5.2 percent in 1973. (Figure 2 and Table 3)

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[10]General Accounting Office, "Research and Demonstration Programs to Achieve Water Quality Goals; What the Federal Government Needs to Do," January 16, 1974, p. 61.

[11]Ibid, p. 80

[12]Ibid, p. 81

[13]Ibid, p. 92

FIGURE I

TRENDS IN FEDERAL SPENDING FOR WATER RESOURCES RESEARCH 1965-1973

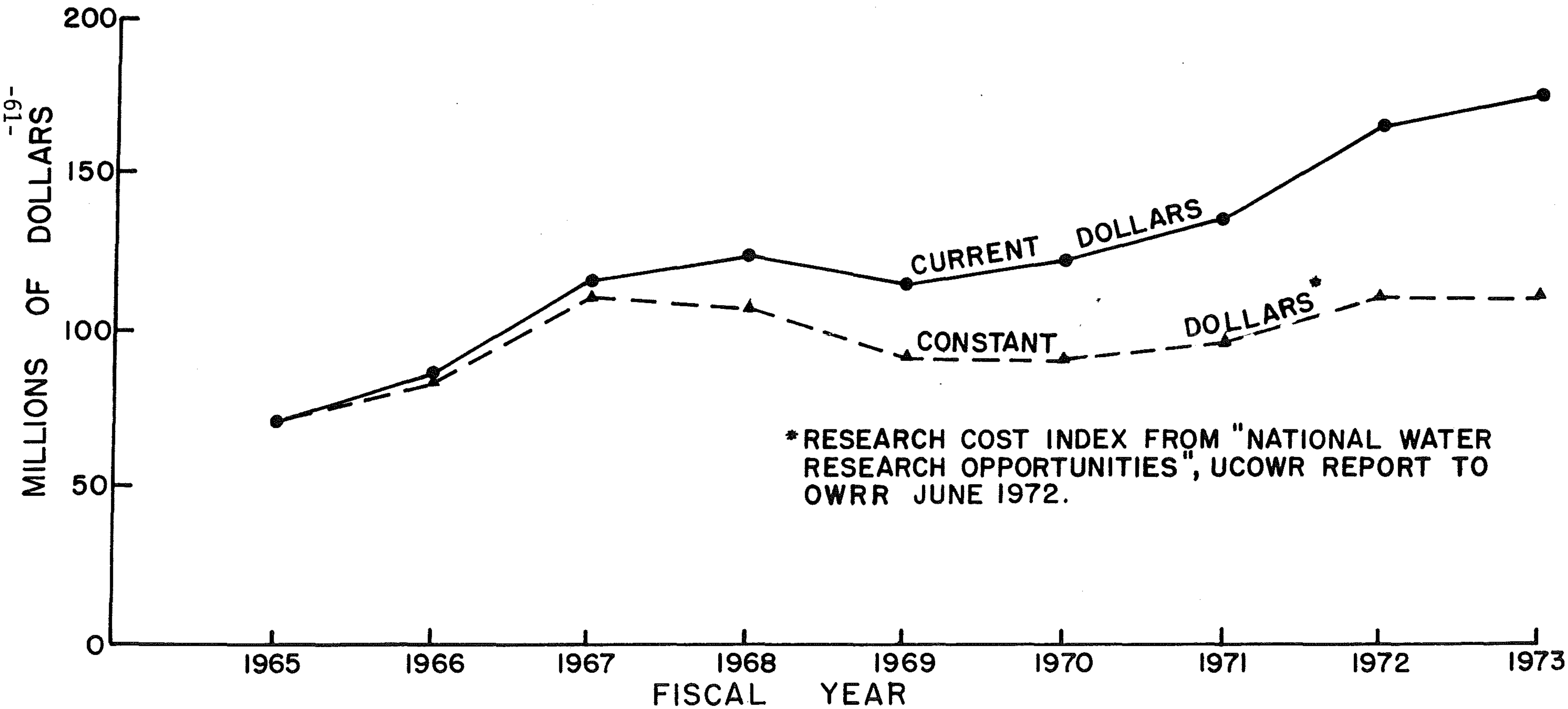


Table 1

FEDERAL SPENDING FOR WATER RESOURCES RESEARCH (MILLIONS DOLLARS)

	Fiscal Year									
Federal Agency	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973*
Agriculture	11.0	13.7	17.0	18.7	19.1	20.8	25.4	27.8	31.6	30.0
Commerce	1.2	0.9	0.7	0.8	0.8	5.2	5.8	6.9	10.1	15.1
Defense	3.4	3.6	3.9	5.6	6.5	9.5	10.2	10.3	11.8	11.2
H.U.D.	13.2	13.5	0.7	0.9	1.0	0.7	2.1	2.0	0.5	0.4
Interior	30.0	33.2	60.0	86.0	90.2	37.5	42.0	46.1	49.7	49.1
Transportation	--	--	0.3	--	0.6	1.7	1.9	2.5	3.4	3.8
A.E.C.	3.1	2.8	2.7	2.3	2.3	3.7	3.7	4.1	4.4	6.1
E.P.A.	--	--	--	--	--	30.8	25.3	31.3	43.3	48.2
N.A.S.A.	--	--	--	0.3	0.6	0.4	0.5	0.5	0.3	1.9
N.S.F.	1.7	1.7	1.7	1.2	1.4	2.2	2.2	2.9	8.5	10.3
Smithsonian	--	--	--	--	0.4	0.4	0.5	0.5	0.9	0.9
T.V.A.	0.9	0.6	0.7	0.9	1.0	1.2	1.2	1.1	1.2	1.2
Total	64.7	70.0	87.7	116.8	124.1	114.1	120.8	136.1	165.7	178.3

1972 - 1973 Data from COWRR (unpublished)
1964 - 1971 Data from annual FCST publications, "Federal Water Resources Research Program for 1966 - 1971.

*Totals do not always equal sum of individual agency programs because of rounding of figures.

Table 2

ADJUSTED FEDERAL SPENDING FOR
WATER RESOURCES RESEARCH
TO ACCOUNT FOR EFFECTS OF INFLATION

Fiscal Year	Current Spending (Millions Dollars)	Research* Cost Index	Adjusted Spending (Millions Constant Dollars)
1965	$ 70	1.000	$ 70
1966	88	0.965	85
1967	117	0.949	111
1968	124	0.873	108
1969	114	0.807	92
1970	121	0.754	91
1971	136	0.709	96
1972	166	0.670	111
1973	175	0.633	111

*"National Water Research Opportunities," UCOWR, Report to OWRR, June 1972.

FIGURE 2

FEDERAL SPENDING
FOR
WATER RESOURCE RESEARCH
VS.
WATER RESOURCE DEVELOPMENT

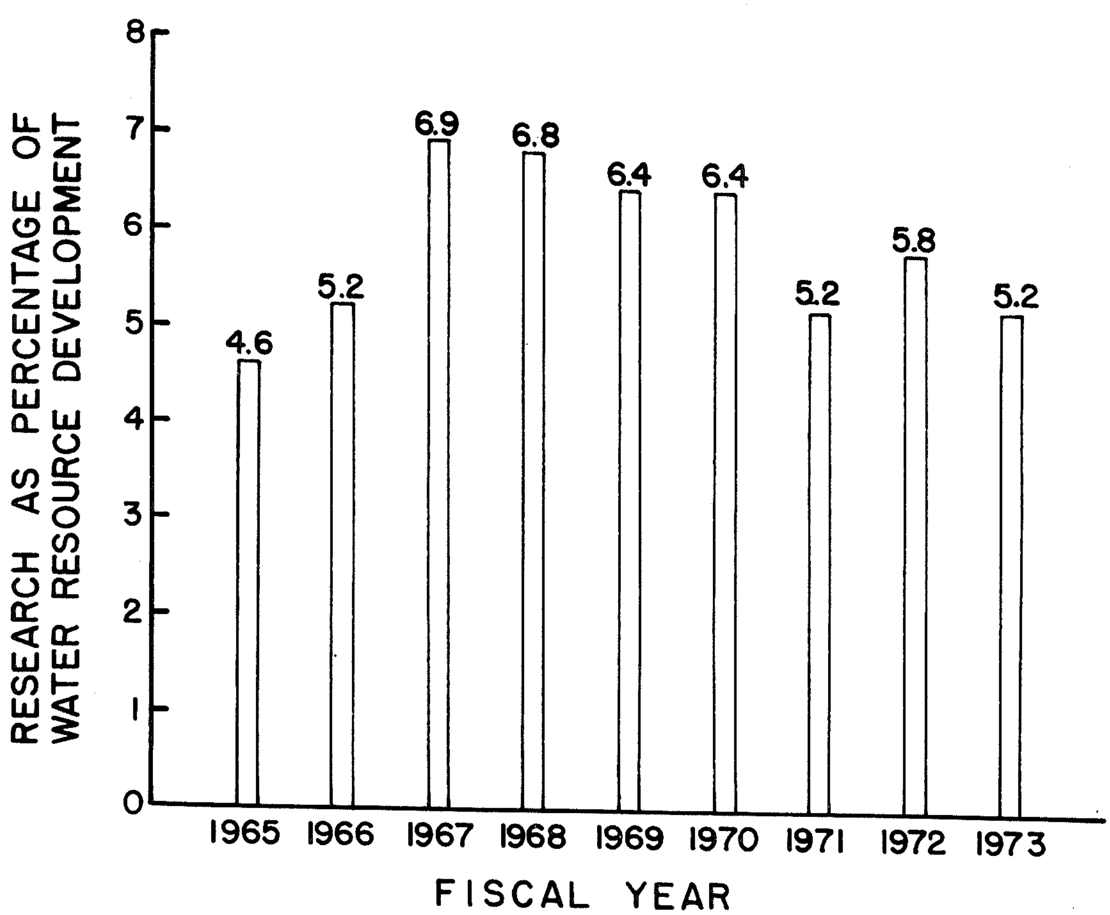


Table 3

FEDERAL SPENDING FOR WATER RESOURCE RESEARCH AND WATER RESOURCE DEVELOPMENT

Fiscal Year	Federal Spending in Millons Dollars: Development[1]	Research[2]	Research As Percent of Development
1965	1513	70	4.6
1966	1664	88	5.3
1967	1706	117	6.9
1968	1837	124	6.8
1969	1775	114	6.4
1970	1884	121	6.4
1971	2618	136	5.2
1972	2871	166	5.8
1973	3347	175	5.2

[1]OMB Annual Special Analyses of Budget

[2]FCST Annual Reports and Unpublished Data for FY 1973

While aggregate levels of research spending are significant, there is much to be gained by closer examination with respect to research planning objectives. Figure 3 contrasts projected research objectives for fiscal year 1971 under the "Ten-Year Program" with actual spending. Rather than increase at the projected rate, the real value of federal research spending dropped well below the 1967 level, missing the five-year goal by some $103 million. In brief, research was sustained at only half the level determined to be necessary by COWRR in its 1966 report. Figure 4 contrasts actual versus projected spending by FCST Category for FY 1971 -- the COWRR target year. The trends in water resources research by FCST category over the five-year period 1969-1973 are shown by Tables 4 and 5 (actual dollars) and Figure 5 (constant dollars).

Moving from comparisons of actual performance with the COWRR Program to the current picture, it is helpful to examine federal spending for water resources research in more recent years. Actual spending by FCST Category is shown for the five-year period 1969-1973 in Table 4. The data are transposed into percentages of total effort in Table 5 and Figure 5. Table 6 and Figure 6 present 1973 data -- the most recent year for which final data are available. From this it can be seen that research on water quality management now takes 45 percent of the federal effort. This would appear to be consistent with the national emphasis on water quality as the most important aspect of water resources planning and management. Research on the water cycle comes second with 19 percent, with water supply, augmentation and conservation following at 11 percent. In view of the many difficult problems associated with the planning sector, it seems reasonable to conclude that eight percent of the total for planning research is far out of proportion to the importance of planning in the total picture. Whether the water cycle continues to deserve the emphasis it receives at 19 percent, while water supply augmentation, conservation and planning receive relatively less attention, is a question deserving some consideration. On its face, at least, there would seem to be some imbalance.

The distribution of effort within each federal agency program is also of interest and serves to further illuminate the allocation of federal research funds. (Figure 7) The vast proportion of spending by the Department of Agriculture lies within only four of the ten categories. Sixty-three percent is evenly divided between research on the water cycle and water quality management. Thirty-three percent is split between water supply augmentation and conservation and water quantity management. Planning takes only two percent of the total.

Even in the Department of Defense research on the water cycle takes 15 percent. A fourth goes toward water resources planning and nearly half to research on engineering works. Water quantity and water quality involve five and six percent respectively.

The Department of Commerce allocates nearly a fourth of its funds to research on the water cycle and a third to water quality management. Planning receives only ten percent and resources data eighteen percent. Since one of the principal functions of Commerce agencies is data collection and analysis, there might be some question as to whether this area is receiving proportionate attention in research.

FIGURE 3

ACTUAL VS PROJECTED FEDERAL SPENDING FOR WATER RESOURCES RESEARCH 1965-1971 (CONSTANT DOLLARS)

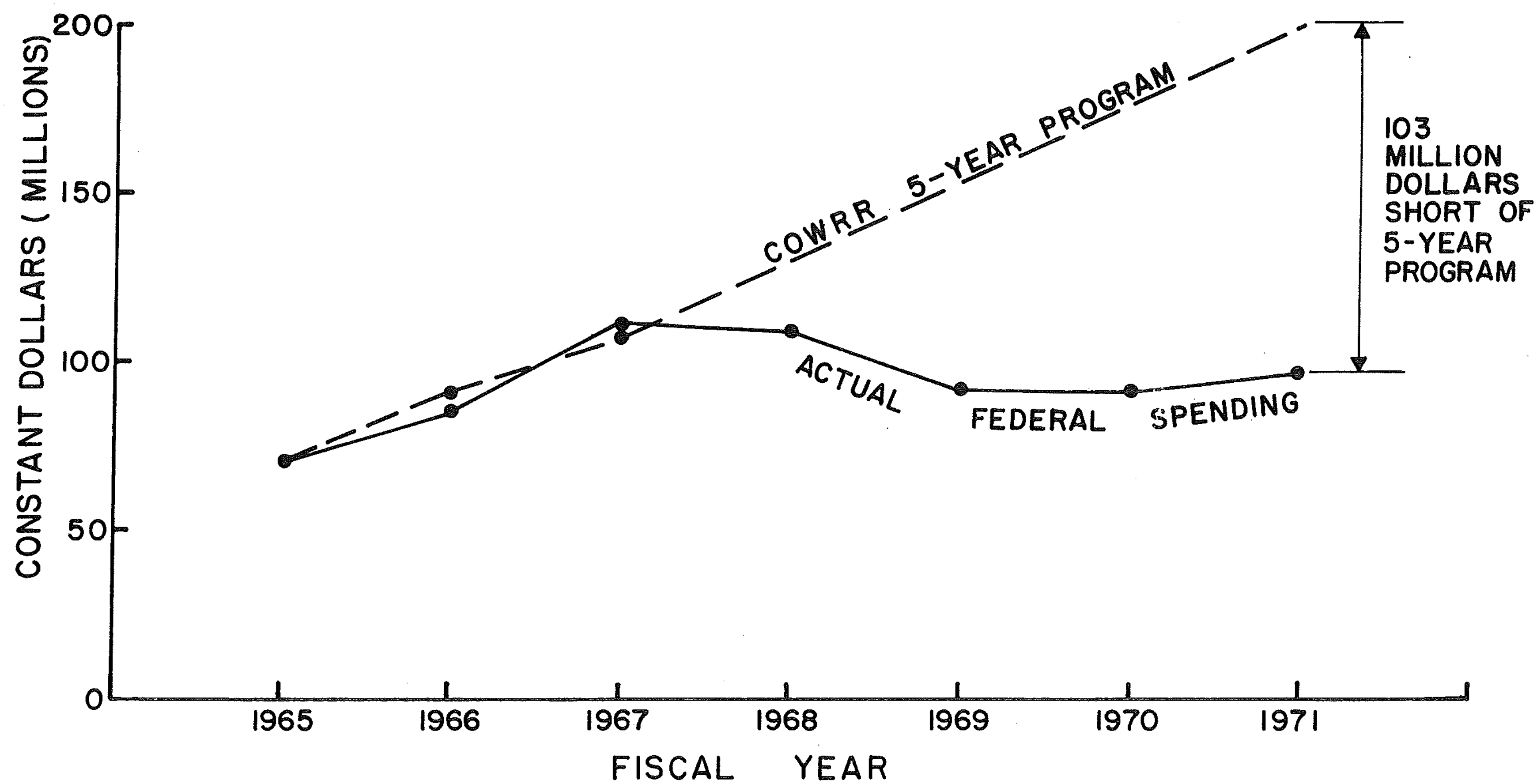


FIGURE 4

ACTUAL VS PROJECTED FEDERAL SPENDING FOR WATER RESOURCES RESEARCH BY F.C.S.T. CATEGORY (CONSTANT DOLLARS) FY 1971

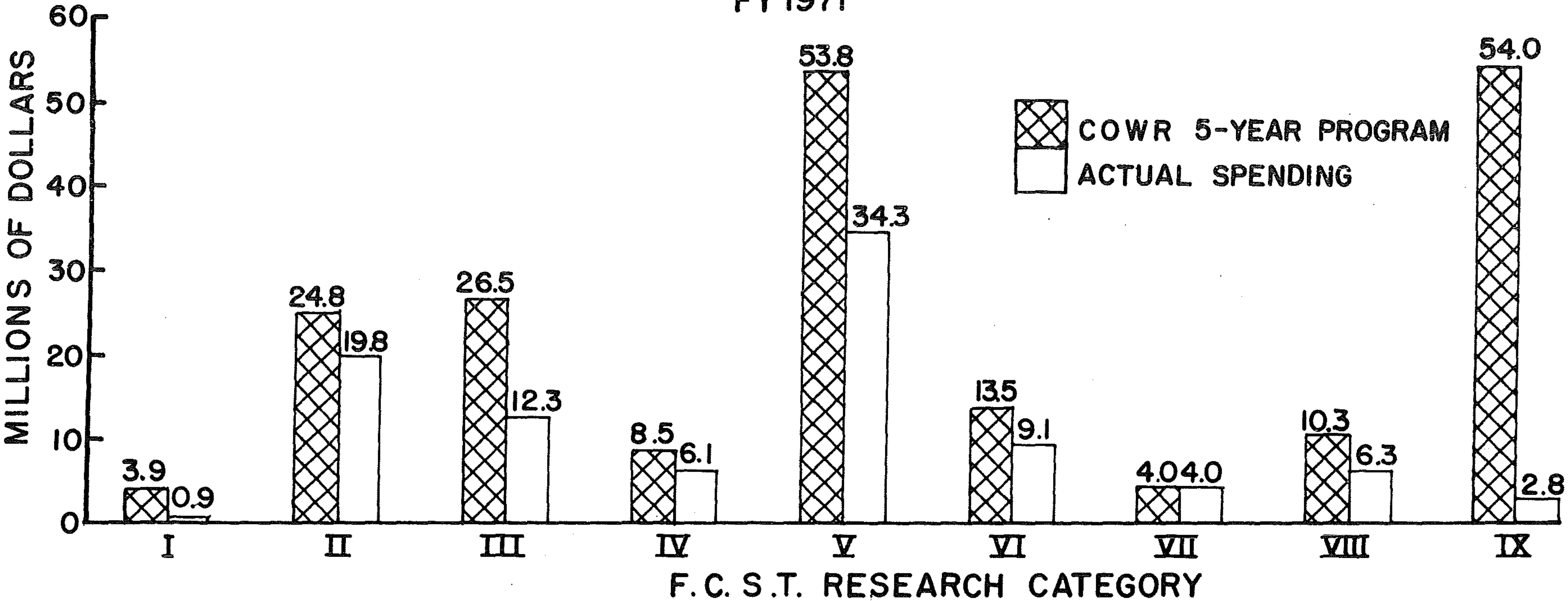


Table 4

WATER RESOURCES RESEARCH BY
FCST CATEGORIES (MILLIONS OF DOLLARS)

FCST Categories	Fiscal Year				
	1969	1970	1971	1972	1973*
I	1,119	1,255	1,268	1,144	1,447
II	24,570	26,567	27,860	30,119	34,303
III	15,322	16,291	17,365	20,842	19,373
IV	6,531	7,932	8,613	10,486	9,757
V	33,589	39,235	48,396	69,406	79,983
VI	9,555	11,495	12,905	14,040	13,587
VII	3,101	4,534	5,580	5,313	7,282
VIII	8,828	9,266	8,896	10,416	8,307
IX	10,686	3,316	3,864	4,354	3,191
X	775	883	1,366	613	1,031
Total	114,076	120,774	136,113	166,733	178,261

1972 - 1973 Data from COWRR - FCST (unpublished)
1969 - 1971 Data from COWRR - FCST Report "Federal Water Resources Research Program for 1971."

*Estimated by COWRR

Table 5

WATER RESOURCES RESEARCH BY
FCST CATEGORIES (PERCENT OF TOTAL)

FCST Categories	Fiscal Year 1969	1970	1971	1972	1973
I	1	1	1	1	1
II	22	22	20	18	19
III	13	13	13	13	11
IV	6	6	6	6	5
V	29	32	36	42	45
VI	8	10	9	8	8
VII	3	4	4	3	4
VIII	8	8	7	6	5
IX	9	3	3	3	2
X	1	1	1	<1	<1
	100	100	100	100	100

FIGURE 5

TRENDS IN WATER RESOURCES RESEARCH BY F.C.S.T. CATEGORY PERCENT OF TOTAL FEDERAL SPENDING 1969-1973

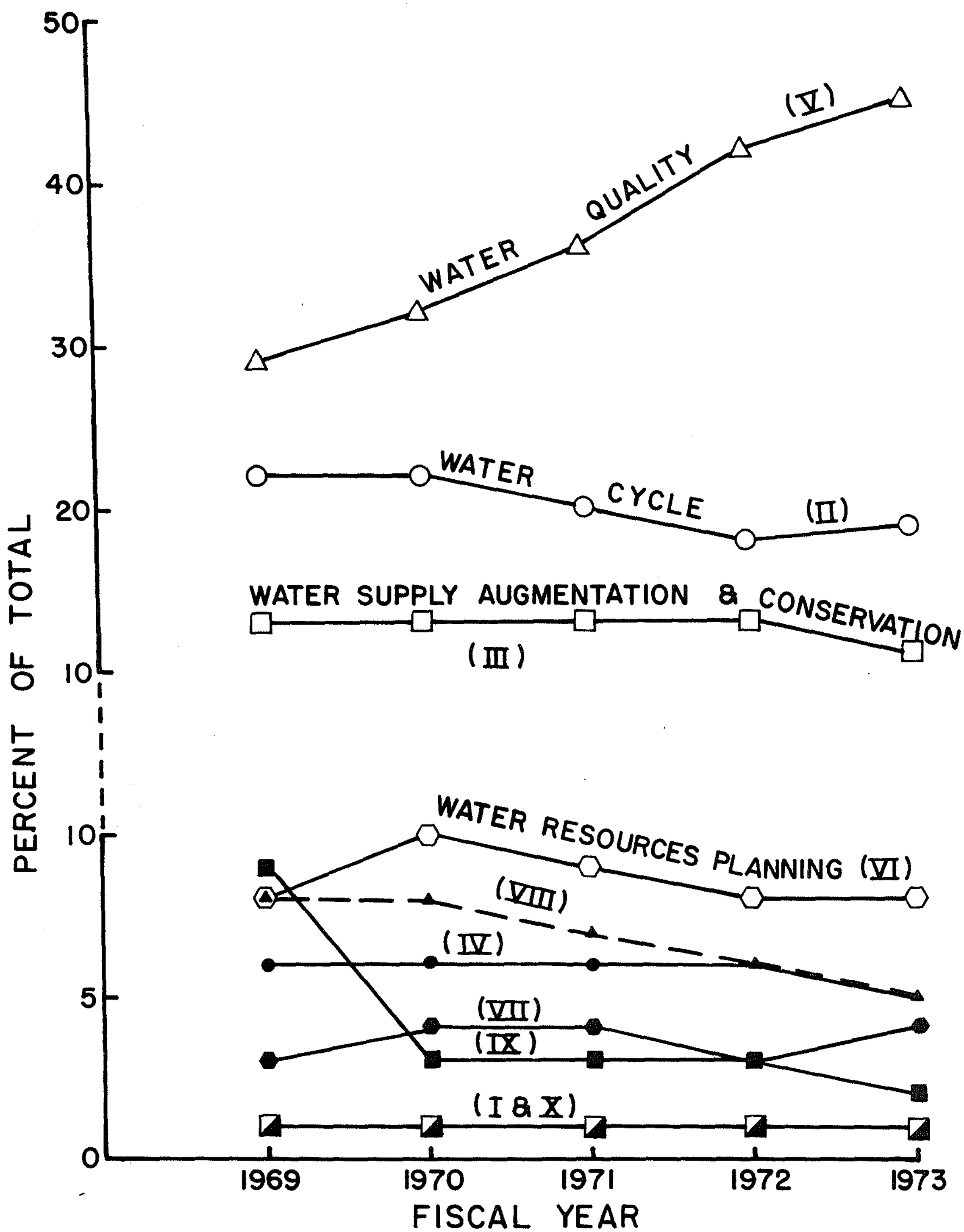


Table 6

FEDERAL SPENDING[1] FOR WATER RESOURCES RESEARCH BY AGENCY AND FCST CATEGORY FY 1973 (THOUSANDS OF DOLLARS)

Agency	I	II	III	IV	V	VI	VII	VIII	IX	X	Total
Agriculture	42	9,552	4,717	5,155	9,459	691	204	245	--	--	30,065
Commerce	500	3,545	10	320	5,044	1,530	2,660	--	1,007	520	15,136
Defense	--	1,726	--	500	720	2,792	10	5,363	--	67	11,178
H.U.D.	--	--	--	--	--	400	--	--	--	--	400
Interior	905	10,137	13,548	2,873	9,421	5,780	2,273	2,019	2,084	94	49,134
Transportation	--	1,550	--	740	665	--	--	680	92	55	3,782
A.E.C.	--	1,862	1,098	--	3,058	--	--	--	--	--	6,018
E.P.A.	--	--	--	--	46,980	1,011	197	--	--	--	48,188
N.A.S.A	--	--	--	--	--	--	1,938	--	--	--	1,938
N.S.F.[2]	--	5,233	--	--	4,141	939	--	--	--	--	10,313
Smithsonian	--	440	--	--	--	150	--	--	--	295	885
T.V.A.	--	258	--	169	495	294	--	--	8	--	1,224
	1,447	34,303	19,373	9,757	79,983	13,587	7,282	8,307	3,191	1,031	178,261

[1]Unpublished COWRR data

[2]Breakdown not available. Estimated from "Summary of Awards - Div. Env. Systems & Res.," RANN-NSF, July 1973

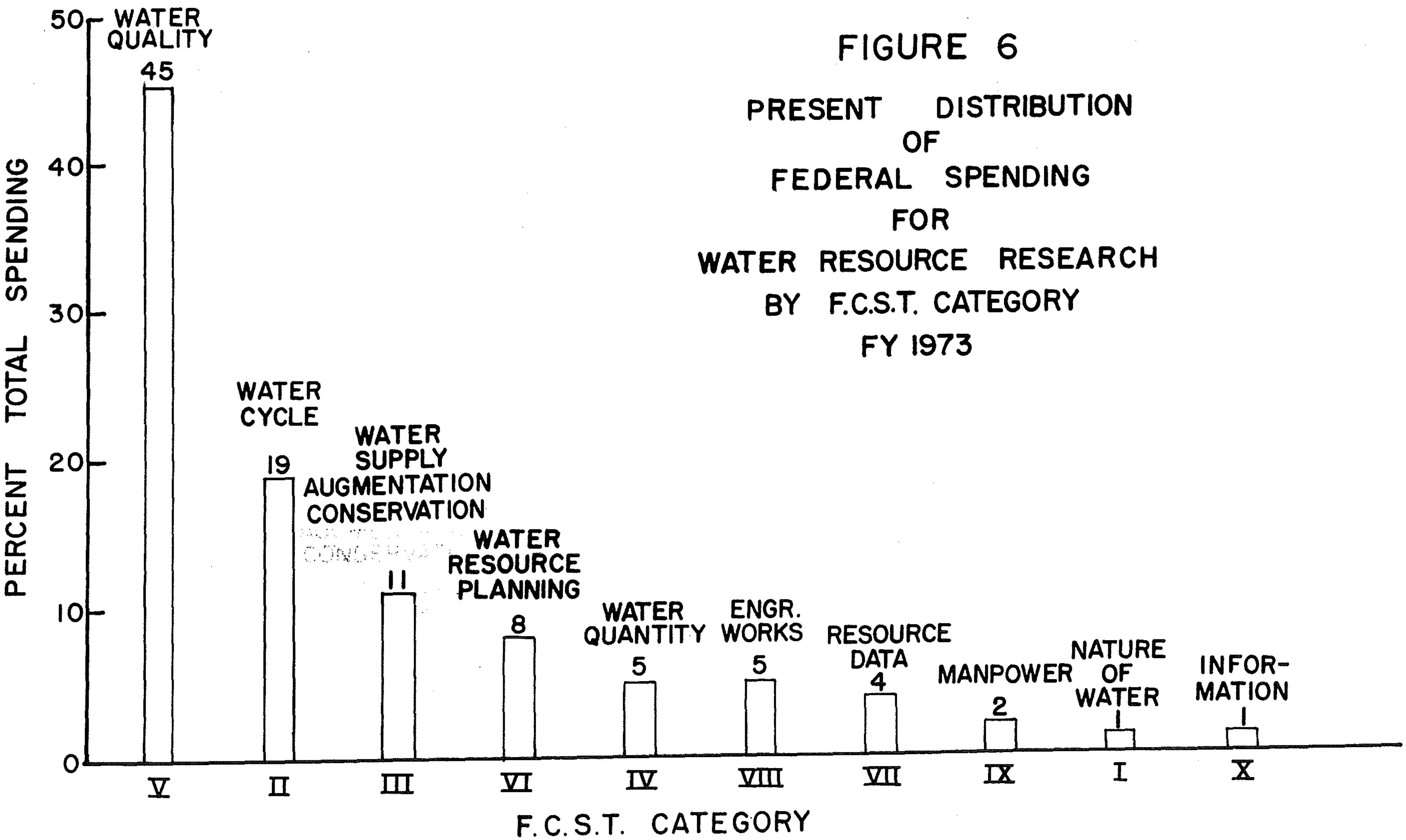
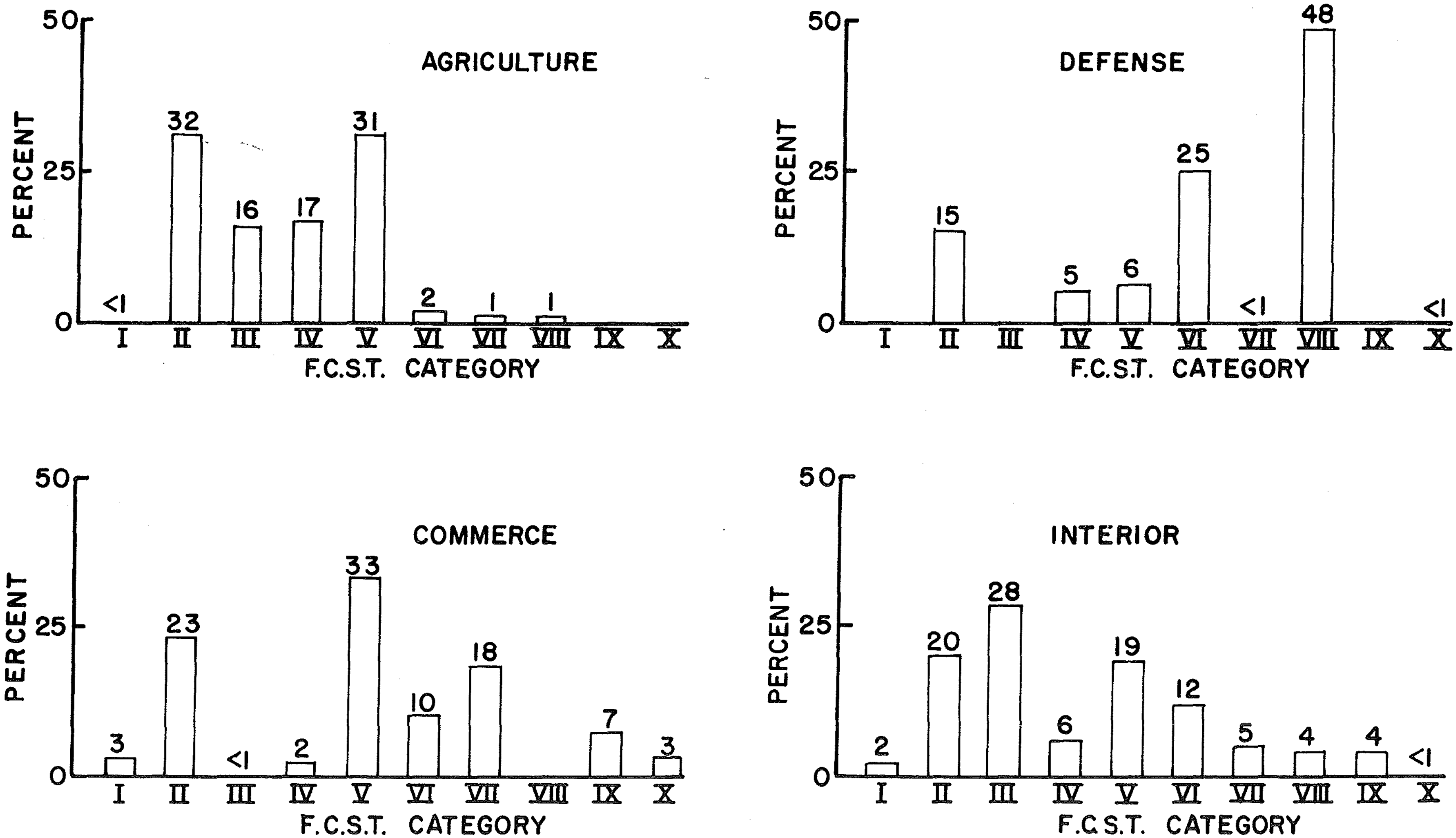
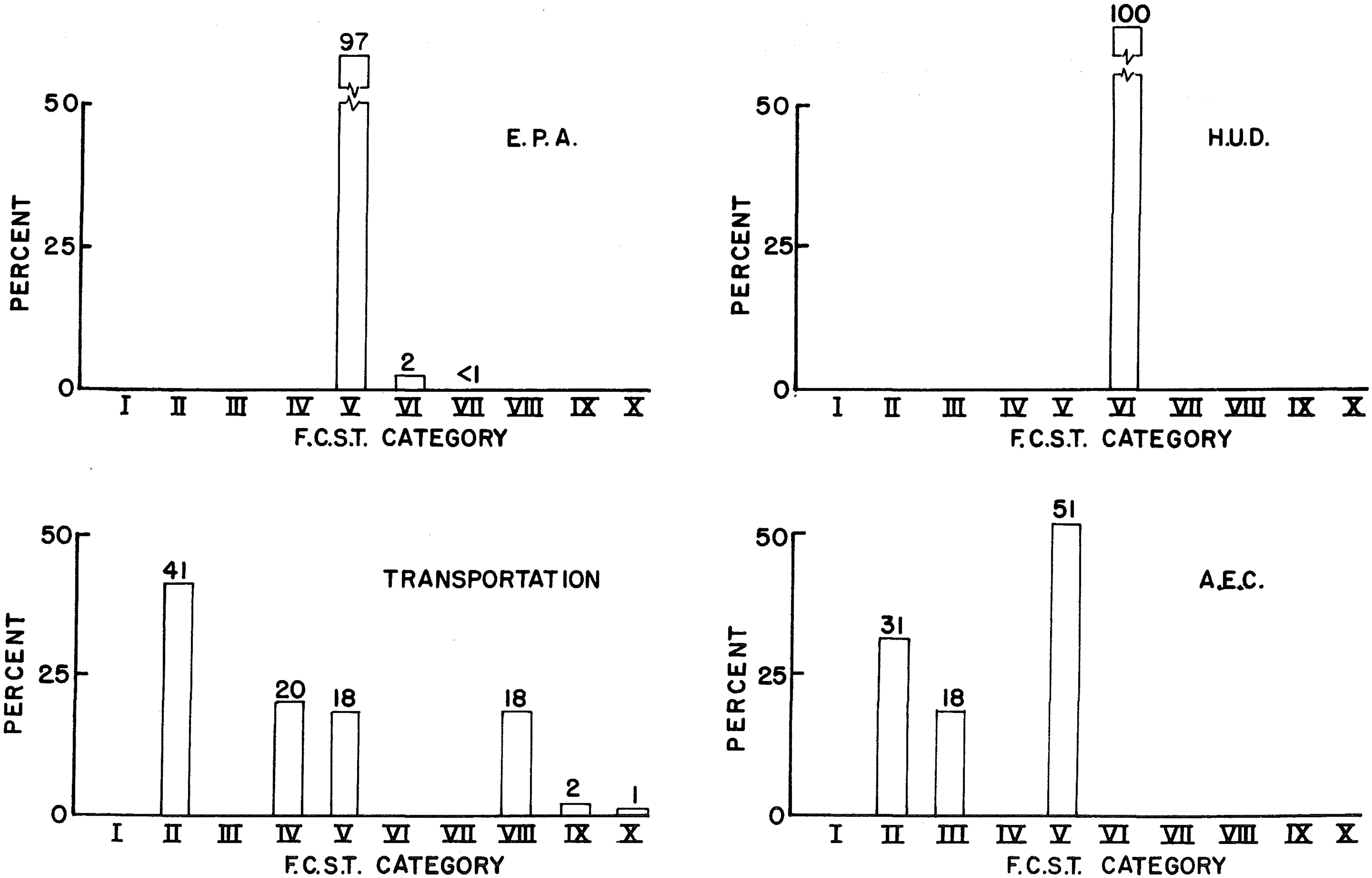
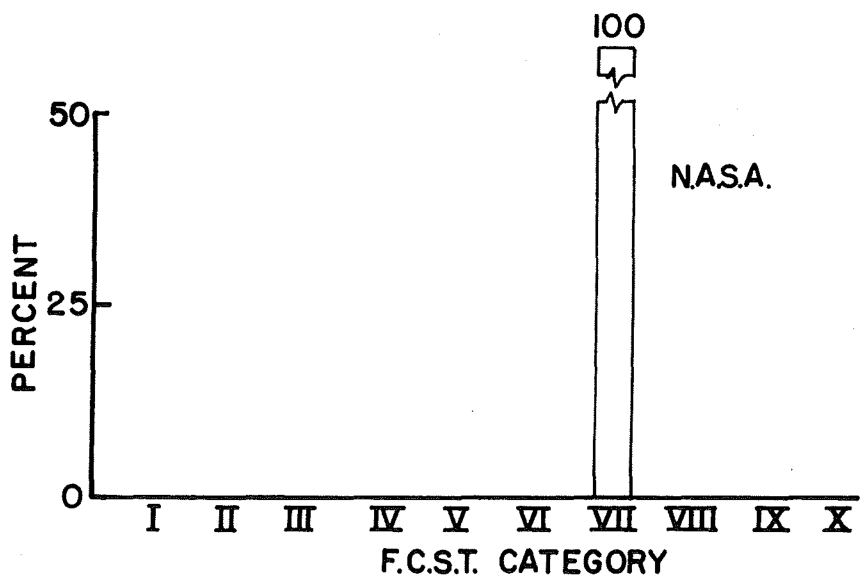


FIGURE 6
PRESENT DISTRIBUTION OF FEDERAL SPENDING FOR WATER RESOURCE RESEARCH BY F.C.S.T. CATEGORY FY 1973
PERCENT TOTAL SPENDING
0
10
20
30
40
50
WATER QUALITY
45
WATER CYCLE
19
WATER SUPPLY AUGMENTATION CONSERVATION
11
WATER RESOURCE PLANNING
8
WATER QUANTITY
5
ENGR. WORKS
5
RESOURCE DATA
4
MANPOWER
2
NATURE OF WATER
1
INFOR-MATION
1
V
II
III
VI
IV
VIII
VII
IX
I
X
F.C.S.T. CATEGORY

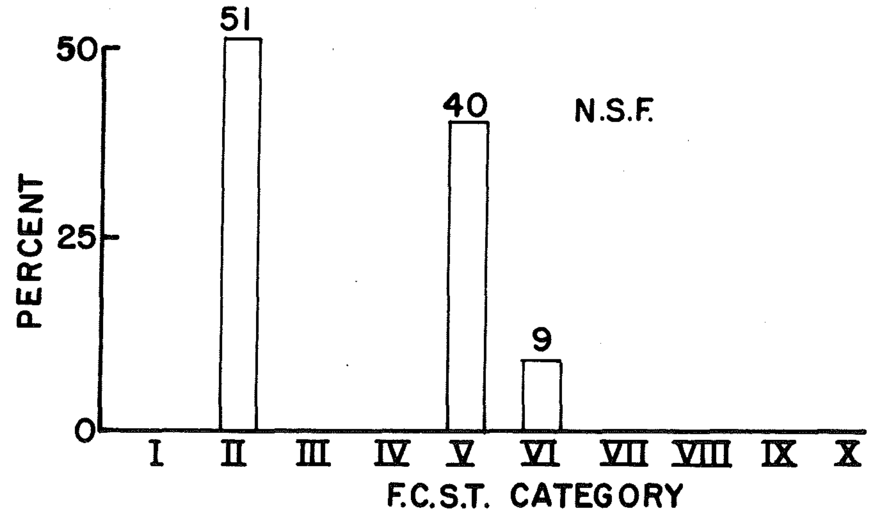
FIGURE 7
FEDERAL SPENDING FOR WATER RESOURCES RESEARCH BY AGENCY AND FCST CATEGORY FY 1973 PERCENT OF TOTAL



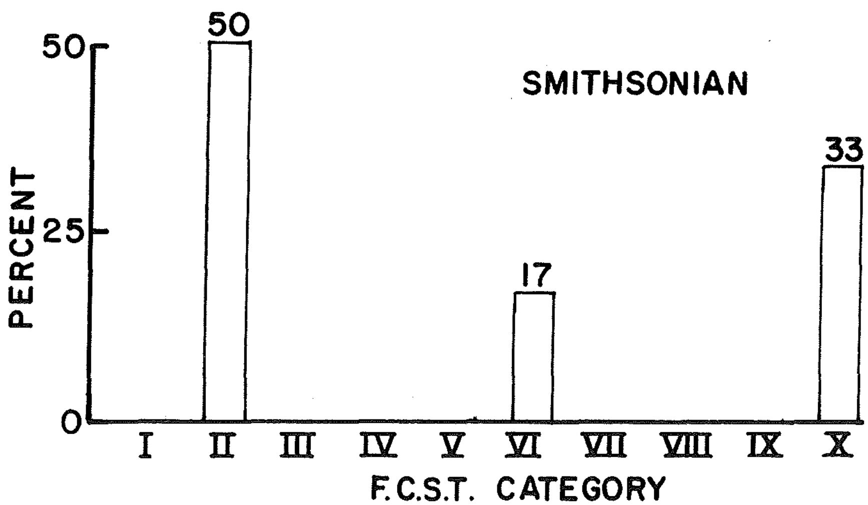

E. P. A.
PERCENT
50
25
0
97
2
<1
I II III IV V VI VII VIII IX X
F.C.S.T. CATEGORY
H.U.D.
PERCENT
50
25
0
100
I II III IV V VI VII VIII IX X
F.C.S.T. CATEGORY
TRANSPORTATION
PERCENT
50
25
0
41
20
18
18
2
1
I II III IV V VI VII VIII IX X
F.C.S.T. CATEGORY
A.E.C.
PERCENT
50
25
0
31
18
51
I II III IV V VI VII VIII IX X
F.C.S.T. CATEGORY



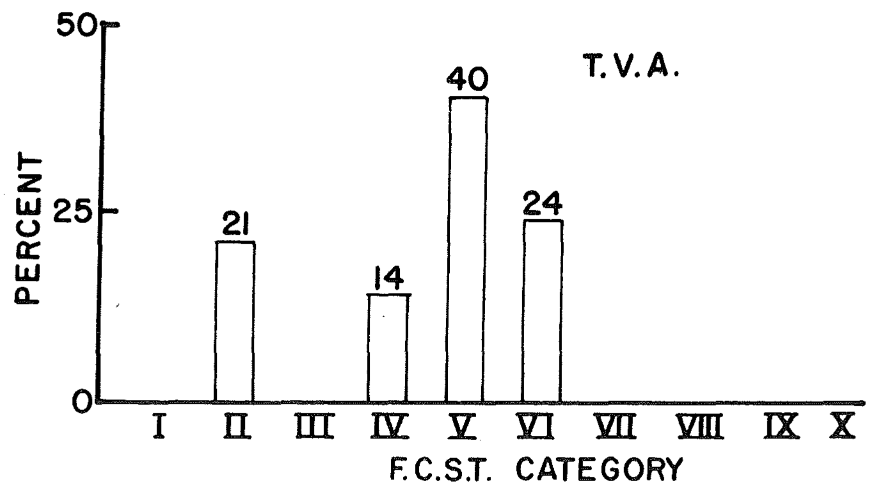
100
50
25
0
PERCENT
N.A.S.A.
I II III IV V VI VII VIII IX X
F.C.S.T. CATEGORY



51
40
9
50
25
0
PERCENT
N.S.F.
I II III IV V VI VII VIII IX X
F.C.S.T. CATEGORY



50
17
33
50
25
0
PERCENT
SMITHSONIAN
I II III IV V VI VII VIII IX X
F.C.S.T. CATEGORY



21
14
40
24
50
25
0
PERCENT
T. V. A.
I II III IV V VI VII VIII IX X
F.C.S.T. CATEGORY

The Interior research program reflects a wider range of research activity and less specialized emphasis than many other agencies. The three top categories are water cycle, supply augmentation and conservation, and water quality management. Despite the emphasis placed on planning problems, only twelve percent of the funds goes to this sector. Whether five percent for research on water resource data systems represents sufficient emphasis in the face of U.S. Geological Survey responsibilities is also worthy of inquiry.

Essentially all of the Environmental Protection Agency research program deals with water quality management, as might be expected. With the Agency's important responsibilites for planning under P.L. 92-500, however, the two percent devoted to water resources planning is obviously inadequate. Persons familiar with the state-of-the-art might also conclude that there are major deficiencies here that demand attention of the research community. The recognized need for integration of water quality with water resource planning and both with land use planning underscores this need. The Agency's overall preoccupation with the regulatory function has served to downplay the planning function, and it is reasonable to expect that this would also be relfected in related research.

The role of the university community in water quality research has changed dramatically over the past three years. Within the extrmaural research program of the Environmental Protection Agency, university researchers now play a minor part. Table 7 shows that of the $48.2 million spent by that Agency for research in F.Y. 1973, only about one-sixth was extramural. Less than $1 million went to universities. In 1972, of the $1.6 million extramural research only half was invested in university research. University participation in F.Y. 1971 was thirteen percent. Much of this is due to the movement away from grant to contract research where the extremely limited notice and time for completion shuts out much of the university. This is regrettable for a number of reasons. First, the use of the contract method presupposes the availability of highly competent and informed research managers who can foresee all needs and properly design specifications to accomplish their objectives. This utopian situation doesn't exist in any agency, and to foreclose the less constrained university response is to cut off the agency from a valuable flow of ideas which they must have in the long run. Second, the simultaneous phasing out of training grants and sharp reduction of research grants eliminates the principal means for training graduate students eventually required by the Agency to staff its programs. While the need for a strong in-house research program and use of contract research is recognized, it is felt that the pendulum has swung too far and that remedial steps are necessary in the self interest of the Agency as well as the broader national interest.

Moving on through Figure 7, it can be seen that the H.U.D. program is entirely devoted to planning. The level of funding is so small, however, as to not offset deficiencies in other programs. Transportation puts forty-one percent of its money in water cycle research with the remainder about evenly divided between water quantity, water quality and engineering works. The Atomic Energy Commission gives more than half of its attention to water quality, nearly a third to research on the water cycle, and eighteen percent to water supply augmentation and conservation. There is no reported effort in the planning sector, which would seem to be a major deficiency.

Table 7

WATER RESOURCES RESEARCH ENVIRONMENTAL PROTECTION AGENCY
(MILLIONS OF DOLLARS)

Fiscal Year	Total EPA Water Resources Research	Extramural[1]		
		University	Other	Total
1971[3]	31.3	0.2	1.6	1.8
1972[3]	43.3	0.8	0.8	1.6
1973[2]	48.2	0.9	6.9	7.8
Total	122.8	1.9	9.3	11.2

[1]Unpublished EPA data

[2]Unpublished COWRR data

[3]FCST Report, "Federal Water Resources Research Program for 1971"

The sole emphasis in NASA is research on water resources data, as might be expected. The National Science Foundation allocates more than half to water cycle research, forty percent to water quality management and nine percent to water resources planning. A major difficulty in working with NSF data is reconciliation of data reported to COWRR and that published in their own reports. Many, if not most, of the water-related research projects also deal with other aspects of the environment and allocation of effort must be very difficult. The writer attempted to reconcile data in the F.Y. 1972 and 1973 RANN reports with NSF data reported to COWRR without success. The question of data reliability is much broader than this one agency, however. As one goes into detail and examines individual projects, even more questions arise. Many of the larger extramural projects reported by EPA for F.Y. 1973, for example, involve what is cleary technical services where the characteristics distinguishing this from research are beyond the usual semantical considerations. This emphasizes the need for continued efforts to sharpen up the classification and reporting systems.

The Smithsonian Institution allocates half of its resources to research on the water cycle, one third to scientific and technical information, and seventeen percent to water resources planning. The Tennessee Valley Authority places a fourth of its efforts in planning, forty percent in water quality management, fourteen percent in water quantity management, and twenty-one percent in research on the water cycle.

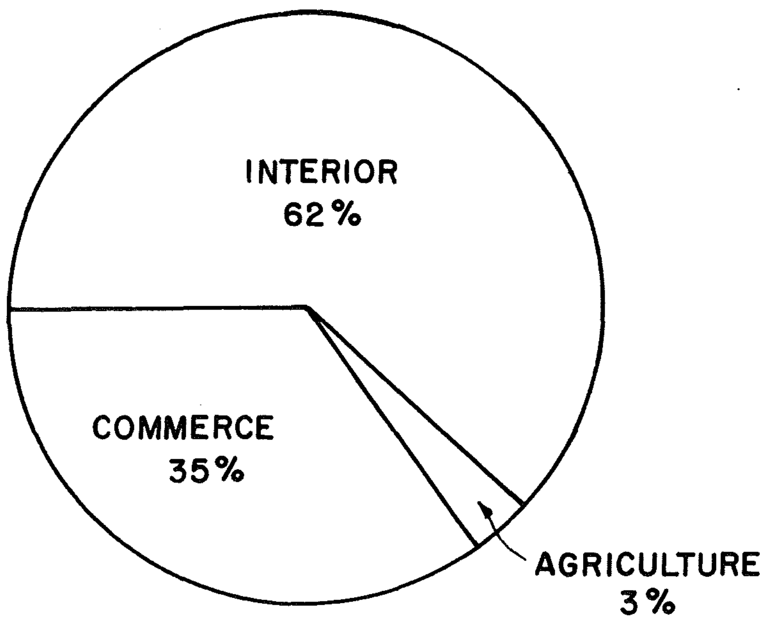
A different perspective on the contributions of the different water resource agencies and their particular emphasis with respect to FCST Categories is given in Figure 8. The Department of the Interior contributes the greatest proportion of funds to research on the nature of water, water cycle, water supply augmentation and conservation, water resources planning and manpower. Agriculture leads in research on water quantity management, EPA in water quality management, Commerce in water resources data and scientific and technical information, and Defense in engineering works.

Since the Office of Water Resources Research in the Department of the Interior is somewhat unique among the research agencies, it might be of interest to examine the variable emphasis given to the FCST Categories by its two component programs, i.e., Title I and II Programs. Cumulative data for the period 1965-1974 are shown in Table 8 and graphically portrayed in Figure 9. Within the Title I Annual Allotment Program, water quality research has represented forty-one percent of the total. This also accounts for twenty-nine percent of Matching Grant funds in contrast to eleven percent for Title II. The domination of water pollution and related concerns at the state and regional level could easily account for this. The situation is reversed with respect to water resource planning where the Title II Program has put 62 percent of its funds, with Matching Grants following with thirty-nine percent and the Annual Allotment Program with twenty percent. The differences become less marked through the remaining categories. It is expected that the distribution of planning research between the programs will change as the Title II Program becomes more closely related to mission-oriented research and the state institutes become increasingly involved in research supporting the state and regional planning functions.

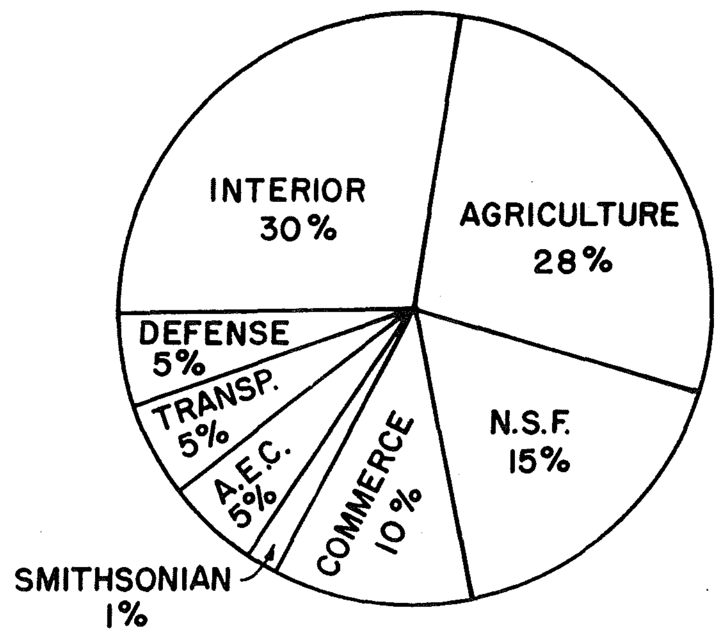
FIGURE 8

FEDERAL AGENCY PARTICIPATION IN WATER RESOURCES RESEARCH BY F.C.S.T. CATEGORY FY 1973

NATURE OF WATER
(F.C.S.T. I)

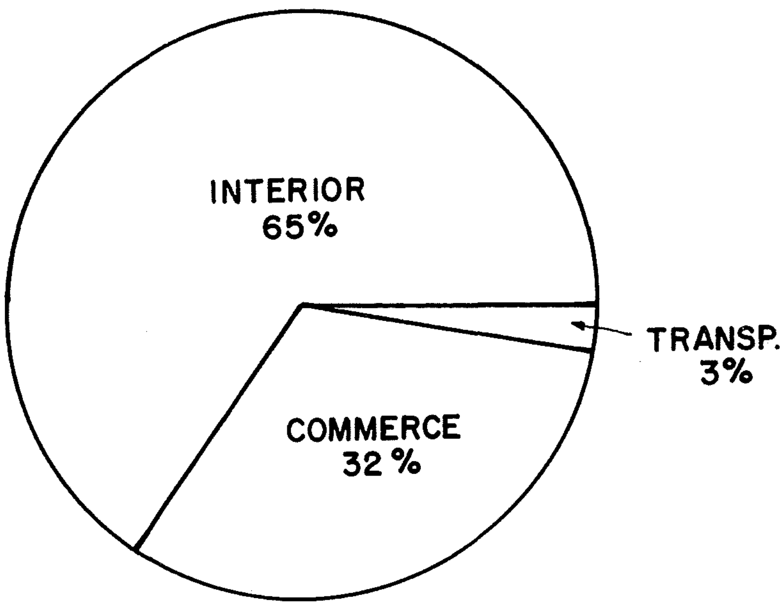


WATER CYCLE
(F.C.S.T. II)

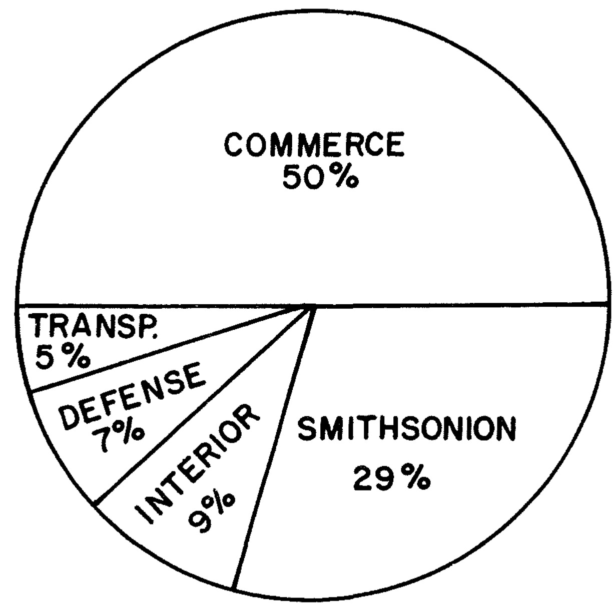


MANPOWER

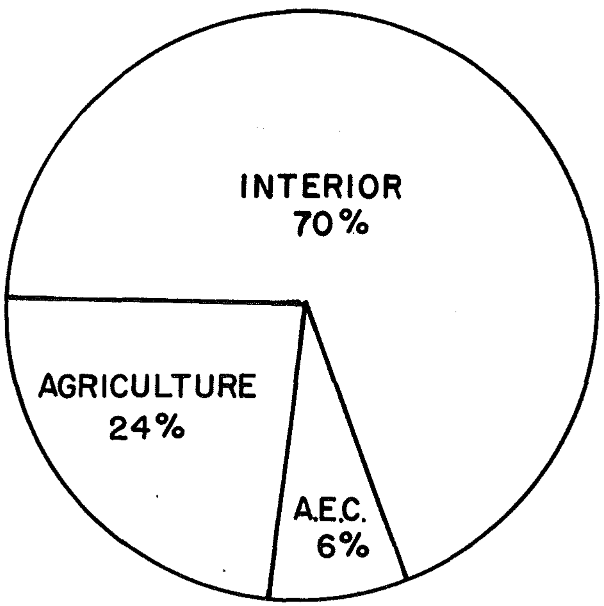
(F.C.S.T. IX)



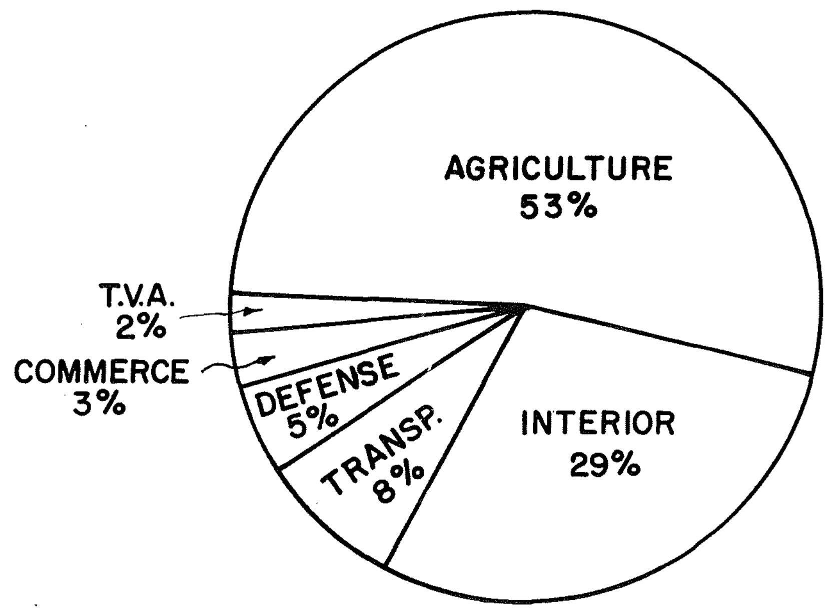
SCIENTIFIC & TECHNICAL
INFORMATION
(F.C.S.T X)



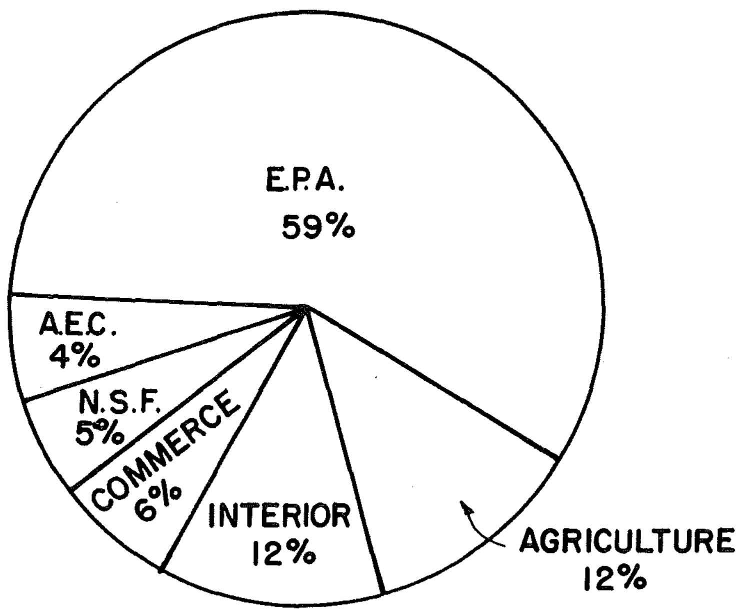
WATER SUPPLY AUGMENTATION & CONSERVATION (F.C.S.T. III)



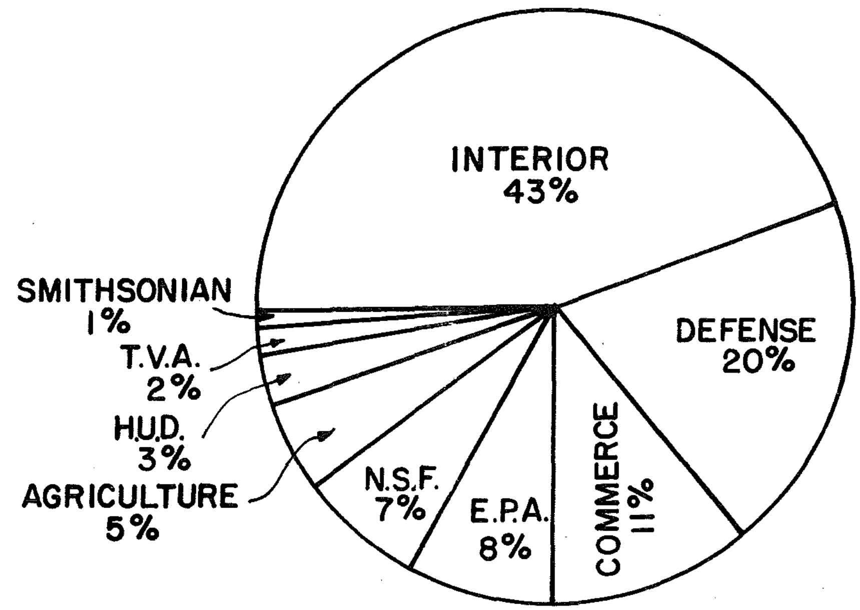
WATER QUANTITY MANAGEMENT (F.C.S.T. IV)



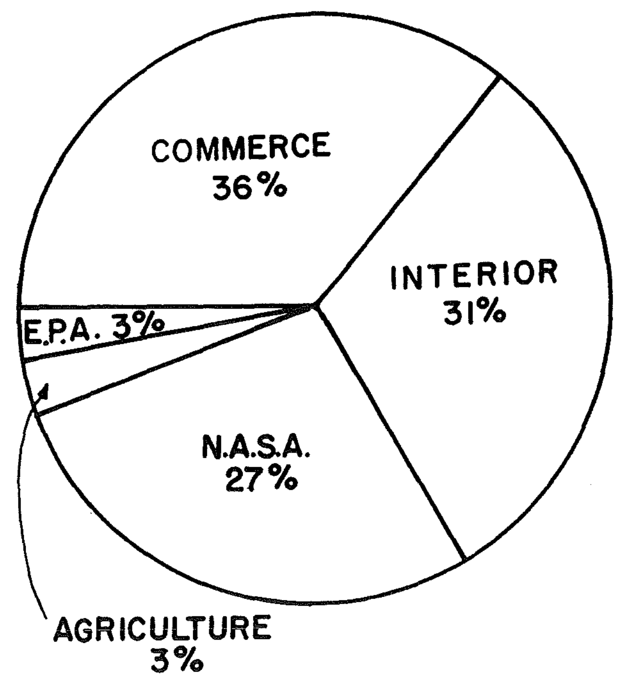
WATER QUALITY
MANAGEMENT
(F.C.S.T V)



WATER RESOURCE
PLANNING
(F.C.S.T. VI)



WATER RESOURCES DATA
(F.C.S.T. VII)



ENGINEERING WORKS

(F.C.S.T. VIII)

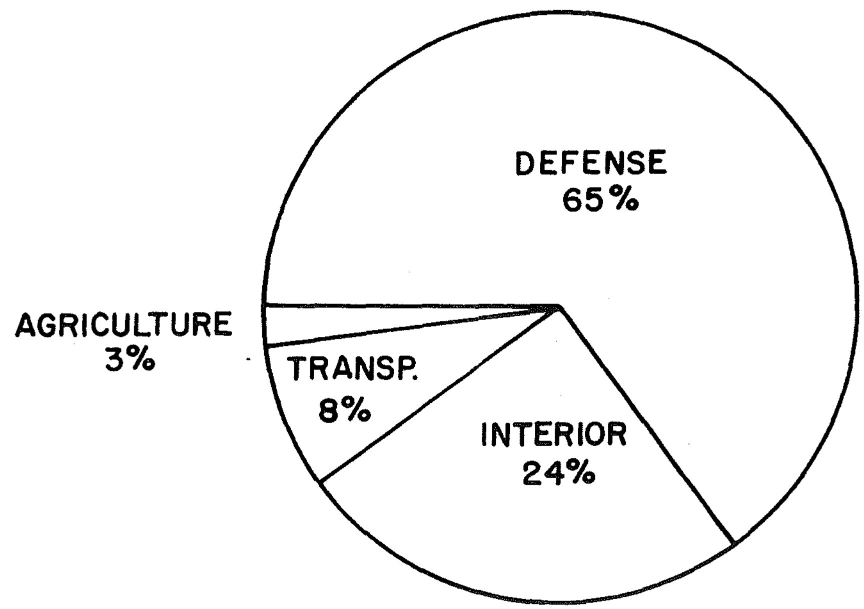


Table 8

PROGRAM EMPHASIS - OFFICE OF WATER RESOURCES RESEARCH

FCST Category	Percent of Program by Fiscal Year											
	1965-1972			1973			1974			Total		
	Title I		Title	Title I		Title	Title I		Title	Title I		Title
	AA	MG	II	AA	MG	II	AA	MG	II	AA	MG	II
I	2	<1	--	2	<1	--	<1	<1	--	2	<1	--
II	17	17	9	20	10	18	18	7	11	18	15	11
III	7	6	2	4	4	5	3	10	5	6	6	3
IV	9	8	7	5	3	7	5	5	10	8	7	7
V	40	25	9	48	40	9	49	41	25	41	29	11
VI	20	39	67	17	40	56	17	35	46	20	39	62
VII	3	3	2	3	2	4	4	<1	--	3	2	2
VIII	2	1	3	<1	1	2	<1	2	3	2	1	3
IX	<1	--	<1	<1	--	--	<1	--	--	<1	--	<1
X	<1	<1	<1	1	--	--	<1	--	--	<1	<1	<1

Source: OWRR Annual Report FY 1973

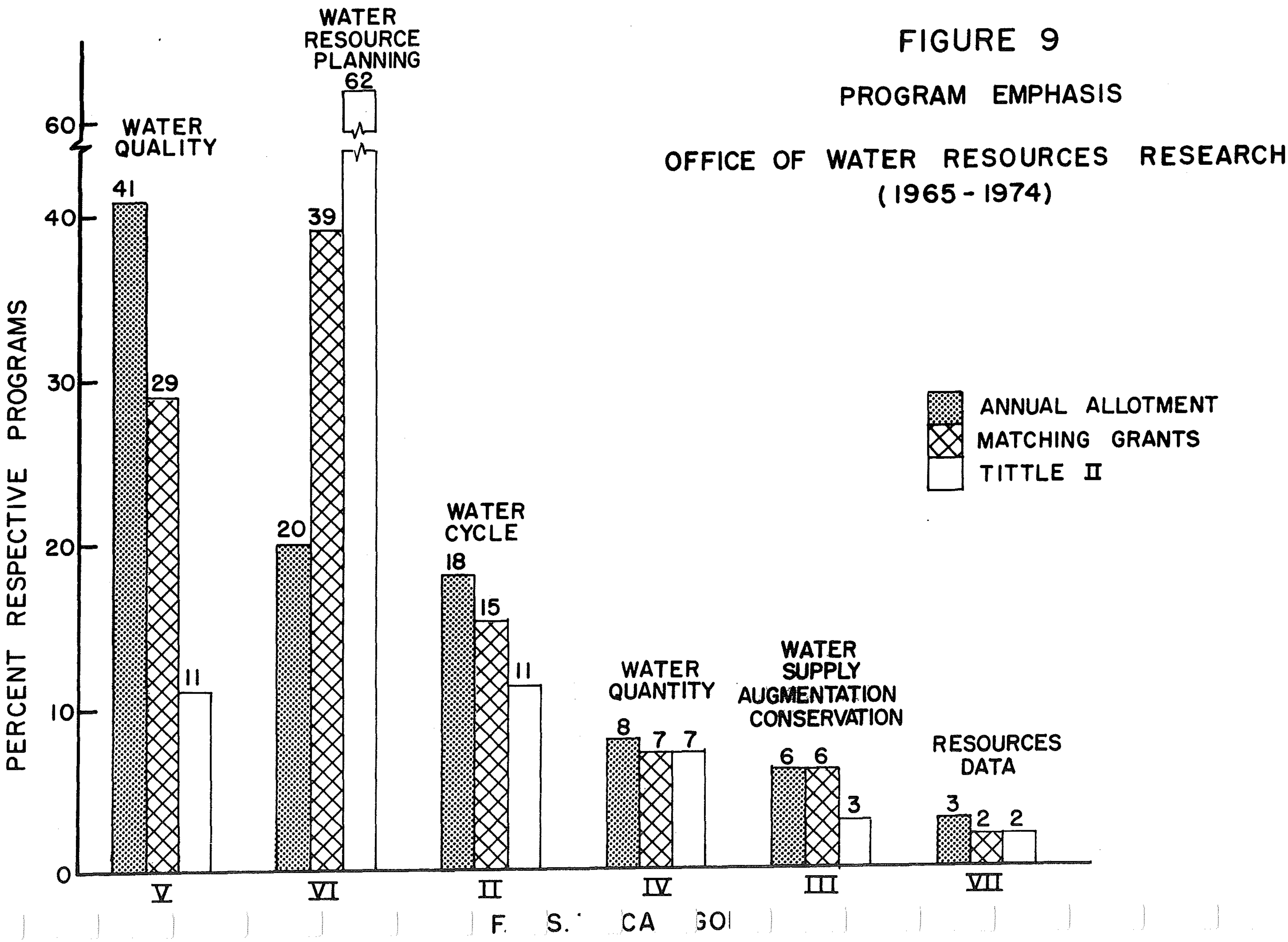


FIGURE 9

PROGRAM EMPHASIS

OFFICE OF WATER RESOURCES RESEARCH (1965 - 1974)

In reviewing the sequence of events starting with COWRR and its "Ten-Year Program," one can't escape the conclusion that the major deficiency in water resources research -- probably applicable to most research -- is the absence of a policy and methodology for problem identification and analysis, research planning and coordination. This was cited by the 1972 UCOWR study, by the 1974 GAO investigation, and to some degree by the National Water Commission Report. The Office of Water Resources Research has assumed increasing leadership in this area in cooperation with the State Water Resources Research Institutes. While initially applicable to the Title I Program, it has the potential for much broader application.

The OWRR-Institute activity is a three-step procedure involving:

(1) water problem and research need identification by the state institutes;

(2) formulation of state, regional, and national programs; and

(3) rigorous analysis of individual problems and research needs.

Each state institute is currently going over its assessment of water problems and research needs and reclassifying according to a standard classification matrix developed by Dr. Warren Hall and his staff and shown in Figure 10. Problem areas are classified under the general headings of water quantity, water quality, planning and management. Sufficient sub-headings are used to meet the needs of each state. Following this step, each problem area is examined with respect to the principal elements of the systems within which the problem is embedded. These include hydrological, biological, socio-economic, planning, engineering, and data measurement systems and processes. Each element of the systems in which research is required to solve the problem is subjectively assigned a priority of critical, serious, important or minor. The state compilations are to be integrated into regional and national programs. Common regional and national research needs can be sorted out and given the emphasis and specialized attention they deserve. Problems of unique state interest can then be addressed at the state level, shared problems at the regional level, and common problems at the national level. While nothing in the world of man works beyond the capacity of human beings and their willingness to cooperate and work together, the classification system appears to offer sufficient promise to justify a concerted national effort. With experience will come improvements and hopefully a progessively better system.

Following the classification and program formulation stage comes the intensive analysis of individual water problems and research needs shown by Figures 11 and 12. This involves a sequential procedure for examination of the need for research with respect to problem definition, goals and objectives, and knowledge of relevant system; knowledge of alternative courses of action to solve problems, their feasibility, and consequences; and a comparative evaluation. The effectiveness of the process depends on the knowledge of problems by participants and their willingness to persist in the face of the inevitable frustrations. As with the preliminary steps, the effort is never quite complete and at best represents a close approximation. It, too, must be repeated as research progresses and new understanding permits more accurate analysis. To this observer, at least, the procedure

FIGURE 10
RESEARCH NEEDS AND PRIORITIES

PROBLEM ORIENTED RESEARCH CLASS. / PROB. AREA	I HYDROLOGICAL SYSTEMS & PROCESSES							II BIOLOGICAL SYSTEMS & PROCESSES								III SOCIO-ECONOMIC SYSTEMS							IV PLANNING SYSTEMS	V ENGR. WORKS	VI DATA MEASUREMENT SYSTEMS
	A. PRECIPITATION	B. NON-CHANNEL RUNOFF	C. CHANNEL RUNOFF	D. INFILTRATION	E. INTER FL	F. GROU	G	D.	E.	F.	G.	H.	I.	J.	K.	D.	E.	F.	G.	H.	I.	J.			
WATER QUANTITY																									
A. MANAGEMENT OF EXCESS WATER																									
1. FLOODS			C																						
2. EROSION		C																							
3. DRAINAGE			S																						
4. SALVAGE & CONSERVATION						I																			
B. SUPPLY AVAILABILITY																									
1. WATERSHED USE IMPACT																									
2. SEASONALLY DEFICIENT SUP.																									
3.																									
4.																									
C.																									
1.																									
2.																									
3.																									

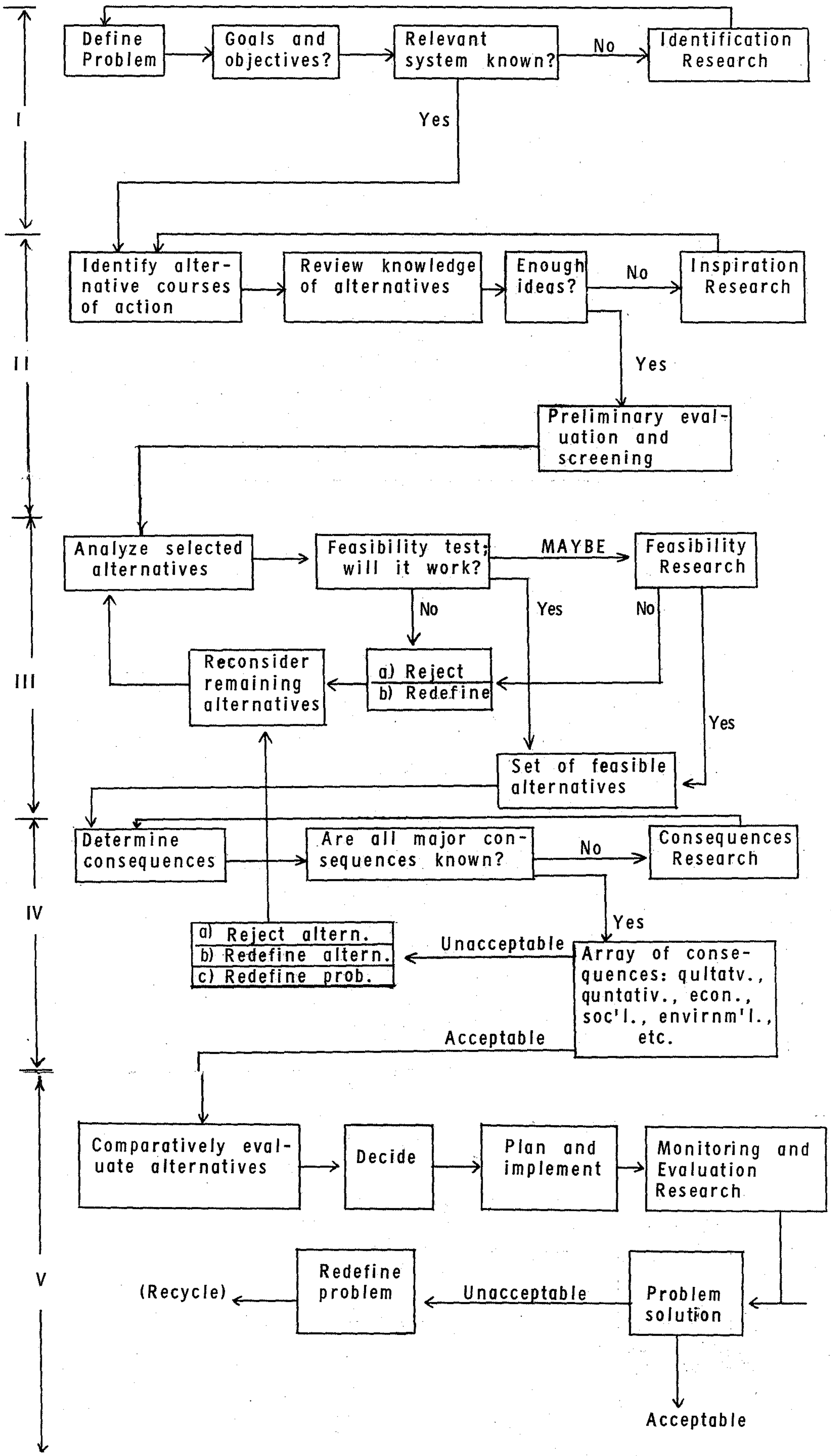
C — CRITICAL
S — SERIOUS
I — IMPORTANT

FIGURE II

SYSTEMATIC APPROACH TO PROBLEM-SOLVING RESEARCH

PHASE	OBJECTIVE	TYPE OF RESEARCH	PRODUCT
I	DEFINE PROBLEM	IDENTIFICATION	SYSTEMATICALLY STATED GOALS
II	IDENTIFY ALTERNATIVE COURSES	INSPIRATION	PRELIMINARY EVALUATION AND SCREENING
III	ANALYZE SELECTED ALTERNATIVES	FEASIBILITY	SET OF FEASIBLE ALTERNATIVES
IV	DETERMINE CONSEQUENCES	CONSEQUENCES	ARRAY OF CONSEQUENCES
V	COMPARATIVELY EVALUATE ALTERNATIVES	MONITORING AND EVALUATION	SOLUTION

FIGURE 12
SYSTEMATIC APPROACH TO PROBLEM-SOLVING RESEARCH



is worth the effort. While all involved are terribly frustrated by the added demands on an already oversubscribed time budget, it can be argued that it is better to have a road map than to depend on instinct for the long haul. Certainly, budgetary justifications based on systematic programming and analysis are more impressive, and this is a consideration of increasing importance as steps are taken to stabilize the economy through reductions in federal spending.

The purpose of water research, said the National Water Commission, is to facilitate the achievement of particular objectives in solving water problems. Research is of no use toward this end unless the techniques and means exist for delivery of research findings to the planners and managers in a form they can understand and utilize. The emphasis given to research application to problem solving by the GAO report underscores the importance of effective delivery systems for research. This must include services ranging all the way from information retrieval from WRSIC to hand delivery and specialized training. While there is mounting concern for this need and increasing efforts to meet it, the resources devoted to the task have been totally inadequate. Since research performed and stored on the shelf is of little value to the problem solvers, one alternative might be to reduce expenditures for research and allocate the money to research-related information transfer activities. It might be better to conduct one good study through research utilization stages than to conduct two good studies with completion reports or published papers on the shelf. This is not a very attractive alternative in view of the backlog of needed research, but it may be prudent in an era of fiscal restraint and limited funds.

A very important component of an information dissemination program is the full utilization of WRSIC. This will never develop its full potential, however, unless some special effort is made to increase awareness of value gained and means of access to the system. At present it is a hidden resource. One daily encounters federal officials -- to say nothing of state and local interests -- who don't even know WRSIC exists. Increased attention to information dissemination and transfer needs and services is essential to an effective national water resources research program.

SUMMARY AND CONCLUSIONS

Water resources research planning and coordination on the national scale started with the COWRR "Ten-Year Program" in 1966. Neither function has progressed significantly during the intervening years, and there is little evidence that requisite planning and coordination between federal programs can be accomplished within the COWRR framework. The multitude of agencies and their competing interests contribute to the problem.

The makeup of COWRR would seem to preclude the serious consideration of ideas perceived by Committee members as unfavorable to their respective agencies' relative stature in the field. Agreement among members as to a national program does not necessarily mean planning in the national interest. It may simply represent a compromise of competing interests. Some means must be devised for input from non-agency research interests and user groups, including the university community.

National Water Commission recommendations for a closer tie between researchers and decision makers emphasize the importance of a more rapid advance in this area.

The Water Resources Council should direct that water resources planning studies include an assessment of research needed to support planning objectives. Planning documents should speak to research needs and planning officials should recognize their responsibility to work with researchers in the development of cooperative programs.

COWRR should provide for interaction with and input from the Water Resources Council. At present, it appears too isolated from the user end of the water resources research planning-management spectrum.

Recommendations with respect to the bringing together of a number of federal water research programs into a new Office of Water Technology should be reexamined in view of Interior's establishment of an Office of Water Research and Technology.

The steps being taken by OWRR toward improved research classification; state, regional, and federal research planning; and a more rigorous analysis of water problems and research needs are hopeful signs of improved water research management and deserve the cooperation of all concerned. The effort should remain flexible and adaptive to assure the generation and flow of the creative thinking needed to solve the present and emerging problems. The ultimate success of systemized water research planning of this type depends on all of the affected agencies, not just OWRR.

The resources devoted to the dissemination and utilization of research findings are totally inadequate. A serious effort should be made to establish the Water Resources Scientific Information Center (WRSIC) as the major national center for water resources information in accordance with the General Accounting Office recommendation. This should include more than a computer system and set of published abstracts. It needs the publicity, staff and communication capability to make it an effective national system. The Office of Water Resources Research is encouraged to vigorously publicize the services of WRSIC and establish a senior staff position for a person highly skilled in this area to provide agency leadership and establish an agency program pursuant to the 1971 amendments to the Water Resources Research Act.

The level of federal spending has not responded to the earlier assessment of research needs, has not increased in real value, and has fallen steadily with respect to investment in water resource development. The significance of this trend should be fully assessed as to its effects on national needs.

The accuracy of data on federal spending for water resources research is open to question, and steps should be taken to establish improved reporting criteria to assure consistency and reliability.

Allocation of research spending by federal agencies with respect to FCST categories deserves to be thoroughly reexamined to determine whether more efficient use can be made of limited research funds.

The universities are faced with a triple-edged blade with respect to federal water resources research funding:

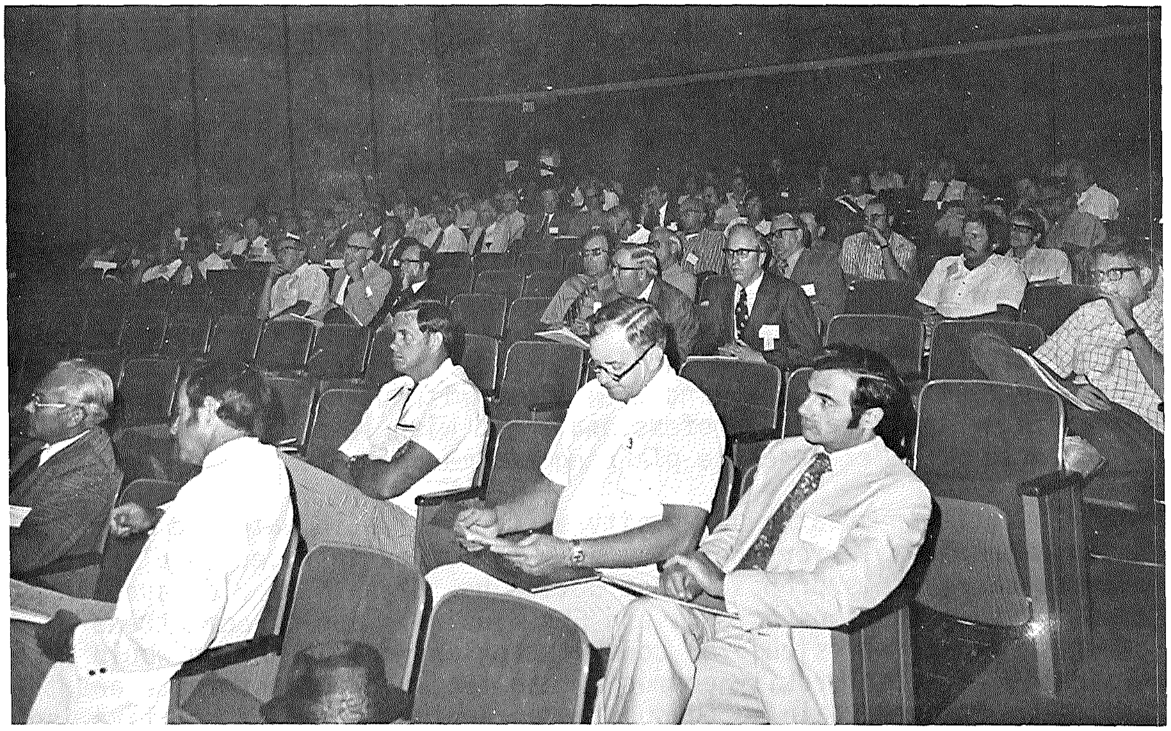
(1) appropriation levels are demonstrably below the levels required to meet national needs;

(2) the proportion of appropriated funds available to the universities is being steadily and seriously eroded; and

(3) the phasing out of training grants transfers the full burden of student support to an inadequate and deteriorating research base.

UCOWR must broaden and intensify its efforts on behalf of university participation in water resources research to include all federal agencies having significant programs in this area. There must be a more favorable balance between in-house and extramural research with greater opportunity for university participation in the latter. If the tempo is not stepped up, the universities may soon find themselves without sufficient funds and research to train needed professionals and with lessening influence on the course of water resource planning and management.

Implicit in greater university participation in water resources research is an expanded role for the university community in research planning. As a first step, it is proposed that action be taken to provide such input into the deliberations of OWRT and EPA. Joint planning committees or other suitable provisions for consultation and collaboration would appear desirable. The university community has too much to contribute and the nation too much to gain to pursue the present practice of relative isolation from the research planning process any longer.



General Session

REGIONAL WORKSHOP

I - NORTH ATLANTIC

ENERGY PRODUCTION AND WATER SUPPLY IN THE NORTHEAST

by

William Whipple, Jr.
Rutgers - The State University

The Northeastern part of the United States is normally considered relatively well off in water supply as compared to the arid West. This is true as long as we talk of runoff per square mile. However, when one calculates runoff on a per capita basis, the North Atlantic is the most water-short region of the country. We have predominantly high populations and attendant large industrial areas. Whereas rainfall is sufficient to limit requirements for irrigation, our problems of maintining water quality in our rivers are extremely acute. We need to maintain pure water in our watersheds, but equally important, and much less well understood, is the need of maintaining a clean environment for the living and recreation of our vast and growing populations, while at the same time providing for the great industrial growth of the future. Overall, water is already short in the Northeast, and it will become increasingly so.

The best way to visualize the overall water resources situation in this region is to turn to the framework plan of the federal agencies called the North Atlantic Regional Water Resources Study.[1] This is referred to as the NAR plan. This 1972 study estimated that the need for publicly supplied water would approximately double by the year 2000, from 5500 mgd to 10,700 mgd,[2] but the need for the industrial self-supplied water would increase more than three times, from 3,800 to 12,700 mgd. The lower reaches of the principal rivers and estuaries of the region, such as the Potomac, Delaware and Hudson, constitute nationally-known pollution problem areas. Most of the smaller rivers in metropolitan areas, such as the Merrimack, the Passaic, and the Raritan, are similarly low in quality. The NAR study[3] indicated that gross pollution from industrial sources will increase 4½ times by the year 2000. Although state, regional and federal pollution control authorities have enacted ambitious water quality objectives and active enforcement plans, the quality of the rivers obstinately remains low. This is due partly to certain technical imperfections in the usual methods of analysis, but more importantly by reason of failure to consider in the analysis pollution from

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[1] "North Atlantic Regional Water Resources Study." An interagency report. North Atlantic Division, Corps of Engineers, February 1972.

[2] Table 43, main NAR report.

[3] Table 45, main NAR report.

urban runoff and other unrecorded pollution. It is gradually being recognized that these unrecorded sources often contribute more pollution loadings than do the effluents. However, previous forecasts of improving water quality did not consider these aspects and accordingly were optimistic. The improvement of our metropolitan area water quality is a much more complex and difficult task than was previously thought; and the ability of the Northeast to achieve the mandated water quality standards at any date or even to protect its existing water supplies remains to be demonstrated.

It is against this water resource background that the energy problems of the Northeast must be evaluated.

ELECTRIC POWER REQUIREMENTS

The projections as to future electrical demand in the Northeast are very large. This region demands and uses about 20 percent of the national electric load, and is expected to continue to do so.[4] Energy demand in 1968 was 243,000 gigawatt hours, by 1980 it was projected to be 2.7 times as great, and by the year 2020, 20 times as great,[5] with an installed capacity of 116 million kilowatts already by 1980. This is equal to one-third of the installed capacity for the entire United States in 1970.

Such estimates are made by methods which are essentially extrapolations of existing trends in population, industrial growth, and consumers' use of electrical energy. They do not take into full account the possibility of economic and physical factors, which might make such projections unrealistic, since the "feed-back" part of the NAR plan was never completed. Moreover, national population rates have now turned downwards. Perhaps even more important, these projections were made prior to the national recognition of the energy crisis; and the much higher costs for petroleum products will obviously have some corresponding effect in reducing effective demand.

The Ford Foundation's Energy Policy Project[6] has suggested some national scenarios widely differing from the usual assumption of continuation of historical trends in electric load growth. Under one, the use of energy in the U.S. would increase at only half the historic rate. Under another, designated "zero energy growth", the use of energy would grow only slightly, leveling off by the year 2000. This scenario assumes widespread concern with social and economic costs of energy growth, adoption of an "enough is best" ethic, and a major change to the manufacture of more durable items. Although such profound changes in the American way of life are of course conceivable, there are no presently discernible signs that the United States is actually moving significantly in this direction, even under the pressures created by the energy shortage. Even such obvious proposals as additional

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[4]"North Atlantic Regional Water Resources Study," An interagency report, North Atlantic Division, Corps of Engineers, February 1972.

[5]NAR main report, p. 87.

[6]Science, 18:142, April 12, 1974.

taxes for large gas-wasting automobiles seem to have little solid public or political support. Certainly, it appears to be more prudent to assume that our national energy demands will continue to grow, although probably at a somewhat reduced rate than previously.

In light of the above, the conditons which the NAR study forecasts as existing as of the year 2000 may not actually come about until some time later, since various constraints and limitations are likely to affect the outcome.

POWER PLANT COOLING AND ENVIORNMENTAL IMPACTS

The estimated demands for power plant cooling in the NAR study are very great, as indicated in Table 1.[7]

This table was prepared before the onset of the "energy crisis"; but planners could already visualize major changes ahead. It will be noted that the withdrawals of fresh water for cooling are expected only to double, whereas saline water withdrawals would increase five times. Moreover, it is notable that consumption of fresh water in cooling would increase almost 10 times in the same time to a total of 1180 cfs. consumed.

The explanation of these figures comes when one more closely considers particular areas. In 1971, in response to a request from the Delaware River Basin Commission, the electric utilities active in the Delaware River Basin submitted a report summarizing the combined projection of their plans for increased generation facilities in the basin.[8,9] This included a total of almost 60 million kilowatts of additional capacity. The new electric generation capacity would be provided by six new conventional plants, 10 expanded plants, and 11 new nuclear plants. It was apparent that such an enormous increase could not be accommodated by once-through cooling on the Delaware River. The utilities estimated that if cooling towers were used for this additional capacity, the water consumed in evaporation would average 540 cfs. This would be a very large additional requirement, for which no provision has been made in basin planning.

Subsequent review indicated that this total generating capacity was considerably larger than will be necessary in the Delaware Basin within the time horizon indicated. However, this reevaluation does not eliminate the problem; it only postpones the date of major impact.

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[7]Main NAR report, Table 45.

[8]Delaware River Basin Electric Utilities Group, "Master Siting Study: Major Electric Generating Projects, Delaware River Basin, 1972-86," Report to Delaware River Basin Commission, Trenton, New Jersey, December 1971.

[9]Nebraska Water Resources Research Institute, "The Role of Water in the Energy Crisis," Proceedings of a Conference, October 1973.

Table 1

POWER PLANT COOLING REQUIREMENT

		Present	2000
Withdrawal	Saline	23	128
(1000 cfs)	Brackish	12	42
	Fresh	10	21
Consumption	Brackish	120	430
(cfs)	Fresh	120	1180

Studies elsewhere show that once-through cooling projected for the upper Ohio and Allegheny Rivers would exceed their thermal limits by 1990.[10,11] Studies of a proposed nuclear power plant on Cayuga Lake showed probable adverse environmental effects unless cooling towers were used.[12,13] In general, within the limits of temperature prescribed, the relatively small rivers of the Northeast are incapable of handling by once-through cooling the projected increases of electric energy generation.

The substitution of cooling towers in such cases will avoid undue heating of rivers; and this is being required as a result of environmental impact analysis in many cases. Nuclear power plants on the Susquehanna and Ohio Rivers are being required to have cooling towers.[14,15,16] On the other hand some approvals for once-through cooling have still been recommended on the Susquehanna and Delaware Rivers, where local conditions were favorable.[17,18]

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[10]"Dynamic Cooling," Technology Review, 73 (7):54-55, May 1971.

[11]Peterson, E.D. and Jaske, R.T., "Potential Thermal Effects of an Expanding Power Industry: Ohio River Basin I," AEC Research and Development Report, BNWL-1299, UC-70, February 1970.

[12]"Research on the Physical Aspects of Thermal Pollution," Environmental Protection Agency Water Pollution Control Research Series, February 1971.

[13]Eipper, A.W., Arnold, D.E., and Bell, W.T., "Cornell Scientists See Thermal Pollution of Cayuga Lake by Planned Nuclear Power Plant," The Conservationist, 23:2-5+, August-September 1968.

[14]"Final Environmental Statement Related to Operation of Three Mile Island Nuclear Station Units 1 and 2," Directorate of Licensing (AEC), Washington, D.C., Dockets 50289-80 and 50320-38, December 1972.

[15]"Final Environmental Statement Related to the Construction of Susquehanna Steam Electric Sation Units 1 and 2," Directorate of Licensing (AEC), Washington, D.C., Docket 50387-40, June 1973.

[16]"Final Environmental Statement Related to the Beaver Valley Power Station, Unit 1," Directorate of Licensing (AEC), Washington, D.C., Docket 50334-80, July 1973.

[17]"Final Environmental Statement Related to Operation of Peach Bottom Atomic Power Station Units 2 and 3," Directorate of Licensing (AEC), Washington, D.C., Dockets 50277-83 and 50278-77, April 1973.

[18]"Final Environmental Statement Related to Operation of Salem Nuclear Generating Station Units 1 and 2," Directorate of Licensing (AEC), Washington, D.C., Dockets 50272-57 and 50311-57, April 1973.

A 1970 study by the General Electric Company[19] indicated that the next twenty years of growth in steam-electric power generation in New York state could be accommodated without cooling ponds or cooling towers within existing state criteria for thermal discharges. However, this forecast seems unduly optimistic in the light of subsequent developments.

Once-through cooling has been approved for saline waters in appropriate conditions; and suggestions have been made that the larger concentrations of generating facilities may have to be installed at sea. Following up this idea, a large nuclear generating facility has been proposed to be installed behind an artificial breakwater off the coast of New Jersey. However, marine scientists are apprehensive about possible environmental effects; and it is by no means clear that this alternative can be developed in the near future, even though prospects appear favorable in the long run.

ENVIRONMENTAL DISADVANTAGES OF THERMAL DISCHARGES

Despite the very clear and sharply defined regulations as to thermal additions, the evidence of environmental damage due to such conditions is not scientifically adequate. Studies of discharge from a nuclear power plant on the Connecticut River ("Conn. Yankee") indicated that no drastic changes in the bacterial communities occurred because of the increased temperature.[20] Local effects, however, are often marked. Passage of cooling water through condensers may kill diatoms during most of the year, yet accentuate growth of diatoms during certain conditions.[21] Other studies indicate limited damage to fishery resources in discharge canals and mixing zones only.[22]

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[19] Brown, D.H., "Trends of Power Generation and Thermal Discharges in New York State," Proceedings of Conference on the Beneficial Uses of Thermal Discharges, Albany, New York, September 17-18, 1970, pp. 8-18.

[20] Buck, J.D., and Rankin, J.S., "Thermal Effects on the Connecticut River: Bacteriology," Journal Water Pollution Control Federation, 44(1):47-64, January 1972.

[21] Hatfield, H.F., Pfeiffer, M.G., and Wurtz, C. B., "The Effect of the Brunner Island Steam Electric Station's Condenser Discharge Water on the Aquatic Life in the Susquehanna River," American Society of Mechanical Engineers, Publication No. 66-WA/PWR-10, 1966.

[22] Foster, R.F., Jaske, R.T., and Templeton, W.L., "The Biological Cost of Discharging Heat to Rivers," International Conference on Peaceful Uses of Atomic Energy, Geneva, Switzerland, September 6-16, 1971. (Available from UNIPUB, Inc., P.O. Box 433, New York, New York 10016. 1971 Geneva Conference Paper, Nuclear USA, Volume 2, A/Conf-49/p-086, p. 3.3-19-28.)

A study was made of young fish entrained in the intakes of the Connecticut Yankee nuclear power plant and passed through the condenser. Most of the young fish were killed; but 80 percent of the mortality was attributed to mechanical damage during pumping and only 20 percent to heat shock and exposure to heat. About 4 percent of the fish passing by the power plant were entrained in the inlet.[23] The design of intakes to prevent ingress of fish has been much improved although the more elaborate devices are costly.

A study of Massachussetts Water Resources Commission[24] recommended a preliminary hydrothermal and ecological study of the receiving water be made prior to giving consideration to any power plant expansion or new site. The Commission said that usually a physical hydraulic model will be required to predict the dispersing pattern of the heated water under various conditions. Physical hydraulic models of large water bodies are extremely expensive and time consuming; and such a requirement makes it much more difficult and expensive to evaluate alternative sites. The questions arises whether it would not be better for some public agency to take responsibility for such studies.

Charles Luce[25] has summarized the dilemma in which power companies find themselves, due to difficulty in obtaining approval to provide the new generating capacity required to meet the demands of the public. In highly developed areas, there are environmental objections to every addition to plant capacity which can be devised. The evaluation of such objections takes a great deal of time, with a strong probability in each case that the final answer will be negative.

Although initially the effect of these adverse decisions falls upon the power companies, in the long run, the problem is one for the public, which needs the power. As Luce puts it, society is faced with the dilemma of incompatibility between two social goals: protection of the environment and the production of electricity.

THE PETROLEUM INDUSTRY AND WATER RESOURCES

The petroleum needs of the Northeast have always been serviced by one of the largest complexes of petroleum refineries in the world. When the Suez Canal closing turned the world transport fleet decisively towards

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[23]Marcy, B.C., Jr., "Vulnerability and Survival of Young Connecticut River Fish Entrained at a Nuclear Power Plant," Journal of the Fisheries Research Board of Canada, 30(8):1195-1203, August 1973.

[24]Elwood, J.R., "Thermal Pollution Control in Massachusetts Coastal Waters," Journal New England Water Pollution Control Association, 6(1):18-30, June 1972.

[25]Luce, C.F., "Power for Tomorrow: The Siting Dilemma," Environmental Law, 1(1):60-71, Spring 1970.

supertankers for economic bulk transport, the question of a deep water port for the East Coast came to the fore. When the energy crisis threatened to curtail supplies of natural gas and domestic gasoline, the deep water port question became acute. The problem may be illustrated by the situation in the Delaware Estuary.

The Delaware Estuary constitutes one of the major oil refining areas in the Eastern United States. Seven oil companies operate refineries whose combined daily output is about 900,000 barrels. Several of the companies currently anticipate major expansions; and if a deep water port in or near Delaware Bay were to be approved, still further capacity increases would undoubtedly be desired by the companies. The seven refineries and their locations are indicated in the map, Figure 1.

Considerable water pollution in the form of petroleum residuals is contributed to the Delaware River by these refineries. Oil impacted marshes and benthal desposits heavy with petroleum derivatives provide evidence to this effect. These conditions are intolerable and should not be allowed to continue. However, the fault does not lie solely with the companies; several consecutive changes in governmental policy between the agencies concerned have delayed the adoption of definitive plans for treatment.

All of the refineries are above the Chesapeake and Delaware Canal; and all but one are in the upper estuary. Records of oil slicks[26,27] indicate that the largest number of sizeable spills and leakages occur in this same section of the river. The refineries and associated oil deliveries to them probably produced most of the spills which have been observed; but extensive petroleum product distribution facilities and much heavy industry exist in this same reach of river, and, no doubt, their activities account for some of the slicks.

The proposal for a deep water port somewhere on the Eastern Seaboard, with a probability that the site may be near the mouth of the Delaware Bay, has tremendous implications for the future economy and social development of the region.[28,29] The main need for the port, of course, is to accommodate the supertankers which increasingly carry the greater part of the world's petroleum. A vastly increased importation of foreign crude oil appears to be inevitable, even if major measures are taken to curtail unnecessary usage.

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[26]"The Coastal Zone of Delaware," Governor's Task Force on Marine and Coastal Affairs, College of Marine Studies, University of Delaware, 1971.

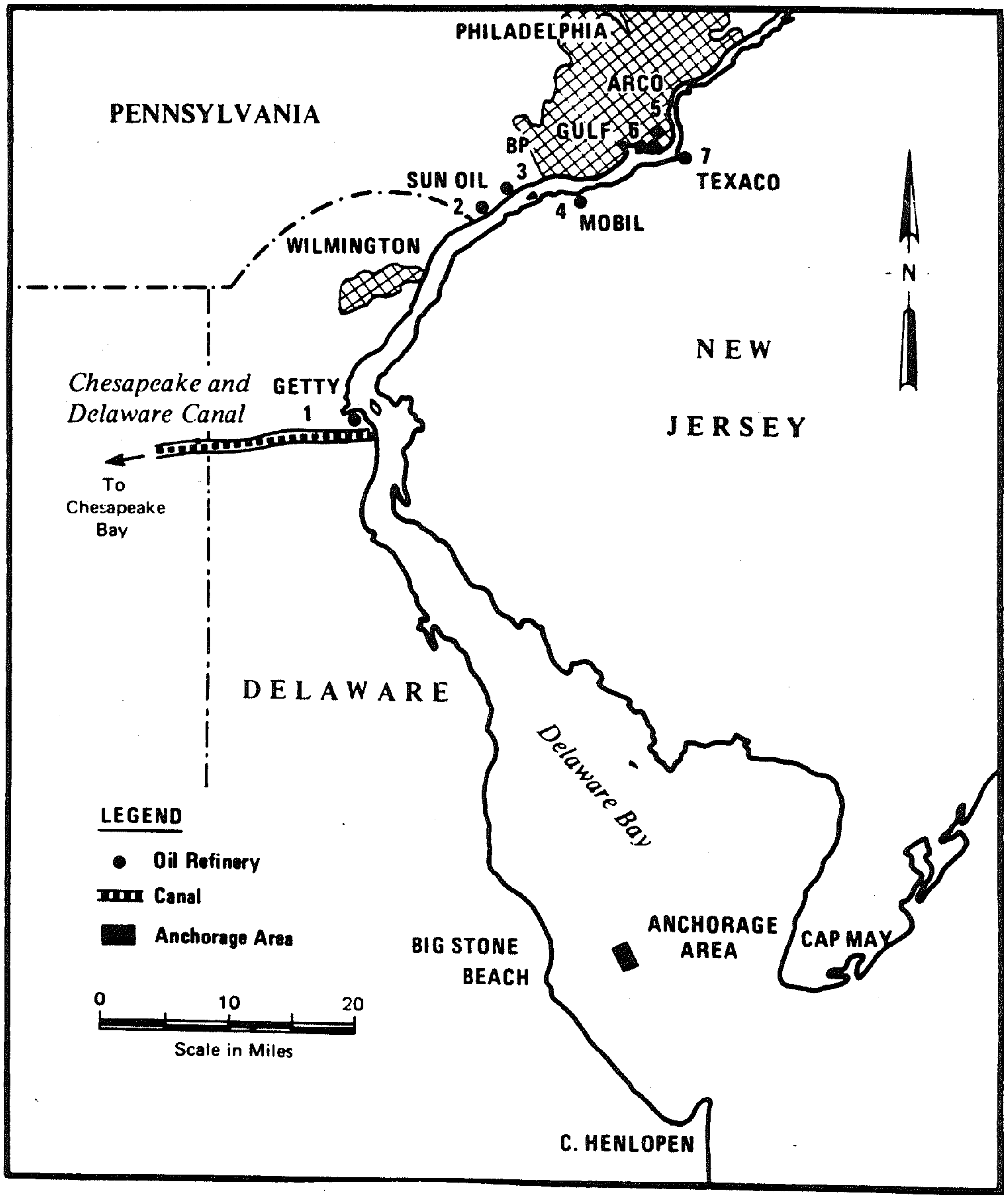
[27]"Energy, Oil, and the State of Delaware," Delaware Bay Oil Transport Committee, University of Delaware, College of Marine Studies, 1973.

[28]"The Coastal Zone of Delaware," Governor's Task Force on Marine and Coastal Affairs, College of Marine Studies, University of Delaware, 1971.

[29]"Energy, Oil, and the State of Delaware," Delaware Bay Oil Transport Committee, University of Delaware, College of Marine Studies, 1973.

FIGURE 1

LOCATION MAP
DELAWARE VALLEY REFINERIES AND LOWER BAY LIGHTERING AREA



From "Energy, Oil, and the State of Delaware," Delaware Bay Oil Transport Committee, State of Delaware

A natural deep water port at the mouth of Delaware Bay but inside the capes is now being used for tankers of about 60 feet in draft, with lighterage to reduce the draft by partial unloading before proceeding up the 40 foot channel to the refineries. (Figure 1) A proposal by the oil companies to deepen this anchorage and add permanent unloading facilities was blocked, at least temporarily, by environmental objections. Wherever such a deep water terminal is located, oil to serve a large region will be brought in, and there will almost inevitably spring up large refineries and perhaps petrochemical plants.[30] Since refinery wastes, polluted runoff, and air pollution are generally characteristic of such developments, there is a strong environmental objection to their location in any area proposed; and, for example, the State of Delaware now has a statutory prohibition of additional refineries within the state. However, the economic incentives are very great, and some local governmental subdivisions are more than willing to accept refineries. Federal, state and regional levels of government are involved, and considerable controversy has been generated.

Possible alternative sites for a deep water port are located off the coasts of New Jersey and Delaware. However, suggestions for such ports have raised cries of alarm by marine biologists and even more loudly by representatives of the entertainment and tourist facilities along the fine beaches of these coasts.

The possibility of oil spills from the proposed deep water port either in the estuary or off shore is a matter of great concern. However, large tankers of over 100,000 tons capacity are already using the bay, through the lighterage operation described above. Although there is undoubtedly some risk, there has never been a major spill from these operations. Presumably a future deep water port would be designed so as to minimize the risk of spills of any magnitude. However, there are many design and management problems associated with the proposal; and the environmental impacts if there should be a major spill from a supertanker, either offshore or in the estuary, would no doubt be extremely serious.

A committee appointed by the Governor of Delaware made a two volume report in 1973[31] in which various deep water port alternatives were explored both from an economic and environmental viewpoint. Although cautiously worded and oriented narrowly towards the interests of the State of Delaware, the report indicates that certain types of offshore ports, based upon artificial islands, are considered environmentally tolerable, at least. In view of the results of previous extensive analyses, it is not believed that one should accept the view that offshore unloading of any type is absolutely unacceptable. In view of the national economic interests involved, and the increasing tension of the energy crisis, it would be appropriate that the

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[30] "Deep Water Ports: Issue Mixes Supertankers, Land Policy," Science, August 31, 1973, p. 825.

[31] "Energy, Oil, and the State of Delaware," Delaware Bay Oil Transport Committee, University of Delaware, College of Marine Studies, 1973.

federal government should press for a solution to the problem. However, the problem is a thorny one, which, like so many other such problems, appears likely to drag on for some time. Federal and state agencies seem better organized to take negative action to protect particular public interests, with the effect of delay, than to obtain a basic decision, either pro or con, in matters where many iterests are involved.

OTHER FUELS -- COAL

Although our coal reserves are immense, coal now supplies only 17 percent of our national energy needs. We export $1 billion worth of coal annually, but domestic use is not increasing. According to Osborn,[32] the first major step in solving our domestic energy crisis is to substitute coal for the oil and gas now being used in electric generating plants.

The U.S. now uses coal for 55 percent of the electric power generated from fossil fuels. To replace the other 45 percent would require 288 million tons of coal annually, in addition to 350 million tons now used by the electric utilities. This coal would replace 1.2 million barrels of oil daily. This would reduce current oil imports by 20 percent.[33]

Moreover, our utilities currently plan additions to plant capacity, exclusive of nuclear power, amounting to 134 million kilowatts during the next five years, of which half is planned for oil and gas. This increase would require another 1.2 million barrels of oil daily to be imported.

Historically, our relatively low usage of coal has stemmed from the low cost and the convenience of gas and oil, as well as certain recurrent difficulties on account of labor problems. At the present time, a major obstacle is the amount of sulfur in most of the coal available to the Northeast. Progress is being made in the technology of removing sulfur from the coal and removing sulfur dioxide from stack gases; but the increasingly strict air pollution standards make this a continuing major problem area.

An even more basic problem is the cost of transporting coal. The coal reserves conveniently accessible to the Northeastern United States are limited. Environmental problems related to coal mining are also severe. The rehabilitation of the countryside ravaged by strip mining has caused great difficulty; and acid mine drainage adversely affects many streams and rivers, particularly in Pennsylvania. There are, of course, very large reserves of coal in other parts of the United States; but the cost of long distance transport is a problem. Perhaps by using special combinations of means, the unit cost of transport could be reduced. For example, there are very large coal fields in eastern and central Oklahoma, which are accessible to the Arkansas River, which was recently opened for navigation. There are

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[32]Osborn, E.F., "Coal and the Present Energy Situation," Science, 183:497, February 8, 1974.

[33]Ibid.

many other coal fields in central United States. It would be feasible to barge coal in quantity up the Ohio River to the vicinity of Pittsburgh, generate electricity there, and transmit the current by new types of high voltage lines as far as the Atlantic Seaboard. However, besides the questions of capacity of navigation systems, the problem of adequate cooling water would have to be faced. The increased use of coal as an energy base will inevitably impact upon our water problems in several different ways.

OTHER POSSIBILITES AND SUGGESTIONS

There are still substantial opportunities for hydroelectric power production in the Northeast, but existing constraints make this resource more apparent than real. The largest unexploited hydroelectric power resources are in Maine, remote from the major load centers, and in New York, which has extermely strong political resistance to building dams in its mountainous regions. Other possibilities for hydropower production exist, such as the Tocks Island project on the Delaware River; but this project became so involved in environmental objections that it may have to wait another decade until existing feelings have subsided, or, as some think, it may never be built. In any event, its power production would not be very great. More important possibilities exist for additional pumped storage power, which could provide valuable peaking capability as well as a reserve in the event of threatened blackouts. However, these projects also may become involved in prolonged controversy. The embattled Storm King project of the Consolidated Edison Company on the Hudson River would have very great economic and operational advantages; but environmental controversies have been so great that it cannot get underway. In sum, hydroelectric power cannot be counted on except for a small and decreasing fraction of the region's power needs.

Dr. Viessman and Mrs. Stork[34] point out the long range potentialities of solar and geothermal energy, neither one of which, however, is a particularly good prospect for the Northeast. Obviously, we must also consider opportunities for major savings in energy use. Besides the automobile, which is probably our most important example of unnecessary energy waste, Viessman and Stork consider the use of energy in municipal and industrial water supply to be excessive.

The most interesting suggestions by these authors relate to institutional aspects. They suggest that energy might be considered as the third objective of our national water resources planning, along with economic efficiency and environmental quality as specified in the procedures of the National Water Resources Council. Also, there might be a national requirement for Energy Impact Statements. Perhaps we have not reached the point where such approaches are politically feasible. However, there seems to be no doubt that we should be taking our national energy situation a great deal more seriously than we are.

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[34]Viessman, Warren, Jr., and Stork, K.E., "Water and the Energy Crisis," Water Resources Bulletin, 10(2):221, April 1974.

Also, there is no doubt that in the Northeast, as elsewhere, programs to deal with the production of adequate energy are closely related to the region's water problems. One of the most obvious and basic difficulties is the lack of any governmental machinery to assure decision making on controversial issues involving energy, water resources, and the environment. The importance of these matters warrants more attention. If any one agency in the Executive Branch had a positive mandate to accelerate the decision processes, these matters would not be left to drag on year after year. The economic costs of inaction can be very great, since when a proposal is held up, without a decision, the alternatives cannot be pursued. Our institutional analysts might well give attention to this problem.

CONSERVATION AND MANAGEMENT OF ENERGY, ENVIRONMENT AND WATER

by

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The more I become involved with the subject of energy, the more complicated it seems to become. Each step in our society's development, lately, seems to usher in broader and broader academic concerns -- such as environment, materials, energy and protein -- and each time another of these fields comes along, it seems to generate more academic confusion than the last.

In a recent issue of Man-Environment Systems,[1] Mr. John B. Calhoun presents a stimulating thesis on the evolution of consciousness and the emergence of prosthetic-synergistic brain, which will increase our conceptual space and help us relate better to our environment -- all of which is to say that perhaps my biological development just has not matured sufficiently for me to understand what is going on.

Mr. Calhoun also indicates that the main function of this newly emerging brain is to develop qualities of compassion and empathy, and I certainly can understand why. We need people with these qualities if we are going to discuss such topics as "Conservation and Management of Energy, Environment and Water."

OBJECTIVES

The scope of my paper is two-fold:

(1) to encourage analysis of the energy-environment-water question from a resource flow point of view; and

(2) to encourage consideration of alternative criteria for evaluating management programs and policies.

Two diagrams (Figures 1 and 2) are presented to help define some of the resource flows that will be considered.[2]

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[1]Calhoun, John B., "Environmental Design Research and Monitoring from an Evolutionary Perspective," Man-Environment Systems, Vol. 4, No. 1. January 1974, p. 3-30.

[2]These figures were developed from a diagram presented by Talbot Page, "Economics of Recycling," Resource Conservation Recovery and Solid Waste Disposal, Comm. Print. 93rd Congress, 1st Session, November 1973, Serial No. 93-12, p. 10.

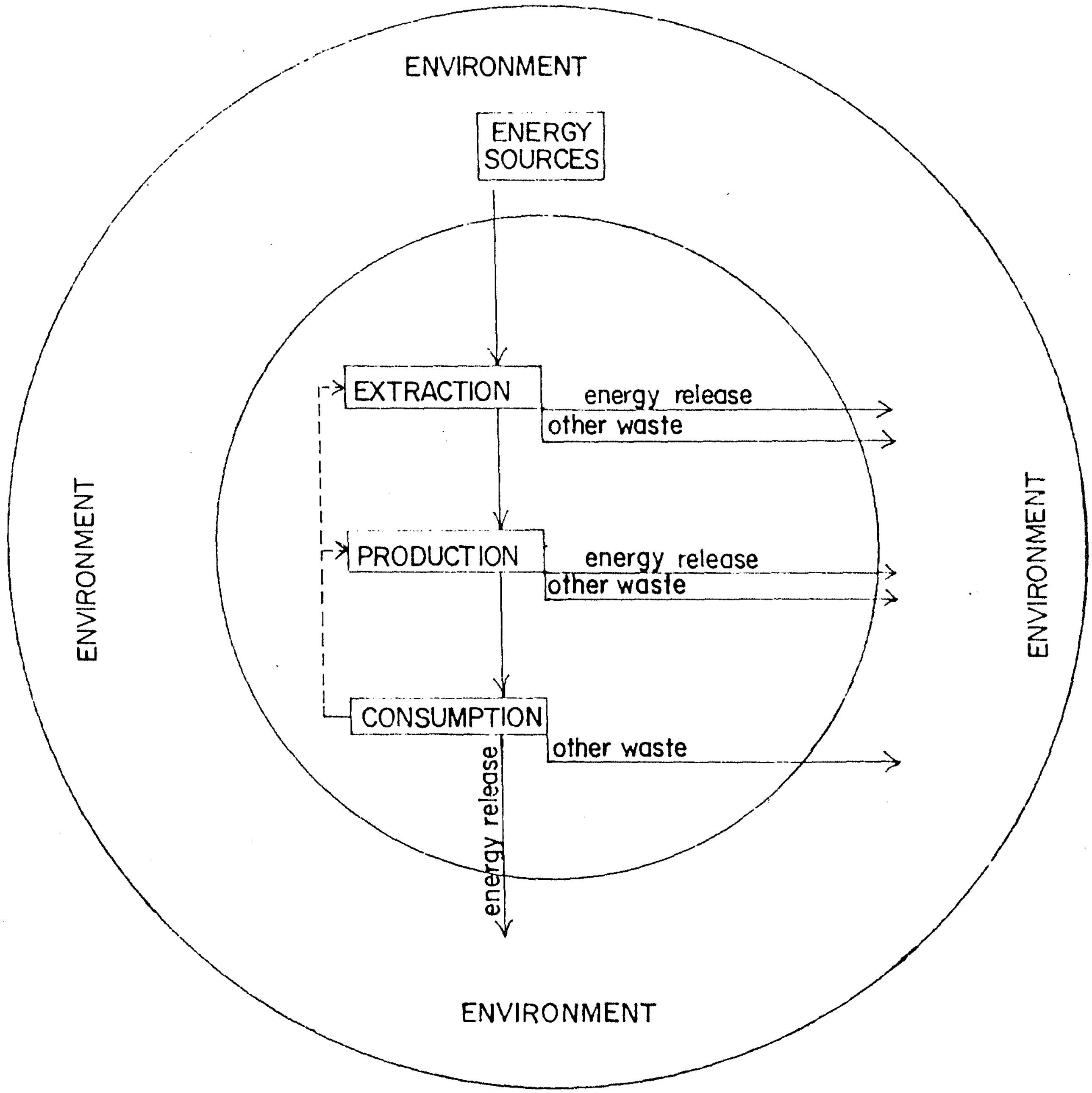

Figure 1 - DIAGRAM OF ENERGY FLOWS

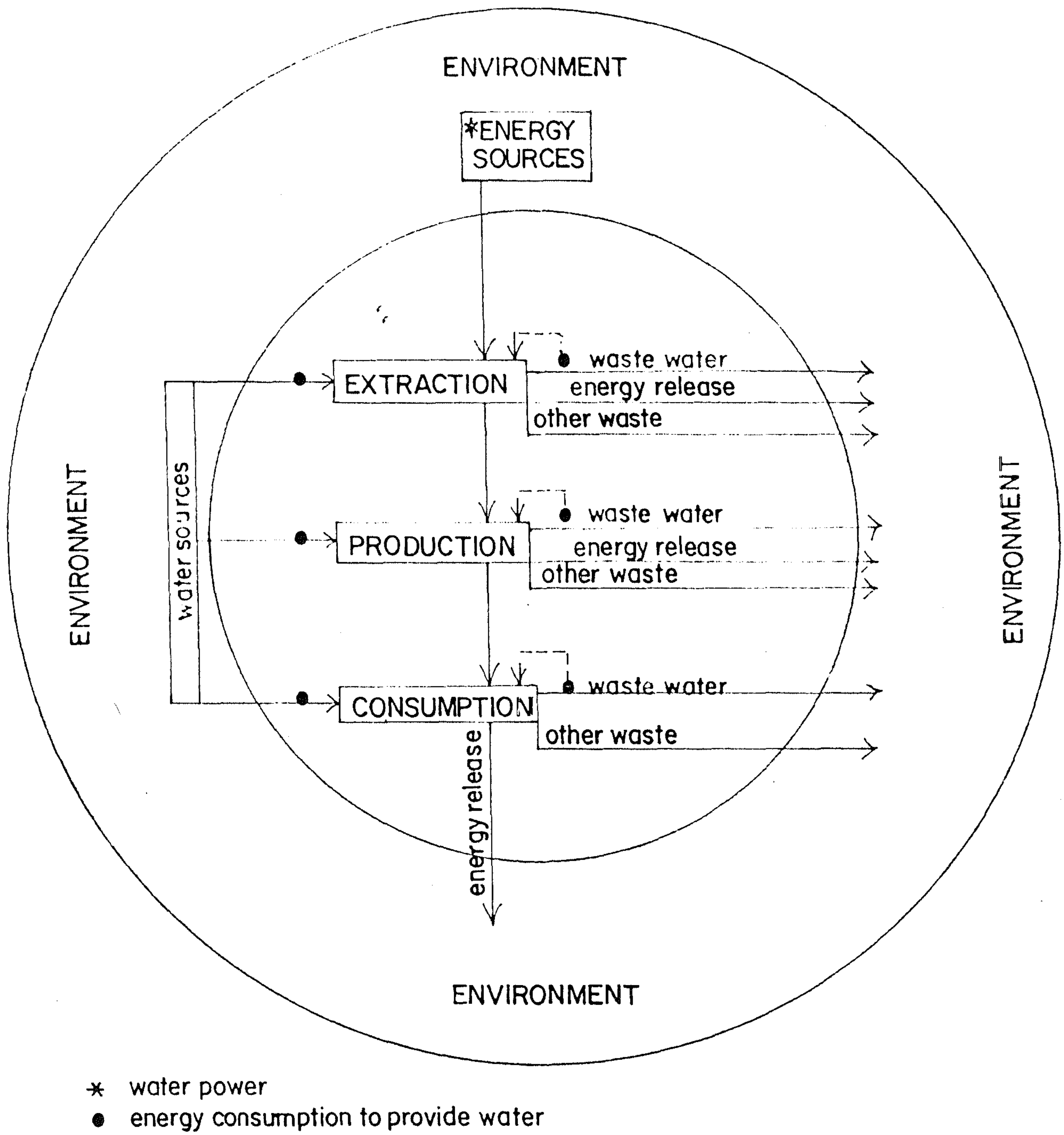

Figure 2 - DIGRAM OF WATER AND ENERGY FLOWS

WATER-ENERGY FLOWS

Energy sources in the form of fossil fuels are receiving much of the public's attention today, but there are many other natural endowments with an energy generation potential. These include radioactive isotopes and other non-renewable stock sources; renewable stocks such as food plants, animals and timber; and such flow sources as solar radiation, gravitation in the form of waterfalls, flowing rivers and tides, winds, geothermal pressure and heat, absorption and the earth's magnetic field. Care must be taken not to exclude any of these sources from management considerations. Depending on the selection criteria employed, different combinations may be called upon for good reason to produce future energy supplies.

What constitutes a source of energy mainly depends on man's ingenuity or inventiveness. The "energy plantation concept" is a new plan for reactivation of the forests as a possible source of energy.[3] The liquid metal fast-breeder reactor is a development which makes use of uranium.[4] And, as you are aware, it appears that some of the waste materials generated by society today can be utilized to produce energy.[5] Technological development will continue to make available many new energy sources. The only absolute constraint on such progress that I can envision is diminishing returns in the field of technological development itself.[6] To facilitate policy formulation, it is essential to classify and inventory the various sources of energy and to assess their physical supply potentials.[7]

Providing energy in our society is a complicated process. Nature provides us directly with very little energy. We have to work for it by changing the form, quality or location of the various energy embodying materials about us. This is a costly undertaking, which in itself consumes a great deal of energy. Energy, in other words, grows largely by way of magnifying the applications

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[3]See: Szego, George C. and Kemp, Clinton C., "Energy Forests and Fuel Plantations," Chemtech. May, 1973.

[4]See: Novick, Sheldon, "Nuclear Breeders," Environment Vol. 16, No. 6, July-August 1974.

[5]For examples see: "Resources from Waste," Columbia Engineering Research, 510 S.W. Mudd Building, Columbia University, New York, No. 7, December 1973; and Jawahar Patel and Rasik B. Patel, "Compost Science," Journal of Waste Recycling, Vol. 12, No. 5, September-October 1971.

[6]For a position with regard to the availability of natural resources generally see: Senator Gaylor Nelson, Congressional Record, Proceeding and Debates of the 93rd Congress, 2nd Session, March 21, 1974.

[7]See: Rose, David J., "Energy Policy in the U.S.," Scientific American, Vol. 230, No. 1, January 1974, p. 22.

of energy. Think of the mining, transporation, generation of power and transmission required to deliver electricity to our homes. In short, energy is produced and released back to the environment like any other economic good.

Not only is man a producer of energy, but he is also a consumer. Consumption, we are told, does not destroy energy but returns it to the environment in a form which is much more difficult to utilize. Most generally, energy is converted from a concentrated to a more dilute form during the consumption process.

Final consumption is not the only point in the flow where a release to the environment occurs. Some energy is released at each of the steps in the extraction-production-consumption sequence. If some of this energy could be rerouted back into the mainstream, it would contribute to the usable supply. Some research already is underway to determine whether waste energy can be utilized for heating greenhouses, warming the soil and other purposes.

Next, it should be noted that water is needed at every node in the energy flow system, Figure 2. Secondary stages of oil recovery in the United States take as much as 560,000 acre feet of water per year.[8] A coal gasification plant of 250 million cubic feet per day capacity requires 10,000 to 20,000 gallons of water per minute in the gasification process, and additional water up to 100,000 gallons per minute for cooling and other process requirements.[9] A typical 1000-mw light water reactor steam electric plant operating 80 percent of the time consumes 163 million gallons annually, and another 160 million gallons are required annually by the power plants supplying electricity for the enrichment process.[10]

Energy consuming processes such as transportation and space-heating also require inputs of water, as do such common household operations as cooking and washing. If water is not available for these uses, economic development is curtailed.

On the output side of the diagram, waste water discharged from each of the nodes is a potential threat to the environment. The problem may take the form of mine drainage from the extraction of coal, thermal pollution from the production of electrical power, eutrophication of streams from the

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[8]Davis, George H. and Wood, Leonard A., "Water Demands for Expanding Energy Development," U.S. Geological Survey, Circular 703, National Center, Reston, Virginia, 1974, p. 2.

[9]Illinois Institute for Environmental Quality, "Health Effects of Coal Gasificaiton...", <u>Environmental Health Resource Center News</u>, No. 7, January 1974, p. 2.

[10]Op. cit. Davis and Wood, p. 3.

discharge of municipal effluent, etc. Laws to prohibit the discharge of these pollutants may have a significant effect on the source of supply selected and on the total quantity of energy produced.

Finally, water in itself is a natural resource from which energy can be derived. Water power is a case in point. And we must remember that without energy, we cannot make use of water in raw material processing or recycle water for environmental protection. Quoting an earlier paper by this author, "...we have an energy supply that is highly dependent on water for its development and utilization, and we have an economic supply of water that is dependent on energy for its purity and availability. Suffice it to say, the problems of one soon become the problems of the other."[11]

THE NATURE OF THE MANAGEMENT PROBLEM

Having defined a system of water-energy flows, we are ready to ask how the network should be managed to achieve accepted social objectives. It is at this point that a strong need arises for that prosthetic-synergistic brain which I mentioned earlier.

Model builders undoubtedly will direct their attentions to the water-energy-environment flow system. Hopefully, through their efforts, allocation problems will be handled in a fairly complete and systematic manner. Input-output models, materials balance models, linear programming models and the like may have application in trying to arrive at solutions, although the extensive use of such procedures is not in an advanced state of development in the management field today.[12] Approaches are disjointed; empirical data on production and consumption functions are lacking; and, most importantly, public opinion with regard to criteria for evaluating alternative solutions is divided. Nonetheless, I feel that models of the kinds mentioned very definitely hold the key to ultimate management decisions.

Recognizing that an over-all assessment of the management problem cannot be made at this time, I would like to direct the remainder of my discussion to an evaluation of four practical management guidelines. The merits of each in achieving the objectives of conservation, economic efficiency, and environmental protection are considered.

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[11]Frey, John C., "Regional Energy-Water Problems, Ohio-Great Lakes," The Role of Water in the Energy Crisis, Proceedings of a Conference, The Nebraska Water Resources Research Institute, Lincoln, Nebraska, October 23-24, 1973, p. 151.

[12]For a discussion of the Use of such models see: Orris C. Hefindahl and Allen V. Kneese, "Economic Theory of Natural Resources," Resources for the Future, Inc., Charles E. Merrill Publishing Company, Columbus, Ohio, 1974, p. 305-380.

MANAGEMENT GUIDELINES

One management guideline that has widespread acceptance is increased use of renewable energy resources in place of the non-renewable ones. In other words, this guideline calls for a shift in energy production away from coal, oil and gas and into solar radiation, wind, tides, vegetative plantations and the like.

There is considerable logic to this proposal from an energy conservation point of view. As long as nature keeps replenishing the resources that we exploit, the day of doom can be postponed indefinitely. Conservation of energy-embodying resources, which repetitiously occur at fixed rates, means utilizing these resources to the fullest. If not, the energy embodied in them is lost to man forever.

From an economic efficiency point of view, the logic of following this guideline is much more uncertain. The economic feasibility of shifting from non-renewable to renewable resources depends on marginal rates of substitution in production, as well as the ratio of the prices of the competing factor inputs. As a general rule, production costs are lowest when energy concentrations in nature are highest, thereby encouraging industry to draw heavily upon the non-renewable sources of supply. Oil depletion allowances, low prices for water and other inducements to economic development also may encourage utilization of the non-renewable stocks.

Some experts rule out development of renewable sources of energy because they believe that the output would be inadequate to meet existing demands. For example, David J. Rose says:

> "...Some of the options that have been proposed can be dismissed out of hand. For example, it is easy to calculate that if a low dike were built around the entire U.S. to harness all the tides, the resulting electric power would only satisfy the needs of a city the size of Boston. To supply the U.S. electric needs by wind power would require windmills 100 meters high spaced a few kilometers apart over the entire country. Most of the suitable hydroelectric sites are already developed (hydroelectric generators now account for 10 percent of the U.S. electric-power supply). It is clear that tides, winds, and falling water are not solutions to the nation's energy problem."[13]

From an economic efficiency point of view, Mr. Rose misses the point entirely. Economic efficiency dictates that we bring these flow resources into the production mix, if it is cost-effective to do so. The economy is in the mix; there is no rule which says that all energy must come from a single source. In many instances, however, cost-decreasing technologies have not been developed to make flow resources competitive. Mr. William L. Hughes points out, for example, that storage is a serious problem when

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[13]Op. cit. Rose p. 23.

wind is used for energy.[14] Similarly, it has been reported that swift ocean currents pose a problem in trying to harvest low-cost power from the ocean's heat.[15]

It is extremely difficult to predict what effect increased use of renewable energy resources would have on water supplies as compared to the non-renewable ones. The U.S. Geological Survey has developed data on water demands for energy production using non-renewable resources, but it does not provide comparable data for resources in the renewable class.[16] The report indicates that the largest quantities of water are needed for secondary recovery of oil, retorting and disposing of oil shale, converting coal to gas or electric power and the generation of electric power with nuclear energy.

Likewise, it is difficult to assess the impact of a shift in the energy source on water quality. It does seem, however, that use of the non-renewable stocks, such as the fossil fuels, has produced more than its share of environmental problems. Acid mine drainage from the mining of coal and thermal pollution from nuclear power plants are examples, not to mention the effects of strip-mining on the quality of the land and high-sulfur coal combustion on the quality of the atmosphere. Still we cannot say conclusively that these problems are worse than those which might occur if more renewable energy resources were utilized. Use of energy plantations for fuel conceivably could produce some very severe stream sediment problems. Increased use of other renewable energy resources could also create new environmental concerns. Clearly, there is a need for study of the effects of alternative energy sources on water quality.

A second management guideline that I would like to consider is recovery or recycling of wastes. Both liquid and solid wastes have a reuse potential for energy production. Possibilities are very well exemplified by the Modular Integrated Utility System proposed by the U.S. Department of Housing and Urban Development.[17] The recycle package processes both solid and liquid wastes and returns to the residential complex pure water and waste energy for space heating, air conditioning, water heating and water treatment.

Recycling of wastes for energy production has much appeal from a mass conservation point of view. In a sense, recycling is the conservation of a non-renewable resource into a renewable one, although -- similar to the frog

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[14]See commentary on Professor Hughes' testimony before the Subcommittee on Energy of the House Committee on Science and Aeronautics in Conservation Report, Report No. 23, June 28, 1974, p. 312.

[15]See: "Low Cost Power from the Ocean's Heat," Conservation News, Vol. 39, No. 12, June 1974, p. 4-5.

[16]Op. cit. Davis and Wood, p. 1-4.

[17]U.S. Department of Housing and Urban Development, "Modular Integrated Utility System Offers Prospect of Important Energy Savings," Research, No. 1, February 1974, p. 2-3.

jumping half the distance each time -- the process eventually "winds down." Be that as it may, recycling does hold promise of providing supplementary energy supplies.

The economic potential of resource recovery depends on the marginal rate of substitution between primary and secondary source materials in production and the ratio of the prices of the competing forms of input. It is worth mentioning, however, that mixed wastes are not always good substitutes for primary source materials.

Quoting Tabot Page: "The efficiency criterion places no value on recycling itself. Instead, it directs us to look for inefficiencies in the price system which have led to too much solid waste generation, too much extraction of primary resources and too little recycling."[18] To place secondary source materials on a competitive basis with primary materials, many external costs associated with over-use of "the commons" and pollution of the environment need to be internalized. Until this is done, industry will have little economic incentive to adopt recycling techniques.

To the extent that resource recovery means little or no release of emissions, one can claim that it provides environmental protection. Also, recycling might very well ease some of the pressure on water supplies for energy production. What still remains unknown, however, is whether it takes more water to produce energy from wastes than it does from primary source materials.

A third management guideline is to develop enough new production technology to offset the decline in renewable resource supplies. This approach encourages industry to search for new resource deposits, to develop new extraction and processing techniques and to use substitute materials in the generation of power. Locating offshore oil fields, extracting oil from shale and developing new nuclear power sources are examples.

At first glance, this approach appears to be in direct conflict with the resource conservation objective. It leans in the direction of using more instead of less. Also, it identifies very closely with the history of what the energy industry has been doing. On the other hand, it is difficult to predict what turn technological development might take. Similar to the solution of the food problem by some of the western nations when they made application of advanced agricultural technology, technological change in the energy field may someday "work us free" from scarcity problems of the past. It is possible, for example, that nuclear fusion will come to the rescue and remove the need to conserve some of our present resource supplies.[19]

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[18]Op. cit. Talbot Page, p. 20.

[19]For an explanation of nuclear power sources see: Sheldon Novick, "Nuclear Breeders," Environment, Vol. 16, No. 6, July-August 1974, p. 6-15.

Coal and oil shale deposits are reported to be so large, compared with current and prospective consumption rates, that they probably will not be exhausted for several decades.[20] This means that there still is a margin of time for a major technological "breakthrough" to occur.

From an economic point of view, industry is encouraged to substitute only enough new technology to offset the rising costs of depleted raw materials. Accordingly, one of the problems with this management approach is that the costs of depleted raw materials do not include a charge for excess use of such common ownership resources as air or water or for pollution abatement. Under these conditions, the energy industry is not encouraged to support as much technological development as is needed to direct R and D into pollution abatement programs. Data furnished by Davis and Wood indicate that several of the new technologies adopted by the energy industry have unusually large water requirements. As mentioned earlier, relatively large inputs of water are required for the retorting and disposal of spent oil shale, coal gasification and electric power generation with nuclear energy. Whether or not this constitutes a trend for new R and D programs is difficult to say. Similarly, there is reason to wonder whether this management approach will help achieve the goal of environmental protection. Nuclear production of energy, for example, produces its own emissions problem. There obviously is room for governmental intervention if this management approach is adopted.

The fourth management guideline that I would like to suggest is to bring about change in the energy consumption patterns of society. This can be accomplished by formal controls, such as energy rationing, or by informal controls, such as public advertising or education.

Hittman Associates, Inc., of Columbia, Maryland, concludes from a study that with good quality single-family housing, annual energy consumption could be reduced 40 percent by using home energy conservation practices, without in any way affecting the life style of the occupants.[21] As discussed at the Nebraska Conference on the Role of Water in the Energy Crisis, increasing pumping plant efficiency, re-using irrigation runoff and modernizing management can save substantial quantities of water and energy. Production of less energy-intensive products is another technique being advocated. The U.S. Department of Agriculture, for example, suggests the use of natural fibers in place of energy-consuming synthetics, which now account for 60 percent of the U.S. fiber market.[22] According to the U.S. Atomic Energy Commission, improved transportation efficiency could reduce projected transportation demands by about 5 percent by 1978 and 10 percent by the year 2000.[23]

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[20]Op. cit. Talbot, p. 22.

[21]Op. cit., U.S. Department of Housing and Urban Development, p. 5.

[22]U.S. Department of Agriculture, "Energy to Keep Agriculture Going," Energy Letter, December 1973, p. 7.

[23]Dixy Lee Ray, "The Nation's Energy Future," A Report to Richard M. Nixon, President of the United States, U.S. Atomic Energy Commission, December 1973, p. 83.

Increasing the spatial density of energy-consuming units is another method that has been proposed to economize in the use of energy. To my knowledge, however, studies have not been made to demonstrate the feasibility of this approach. Consolidating consumption units in order that they might utilize a common source of supply is still another recommendation. The district heating plan in Sweden, which makes use of one large heating station per community instead of one boiler per house, is an example of this management technique.[24] It would be useful to have empirical data on the amount of energy that can be saved in this manner.

Reducing energy consumption obviously has an indirect effect on the amount of energy produced. Thus, this management approach contributes to the conservation of natural resources and provides substantial protection for the environment. We don't know how lasting induced changes in consumer behavior will be, but it would seem that the demand side of the water-energy equation is deserving of much more attention than it has had in the past, if a permanent solution to the energy crisis is to be found.

An unknown associated with this management approach is the indirect effect of change in consumption patterns. Do consumers, who spend less for energy, increase their expenditures for other goods and services? And, if so, how much energy is embodied in these other goods and services? Is the net result energy-conserving? If consumers don't redirect their expenditures, what happens to the increased savings? Are these savings reinvested in energy-consuming capital? Clearly, we need some in-depth studies of the direct and indirect effects of introducing a change in the consumption patterns of the American people.

In summary, I have discussed some of the pros and cons of four different management approaches. It should be obvious from the inconclusiveness of my remarks, that what is good management and what is not depends on the objectives that society wishes to achieve. In the final analysis, what objectives society wishes to achieve is a public decision reflecting the values held by all of the people. Since there is more of the public in the audience here today than on the speakers' platform, I feel it is more appropriate for you than me to make the final management decisions. This, of course, is why you are assembled at Logan for discussions for the next couple of days.

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[24]U.S. Department of Housing and Urban Development, "Sweden District Heating," HUD International Information Series 28, May 31, 1974.

ENERGY AND THE WATER ENVIRONMENT

by

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At the outset we must recognize that the threats posed by energy generation and use to our water resources are old -- older in some respects than the most venerable individual participating in this meeting. However, we must admit that success in finding solutions to past problems has not been particularly remarkable. What should concern us now are the implications of the anticipated rapid expansion of electric power generating capacity. We should be particularly aware of the urgency of finding solutions to water quality problems before they overwhelm us.

The mood of the federal government in respect to energy and environment is reflected in its apparent willingness to relax air quality standards through permitting use of coal with high sulfur content. It is possible that those concerned with achieving the high quality of water called for by the Water Quality Act of 1972 will be unable to withstand a national determination to generate the needed electrical energy. Our major concern in water quality protection should necessarily focus on problems associated with steam power plants. Beyond this, the special, and sometimes subtle, difficulties associated with hydropower plants and pumped storage systems should not be ignored. Nor should we forget that relatively new energy generating systems may create novel and unexpected hazards.

The assumption is that the projected very rapid growth of electric generating capacity will create water quality problems not new in kind but rather unprecedented in magnitude. As shown on the following table, the Federal Power Commission estimates that electric power consumption in the Northeast will increase from 262 billion kilowatt-hours in 1970 to 915 billion kilowatt-hours in 1990.

The Commission's projections show that virtually the entire increase will be provided by nuclear plants with a small part of the increase caused by pumped storage systems. It is probable that the new interest in coal use, a consequence of the urge toward independence from foreign oil, will require some revision of the Federal Power Commission's assumption of fuel usage. Few, however, would question the estimate of total electric energy to be required.

EXISTING PROBLEMS

Since the problems we may anticipate are similar in character to those we experience today -- bearing in mind, however, that the increase in intensity

Table 1

ELECTRIC GENERATION BY TYPE OF FUEL AND HYDROPOWER, NORTHEAST REGION (Based on Survey by Fossil Fuel Resources Committee), Years 1970 - 1990[1]

	1970		1980		1990	
	Billion Kwh	%	Billion Kwh	%	Billion Kwh	%
Thermal Generation:						
Coal	157.5	60.0	141.9	27.5	101.5	11.1
Oil	43.9	16.7	30.1	5.0	23.6	2.6
Gas	15.3	5.8	15.1	2.9	12.1	1.3
Nuclear	30.7	11.6	309.3	59.8	747.1	81.7
Int. Comb.	1.3	.5	2.0	.4	3.1	.3
Total	248.6	94.7	498.4	96.4	887.5	97.0
Hydro Generation:						
Conventional	12.0	4.6	11.8	2.3	11.1	1.1
Pumped Storage	1.0	.7	18.4	1.3	16.2	1.8
Total	13.8	5.3	18.4	3.6	27.3	3.0
Total Generation:	262.4	100.0	516.8	100.0	914.7	100.0

[1]The 1970 National Power Survey, Federal Power Commission, Part II, Table 15, pg. 11-1-29.

of their impact, if uncontrolled, will probably be greater than linear -- it would be appropriate to review these problems. The list is familiar, and it is formidable.

Acid Mine Drainage

The problem is basically not technically difficult insofar as active deep mines are concerned. However, this is not the case for abandoned mines. Assignment of responsbility for controlling the harmful drainage from the latter in order that effective regulatory action may be taken appears to present extraordinary difficulty. The major deterrents are legal, institutional and economic. These were the major difficulties 60 years ago, and they remain so today.

Strip Mines

To many, the overall unsightliness of stripped areas is an unparalleled blight on the land. Restoration of such areas is possible, but it is practiced infrequently primarily for economic reasons. Institutional measures to enforce and insure land rehabilitation are usually weak and ineffective. Legislation now under consideration in Congress may correct this situation, and perhaps a degree of optimism in this regard is justified.

Oil Pollution

This represents a primary threat to coastal waters. However, severe episodes of such pollution have occurred in the Great Lakes and in major waterways. There is no need to review here the specific, serious and persistent effects produced by oil pollution. They are familiar to all. They originate in spills from oil tankers, from shore-based storage and distribution facilities, and from offshore oil drilling operations. Legislation designed to prevent such pollution is rigorous at federal and state levels. The penalties may be severe. Research to provide control procedures and devices is generally well supported. The major task is one of controlling the human factor, and preventing human failure.

Waste from Steam Power Plants

Perhaps more has been written on this subject in recent years than on any other form of waste. The stringent federal and state restrictions on maximum allowable water temperatures are testimony to public concern over this form of pollution. It is perhaps surprising, therefore, that questions asked a decade and a half ago on maximum tolerable temperatures compatible with healthy, wholesome aquatic populations still remain largely unanswered. The problem is complex, dealing as it does with the effect of elevated temperatures on the various life stages of important fishlife and on behavior, reproduction efficiency, metabolic requirements, food chain organisms and enhancement of the effects of toxic chemicals. Questions also remain on patterns and effects of heat distribution in the receiving body of water and rates of heat dissipation under various flow conditions. Means for controlling heated water discharges are available, mainly through the use of cooling towers, dry and wet, natural and mechanical draft. However, cooling towers are unsightly, mechanical systems are noisy, wet systems produce fog and ice and, through evaporation, consume 1 to 1.5 percent of the water applied. In addition, closed cycle cooling system blowdown, amounting to approximately 5 percent of recycled water, contains potentially pollutional chemicals used to control corrosion, scaling and sliming. Above all, cooling towers are expensive. Nevertheless, it appears that thermal pollution will not be tolerated despite the shortcoming of cooling systems and their high cost.

Hydroelectric Power Plants

A review of the effects of such plants on water quality and water uses in the Northeast is timely, and, in fact, has been stimulated by, and is proceeding in accordance with, the requirements of the National Environmental Policy Act. Most hydroelectric power plants in the Northeast were granted 50-year licenses in the early part of the century. These licenses are now under consideration for renewal. A review of the nature of adverse effects such plants may produce is opportune. These effects would include:

--Impeding movement of anadramous fish to their spawning areas with consequent possible destruction of valuable fisheries;

--Impairing aquatic life through manipulation of natural stream flows;

--Reducing the normal organic waste assimilation capacity of the stream through flow reduction and through release to the turbines of reservoir bottom waters which normally are low in dissolved oxygen;

--Scouring of unstable stream banks by intermittent stream flow;

--Silting behind the dam.

Remedial measures have been recommended. They include: installation of fish ladders, stabilization of stream banks and, in New England, continuous release of impounded waters equal to not less than 0.2 cubic feet per second per square mile of drainage area.[2] Such measures are applicable to existing hydroelectric power plants. Because of the opposition of conservationist groups, it is unlikely that many new hydroelectric power plants will be developed in the Northeast. However, it remains to be seen whether such opposition can withstand public support for additional dependable regional energy generating capacity. A current test is the proposal to develop a hydroelectric power plant of 830 megawatt capacity on the St. Johns River in nothern New England.

Pumped Storage Systems

The world's largest pumped storage system with 1000 megawatt generating capacity is located at Northfield, Massachusetts, on the Connecticut River within a 30-minute drive of the University of Massachusetts in Amherst. Considerable attention was directed to the potential impacts of this system on water quality and water uses because it was completed at a time of peak

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[2] Report on the Connecticut River Basin Comprehensive Water and Related Land Resources Investigation, Vol. IX, Appendix Q-11-25, June 1970.

national concern over environmental quality degradation, and further, because the plant's upper reservoir was designed to provide a supplemental source of drinking water for the metropolitan Boston area. In brief, the major elements of concern were, and remain: harmful effects of current reversal in the lower reservoir on fishlife; destruction of fish larvae and fingerlings on intake screens and in the turbines; enhancement of bank and bottom erosion as the result of the frequent rise and fall of water level; and destruction of important fish food organisms by such manipulations of water level. An additional interesting and possibly significant observation in the Northfield hydroelectric power plant is associated with the reversal of normal direction of flow that may occur at times of low Connecticut River flow when the turbines are in pumping phase. It was determined by a model study that a portion of the Millers River, a polluted stream entering the Connecticut River 1.5 miles below the plant intake, may reach the upper reservoir on Northfield Mountain at such periods.[3] Of particular relevance is the report that the Millers River contains a substance, still unidentified, that is mutagenic for a widely occuring aquatic fern.[4] The question presented is whether such substance reaching the upper reservoir would constitute a threat to those who will drink the water in metropolitan Boston.

This list of potential threats presented by energy production to the quality of the Northeast's water resources could be lengthened. For example, one might add oil refining wastewaters, coal washing wastes, drainage from coal stored on the ground surface and from coal slag piles, lead and other substances in automobile exhaust discharges that may reach metropolitan area waters in surface runoff, and chemicals captured in scrubbing devices installed in power plant smoke stacks and discharged in plant wastewaters.

It is worth reemphasizing that the foregoing challenges confront us today more sharply than in the past, and they will trouble us increasingly in the near future. While new issues will emerge and will have to be faced, we continue to hope that solutions will be found for the old problems. Perhaps this may take the form of improved technology or management devices whose application will be supported by strong regulatory institutions. We would not wish to assume that problems may be simply exorcised by redefining our water quality requirements and standards.

NEW PROBLEMS

While dealing with the old, we must, of course, consider new or rejuvenated methods of energy generation and their potential impacts, if any, on the water environment. Much interest in the Northeast has been directed to the effective utilization of solar energy, fuel cells, thermionic energy converters, windmills and thermal gradients in the ocean. In addition, some 40 years ago the New England area was excited by the prospect of generating

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[3]Northfield Mountain Pumped Storage Project - River Model Studies for Northeast Utilities Service Company - Millers River Intrusion Studies, Alden Research Laboratories, November 1968.

[4]Annual Report Fiscal Year 1974, University of Massachusetts, Water Resources Research Center, p. 48, July 1974.

energy through exploiting tidal waters as at Passamaquoddy, Maine, where the tidal range averages 18 feet. These possibilities for generating energy will probably be explored to the extent practicable. None of them, it would seem, should have any significant impact on water quality.

Generation of electrical energy by coal gasification, coal liquefaction, and magnetohydrodynamics appear feasible for the near to intermediate future. The first two processes are by no means new. They were first utilized more than half a century ago. They were displaced by the easy availability of natural gas and by abundance of oil. It is generally agreed that these processes will be prominent in the nation's future energy program.

Coal Gasification

Gasification of coal involves the heating of coal with controlled application of oxygen and steam to form carbon monoxide, hydrogen and small quantities of methane. The resulting mixture has a Btu value that varies with the nature of the process and materials used. Gasification of coal lost out and disappeared from the U.S. market place for several reasons including: the high Btu values of natural gas, essentially pure methane; the easy distribution of natural gas by pipeline; and the unsightliness of the local gas house where synthetic gas was produced. The situation appears to have changed. Unfortunately, there is little helpful experience in determining the character and quantities of wastewater resulting from gasification of coal. It has been estimated that the water required in a plant of 250,000,000 standard cubic feet of pipeline gas per day capacity can be expected to range from about 10,000 acre-feet per year to 45,000 acre-feet per year, the higher requirement being associated with poor quality water.[5] The principal differences are in the evaporative cooling requirements and depend on the extent to which air cooling is employed. The average amount of water utilized in coal gasification is indicated to be slightly greater than that used in the fossil fuel plant of similar generating capacity.[6]

It is quite clear that a substantial problem of thermal pollution may result from gasification of coal. Because plants would probably be located near points of coal production, the problem of thermal pollution would exert its impact on small rather than large streams. In addition, severe pollution could be produced by drainage from coal piles and from slag and ash.

Interest appears to be growning in gasifying coal underground. This would involve fracturing the coal seam so that a stream of air and water could flow from one point to another without excessive loss of pressure. The coal would be ignited at one end and the gaseous products of combustion would be extracted from the other. With good contact between gas and coal, the products would include carbon monoxide, hydrogen and methane. One might well assume this process would threaten groundwater supplies.

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[5]Water Demands for Expanding Energy Development, G.H. Davis and L. A. Wood, Geological Survey Circular 703, p. 11, 1974.

[6]Ibid, p. 12.

Coal Liquefaction

The process of coal liquefaction involves producing hydrogen from coal by gasification and reacting the hydrogen with the remaining coal utilizing a suitable catalyst to produce oil. The United States has no dependable experience with liquid waste from this process. Information on the amount of water required and the character and quantity of wastewater that may be involved are highly uncertain. It has been stated that the process requires approximately 20,000 acre-feet of water per year to produce 100,000 barrels of oil per day.[7] This would mean that the process of coal liquefaction would require approximately 25 percent more water than goal gasification for the same Btu output. The wastewater problem would probably be similar to that produced by coal gasification.

Magnetohydrodynamics

The magnetohydrodynamic generator converts heat from combustion gases directly into electricity. Hot, partially ionized gases are directed through a duct surrounded by coils that produce a magnetic field, and lined with electrodes. The movement of the electrically conducting gas through the magnetic field generates a current of gas that is collected at the electrodes. Many design and operating problems remain to be solved before this process may be considered practicable on a large scale. It has been stated that the overall efficiency of this process may reach 60 percent as compared with 40 percent for the conventional fossil fuel plant and 33 percent for the nuclear fuel power plant. The reason for the higher efficiency stems from the fact that the heated exhaust gases may be used to generate additional electricity with conventional steam turbines. The resulting problem of controlling waste heat would be substantially less than in conventional plants of equal capacity.

Site Selection

The Northeast, like other regions, is sensitive to the need to select future steam power plant sites in a manner to prevent or minimize adverse effects on the environment. Site selection involves careful consideration of technologic, economic and environmental factors, as well as social acceptance. The virtual absence of oil refineries in New England and the resulting high costs of power (higher than any other region of the country) attests to the travail experienced by the Northeast on decisions affecting environmental quality.

The Northeast is a well-watered region, but proposals to install a new steam power plant, fossil fueled or nuclear fueled, on any of its waterways, fresh water or coastal, inevitably stimulate prompt opposition by articulate, informed, well organized and determined conservationist groups. Debate on specific site selection will probably be conducted within the context of requirements of the National Environmental Policy Act. It seems reasonable to believe that natural scientists, engineers and social scientists must continue to provide the data on which decisions are made.

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[7]Water Demands for Expanding Energy Development, G.H. Davis and L.A. Wood, Geological Survey Circular 703, p. 13, 1974.

Energy Required by Pollution Control

It is ironic indeed that the program of national self-sufficiency in energy overlaps a conflicting national preoccupation with protection of environmental quality. One aspect of this conflict is the assertion that compliance with requirements of the Water Quality Act of 1972 would place on excessive demand on energy generating facilities.[8] The Environmental Protection Agency countered this claim by stating that "if all wastewater were to be treated to tertiary level, the total operational demand would be only about 0.8 percent of the total national energy demand."[9] In rebuttal, a spokesman for industry stated that the EPA estimate was simplistic and misleading for several reasons:

(1) "The EPA figures are based on the experience of 'exemplary plants' which were able to maximize in-plant containments and conservation techniques. Most plants are not in this favorable position. A more reliable estimate for industry would be 1 to 1.5 percent.

(2) "This estimate would be raised to 2 to 4 percent were one to include municipal wastewater treatment at the secondary level, thermal pollution control, pre-treatment of industrial discharges to municipal systems, and control of toxic trace pollutants. This estimate would apply only to energy requirements for end-of-pipe technology. It would not include the energy required to produce and set in place capital equipment representing a $78 billion investment.

(3) "The 2 to 4 percent is based on the total national energy demand, only 22 percent of which is 'generated electricity'; the estimate would represent 10 to 20 percent of generated electricity."[10]

If this is correct, the coming decades' energy requirements for advanced waste treatment would appear to be significant. It would present a strong argument for land treatment of wastewaters as opposed to use of highly sophisticated and energy demanding technology. Further examination of this issue is justified.

Recovery of Energy from Wastewaters

It belabors the obvious to note the increasing importance of utilizing the energy contained in wastewaters. Two major opportunities are present: anaerobic degradation of organics with maximum use of evolved gases, and

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[8] Water Policies for the Future, Final Report to the President and to the Congress of the United States by The National Water Commission, Chapter 4: Water Pollution Control, p. 75, June 1973.

[9] Impact of Environmental Control Technologies on the Energy Crisis, Program Coordination Staff, News of Environmental Research in Cincinnati, U.S. Environmental Protection Agency, January 11, 1974.

[10] Industrial Prospective: Energy, Money and Pollution, A.J. von Frank, Paper presented at Seminar of the Water Pollution Control Federation, Washington, D.C., March 26, 1974.

recovery of heat from power plant cooling water discharges. Each has long been recognized and, to a limited extent, has been practiced for many decades. Opportunities to derive benefit from waste heat are especially attractive. They include its use in agriculture and aquaculture, space heating and air conditioning, sewage treatment, greenhouse heating, and airport defogging and deicing.[11] Despite these opportunities current wasteage is excessive, even intolerable. The problem is many faceted: technologic, economic, institutional and geographic. The subject warrants an aggressive, imaginative, well-funded research program.

SUMMARY

The national policy for energy independence will place increased responsibility on the regulatory agencies. They will require additional detailed knowledge on the quantities, character and effects of wastewaters from electric energy generating systems. Dependable methods for predicting and reducing these effects are needed. We may anticipate a sharpened conflict of priorities: clean water or lower energy costs. This conflict will be settled in the political arena as well as in the laboratory. Wherever the conflict, the contributions of universities to improved understanding of difficult problems will help resolve them and, in the process, aid those responsible for ultimate decisions on siting of plants and on protecting against potentially harmful effects on the environment.

[11] Evolution of Power Facilities, Berkshire Country Regional Planning Commission and Curran Associates, Inc., pp. 144-146. April, 1974.

ENERGY, WATER AND ENVIRONMENT -- INSTITUTIONAL AND POLICY ASPECTS

by

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This paper will present a definition of the scope for institutional and policy analysis. It will then summarize the general institutional problems identified for the energy-environment questions. Some of the details and opportunities of water-related problems in the Northeast will be introduced. Then a rough strategy for how water institutions might respond to the energy opportunity will be sketched. The results should be quite familiar to students of water policy because the elements of the accommodation of legitimate conflicting interests are so similar.

WHAT IS THE INSTITUTIONAL-POLICY ANALYSIS TURF?

Every discipline or problem area has its own point of view and a potential contribution to policy analysis. The organization of information to provide knowledge for decision making must use inputs from different sources if the character of decision making outputs are to change significantly. Institutional analysis should concern itself with the informal rules and formal regulations, with the incentives and disincentives for alternative behavior, and the organizations available to get specific and unspecific things done. Institutional analysts should also concern themselves with the various active and potential participants in the decision making process, their resources for participation and the stake they have in participation.

The economic analyst who operates in the tradition of micro and macro economics is oriented toward identifying that decision which those affected would choose if they could choose (given the usual caveates of the winners being able to bribe the losers). But here the objective should be to design the structure for decision making such that those affected by a decision would agree that the balance of interests was appropriate. In other words, what set of institutional arrangements would we choose to choose for us if we could choose the choosers?

Such an analysis must have both normative and behavioral components. Some normative rules can be drawn from economic-like reasoning, but most seem to follow from concepts of democratic government, from notions of equity rather than efficiency. Behavioral guidelines follow from the observation of participants and institutions, from some reasoning based upon the social-psychology of the participants and often from deductions based upon an understanding of the technical processes involved.

The following propositions were drawn up in this spirit by a group who examined the institutional problems associated with environmental aspects of the energy crisis at the behest of the Seante Interior Committee.[1] They should look quite familiar to students of water institutions.

(1) The kinds of restraints on energy production and use to deal with environmental effects which will best serve the public interest cannot be scientifically determined.

(2) It is assumed that, in general, a decision by a governmental entity is in accord with the public interest if (a) the views of those affected by the decision have been taken into account in the decision and (b) the views of those affected have been based upon the best available information about the consequences of alternative decisions.

(3) Because of the large number of issues with which government is concerned and the many facets of the problems that must be considered, the reflection of public views on the environmental effects of energy production and use cannot be achieved solely through the processes of election of public officials, such as chief executives and legislators; therefore, supplementary processes are required.

(4) Studies in political science and administrative behaviour clearly demonstrate the tendency of administrative agencies to be strongly influenced by well organized interest groups, both public and private; interests that are not well organized -- even though large -- tend not to have their views reflected in the decisions of administrative agencies.

(5) Studies of individual and organizational behaviour have demonstrated that the alternative policies and programs that an individual or group considers relevant, depend upon the experience and interest of the individual or group; therefore, an administrative agency dominated by individuals trained in a particular profession or influenced primarily by one interest group (such as the petroleum industry) will tend not to view as relevant, alternative programs that would be considered desirable by an agency dominated by another profession or another interest group.

(6) In view of the foregoing considerations, it is concluded that the overall public interest will be served best if:

    (a) Legislative bodies define as precisely as practicable the policies which administrative agencies are to administer.

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[1]Extracted from I. Fox, D. Allee, et. al., "Institutional Arrangements for Dealing With the Envrionmental Effects of Energy Production and Use," A contribution to the Summary Report of the Cornell Workshop on Energy and the Environment sponsored by the National Science Foundation and the Committee on Interior and Insular Affairs, United States Senate, Committee Print Serial No. 92-23, May 1972, Washington, D.C.

(b) Costs or damages to the environment caused by energy production and use are borne by those creating them to the fullest extent practicable.

(c) Each significant set of interests in society is equipped to identify the kinds of policies and programs which will best serve its interest and present these views forcefully to those who make the decisions in behalf of the public.

(d) The institutional structure provides arenas in which the differing interests can bargain about their differing objectives and programs, rather than allowing individual decisions to be made without the tradeoffs being considered.

The panel which agreed upon the above propositions then identified the following four limitations of the then existing institutional arrangements in the energy-environment area at the federal level.

(1) Inadequate provision is made for developing and providing on a continuous basis a solid foundation of information about energy resources, the production and use of energy and the environmental effects of these activities.

(2) There is incontrovertible evidence that because of the imbalance in the influence of various sectors of society over public energy decisions, existing decision making processes do a very unsatisfactory job of reflecting social preferences in this area of public activity.

(3) Energy policies and programs and regulatory decisions are made at a number of separate locations in the federal government so that there is little opportunity to balance off the interrelationships among individual decisions.

(4) Regulatory responsibilities are interwoven with program responsibilities leading to a confusion of the responsibilities of regulatory bodies. On the one hand they are expected to be quasi-judicial in nature and weigh competing claims objectively. On the other hand, they are expected to promote particular programs in which some groups have a special interest.

While progress has been made in almost every one of the above limitations at the federal level, the remainder of this paper will seek to explore the possible adjustments that might be made with special attention to interrelations with water institutions and the regional level -- particularly the multi-state river basin as a management region. However, this examination will have more significance if it is first placed in the context of an analysis of the overall problem. This is essentially an institutonal analyst's version of the other three topics designated for this panel.

TECHNICAL FLEXIBILITY IS SUBSTANTIAL[2]

The Energy Policy Project of the Ford Foundation has tentatively concluded that within the range of possible institution changes there is substantial flexibility to achieve energy needs. Expanded consumption at our long run historic rate (3.4 percent per year) can continue to 2000 with at least three significantly different mixes between imports, domestic fossil fuels and nuclear development. A growth rate of half that level is seen as possible through applications of known conservation technology. Perhaps optimistically, behavior that would lead to such a reduction in expansion is seen as nearly within the range of incentives that resulted from shifting full costs of energy use and production to the market place.

The greatest savings in this lower level of energy use are seen as coming from a relatively small number of the present uses of energy. Space heating and cooling through greater use of heat pumps, insulation and solar energy are seen as needing only small shifts in relative prices to be practical generally to the user. Industrial heat production accounts for over a quarter of energy use and can be made more efficient through heat recovery, combining steam production with electricity production, use of heat pumps, etc. Smaller cars, radial tires, streamlining, power train redesign, diesel engines, expanded mass transit use, and the like are the key to conservation in this large energy category. The result of such changes is the ability to make much wider choices in near-term supply development. Only one of the major energy sources -- oil imports, domestic fossil fuel or nuclear power -- need be developed significantly. Alternatively, the environmentally least disruptive mix of the three could be chosen -- if we have the institutional capability to make a considered choice. The breathing space in supply development could be put to more care and study of our long run options.

If all existing subsidies to energy production and use were removed, to the extent possible, would the resulting prices be enough to achieve growth in demand on half the historic rate? Probably not. Other changes seen as necessary include better information to the consumer on what energy use (and operating cost) is associated with the various appliance and housing options presented. Financing, organizational arrangements and other institutional changes to make low energy options for transporation, space heating and cooling, etc., really competitive options, would be called for. Depletion allowances and favorable freight rates for raw materials as opposed to recycled materials, differences in transportation subsidies, research and development expenditures on energy consumption efficiencies at least equal to those on production improvements are all areas of potential policy change. The energy problem to the year 2000 does not appear to be so much technical in nature as it does institutional.

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[2]This section draws heavily from Freeman, S. David, et.al., Exploring Energy Choices -- A Preliminary Report, Energy Policy Project of the Ford Foundation, 1776 Massachusetts Ave., N.W., Washington, D.C., 20036, 1974.

SPECIAL PROBLEMS IN THE NORTHEAST

The Northeast enjoys some of the largest areas of high density population in the nation. Environmentally, it probably contains the people and their activities about as effectively as any part of the nation, thanks to its higher rainfall per acre. The scars heal more quickly. But the "Faustian Bargain" of nuclear power presents a special dilemma in this situation. The perceived risk of nuclear accident -- of designing, building, operating and disposal of waste without flows -- seems greater where there are so many to be affected. Yet imported oil is not risk-free and coal development will only partly export the environmental problems of supply development. All three modes use water to transmit their environmental consequences. Nuclear development seems to call for institutional capacity the like of which man has not achieved before and it is not at all clear that he has achieved it yet.

Coastal zone management -- with power plant siting, oil spills, and low energy use navigation -- is giving us a chance to develop and test new arrangements to manage natural resource use. The problems are quite similar to those faced by the river basin as a unit of management. Coastal zone management is providing a focal point for a different set of relationships between levels and agencies of government, however. The basin agencies -- and whatever other regional management concept becomes fashionable next -- may have much to learn from this developing experience. Perhaps it will be a return to the metropolitan region with energy conservation as the organizing concept.

Acid mine drainage is a most frustrating problem and has been with us in the Northeast for many years. It is not easy for the operating mine to prevent the leaching, aeration and other processes that lead to the acidification of such huge amounts of water. But when the mine is abandoned and was worked with no thought to the problem, correction becomes complicated indeed. Various methods of sealing and treating have their proponents and detractors. Those that represent high one-time investments with limited year-to-year management offer the potential of appealing to the poltiical processes of water projects. Action programs by the Corps of Engineers and Soil Conservation Service suggest themselves. Alternatively, threatment approaches requiring continuing expenditures may better lend themselves to state and regional initiatives, with some federal inducements. The trick will be to insure that the appropriate burden of cost is placed on the active mine operation (which will only in part be passed on to the fuel consumers). The abandoned sources of acid will have to be a public burden and probably only funded partly, if at all, by the direct beneficiaries. Our history of dealing with pollution from marginal, obsolete industrial plants in areas of limited alternative employment suggests that new regional approaches are called for. Perhaps the Appalachia model will apply.

Cooling water should provide a more immediate test for our slowly developing basin management arrangements to meet an energy related environmental test. Both the Delaware and the Susquehanna compact commissions have the opportunity to deal with power plant siting. The Delaware has considered development of generating capacity less than projected in basin demand growth;

the Susquehanna has had a proposal of more generating capacity than growth of projected demand in the basin. The Delaware could then be said to be importing electric power and exporting environmental impacts. The cooling towers of the next power plant that goes on line along the Susquehanna may put the assured low flow below that which has been agreed as the minimum to be discharged to Chesapeake Bay. Varying temperature standards to reduce evaporation isn't likely to be an acceptable solution. It will be interesting to see how the flow regulation required will come about. Good dam sites are scarce; and ones without controversy may not exist at all.

If the state-oriented basin commissions can't deal with these conflicts, will the traditional federal agencies fare any better? It seems clear that the Congress would welcome a lower level of conflict in water development. And in the East as in the West, energy related opportunities may give our water institutions a new chance to find ways to deliver the bacon without burnt Congressional fingers. What will it take? It is doubtful that controversy can be avoided. The issue is "where can it be best resolved?"

REQUIREMENTS FOR SUCCESSFUL RESPONSE TO THE ENERGY CRISIS BY WATER INSTITUTIONS

If the water institutions fail to resolve the pending conflicts, they will be managed in other arenas to the detriment of the scope and influence of the water instituitons. This does not mean that all participants in the decision-making process must feel and sound satisfied. That just doesn't happen very often in the accommodation of legitimate conflicting interests. What can and must happen is that a working majority of the other participants feel that any one other participant was reasonably and fairly dealt with. Unilateral accommodation rather than bilateral accommodation is much more to the point. Thus the trick becomes searching out those accommodations that will be generally recognized as fair and reasonable. The above elements can be drawn upon to provide the outlines of one or more strategies for finding such accommodations.

First, the water agencies could turn their very considerable planning capacity toward correcting the inadequate information about energy, particularly as it relates to water as a transmitter of environmental effects. Everything is linked to everything else but sometimes the effects are far less than as imagined. Water is often the medium that has to be understood to verify impacts.

Second, the water agencies could and should develop access to the decision-making process for interests that will lead to a more balanced reflection of social preferences in the overall energy decisions. For example, the moderate environmentalist might see the water agencies' participation as leading to more environmental responsiveness than if the energy decision system went its usual way.

Third, the water agencies, as an elaboration of the first point, could use their familiarity with the total physical water system and the related ecosystems to provide more informed coordination between energy modes and otherwise unrelated energy decisions. For example, hydro-electric facility permits, among others, come up for periodic review. The environmental consequences of substitute forms of power should be set against the environmental consequences of alternative future operating rules and the like.

Fourth, the promotional and developmental functions and the regulatory functions of water agencies should be kept as distinct as possible rather than compounding the already difficult problem in the energy agencies.

Finally, the water agencies have opportunities and a stake in demand management. Energy conservation and the resulting breathing space for supply development may allow them to play a more positive role in the long run solutions to the energy problem. But also greater credibility and opportunities for environmental accommodation may be found in energy conservation promoted in water-related decisions.

The general problem in dealing with the energy-water-environment questions is the same as that we have faced in the water-environment questions that have occupied our attention longer. How do we achieve the institutional flexibility to make the best use of our considerable potential technological flexibility?

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DISCUSSION REPORT

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Four position papers were presented and discussed by fifteen delegates from the North Atlantic Region. The papers and the discussion accentuated the appropriateness of the conference theme - "Energy, Environment and Water Resources".

The North Atlantic region is generally considered to be well off with respect to rainfall and runoff to surface water supplies compared with the arid west. While this comparison is true with respect to actual rainfall and runoff, when more realistically considered on a per capita basis, the population of the region makes it the most water-short area of the country. Because irrigation requirements are only for supplemental use, irrigation water supplies needed for this purpose are minimal. However, the North Atlantic Regional Water Resources Study projects a doubling of publicly supplied water from 5500 mgd to 10,700 mgd by the year 2000 and an increase from 3,800 to 12,700 mgd for industrial self-supplied water.

Even less well understood are the needs for a clean environment and the recreational needs of residents while meeting the above industrial needs in order to provide employment opportunities essential to the economy of the area. To emphasize the recreational pressures let me add that Ocean City, Maryland with a year-round population of about 4000 was estimated to have had 150,000 people over the last Memorial Day weekend and 200,000 is considered normal during the summer; 39,000 vehicles crossed the Chesapeake Bay Bridge in one day returning the recreation seekers to the metropolitan areas of Baltimore and Washington.

The Delaware River Basin Commission requested power companies to project their construction plans for the Delaware River. The estimate was for 60 million KW of additional capacity to be met by constructing 6 new conventional plants, 11 new nuclear plants and expanding 10 existing plants. This expansion will create an increase in evaporative cooling water requirements from 120 cfs each of fresh and brackish water to 430 cfs of brackish water and 1180 cfs of fresh water.

From the management viewpoint of water-energy-environment problems, it is obvious that we have a circular syndrome. Without energy we cannot use water, without large quantities of water we cannot convert energy into convenient forms and they both affect the environment. Four management guidelines were discussed as having potential value to the modeling of systems in reaching the decisions necessary for resource allocation.

(1) Sources of Energy

Maximum consideration to use of renewable resources in lieu of non-renewable sources, including solar energy, tidal energy, etc. The logic for this is good but the economics may not be favorable under present state-of-the-art conditions.

(2) Recovery or Recycling of Wastes

There is much appeal to the mass conservation concept, especially for the potential environmental benefits. Again the economics under present constraints may not be favorable.

(3) New Processes and Materials as a Source of Power

Industry, as the large user of energy and non-renewable resources, should be encouraged to substitute advanced technology to minimize use of non-renewable resources.

(4) Change in Public Energy Consumption Habits

To do this will require research on alternatives together with education, economic incentives, and, perhaps, controls on usage.

All of the above items imply research needs. These should go beyond study of the primary results and consider secondary and tertiary effects. For example, if consumers spent less for energy, will the money saved be spent for commodities which in turn require energy and non-renewable resources? If so, this would simply relocate where energy is used and would not be a real net savings.

As we look at the impact of the challenge to the nation to become energy independent within a decade, our concern is the prudent use of water resources. No one would debate this viewpoint, but research to identify what is prudent in the complex interrelationships will be difficult to plan and conduct and even more difficult to apply.

The mood of the federal government is reflected in its apparent willingness to relax air quality standards by use of high sulfur coal. Similarly, those concerned with water quality will be unable to attain the high quality envisioned in the Water Quality Act of 1972 in view of the national determination to expand electrical generating capacity.

Problems which need further refinement include recovery of energy from wastewaters, the long term effect of thermal discharges on aquatic biosystems and the effect of hydropower plants on water quality.

In the latter case, most hydroelectric plants received a 50-year license when constructed. Many of these are to be reviewed for renewal in the next few years and should be examined closely with particular attention to management of reservoir discharges in quantity and techniques.

Little real effort has been addressed to the recovery of waste heat in thermal discharges for use in agriculture, aquaculture or even in improvement of sewage treatment systems.

The most difficult aspect of optimizing the energy-water environment area is that of institutional arrangements. There are physical, economic and political constraints for the management of resources. There are legitimate conflicts for use of resources between power generators, oil refineries, extractive industries, manufacturers, the recreational industry, land uses (agriculture, urbanization, wetlands, wilderness and wild rivers), coastal zone management and other diffuse activities.

The major question then is how are these legitimate conflicts rationalized? The answer is that the decision-making process must be political, and policies are allegedly established by our elected officials and legislative bodies. The executive branches are responsbile for decisions to implement policies in accord with legislative constraints. However, history indicates that agencies organized to regulate management of resource use by segments of the economy have often become captive and advocates of the industries they are supposed to regulate. In view of this fact, the opinion was expressed that the regulated segments of the economy were sometimes in a better position for their viewpoints to be heard than the diffuse users whose uses have not been regulated and who have not developed an advocacy in "the establishment".

The results of the above circumstances are such that competing agencies with regulatory authority are sometimes poorly coordinated so that resource users are whipsawed between changing regulations regardless of size. The dairy farmer with problems of runoff from a 40-cow holding pen may represent one extreme of the scale, while oil refineries and electric power generating systems are the opposite; regardless of size they sometimes find that by the time they comply with, or even prepare designs to comply with, regulations they find that regulations have changed.

In closing the workshop discussions, observations were made pertaining to the need for research-based educational efforts on the alternatives for resource development, management and conservation. Examples cited included mass transit versus individual cars and reducing the use of all forms of energy by industry, governmental agencies and individuals. The educational processes might range from such simple needs as labeling appliances with respect to energy utilization, to such intermediate needs as the energy requirements for different types of construction materials and methods, to the complexities of subsidies as tax incentives to stimulate use of new metals and systems including solar energy utilization techniques.

REGIONAL WORKSHOP

II - SOUTH ATLANTIC-GULF, LOWER MISSISSIPPI, TENNESSEE

ANALYSIS OF SELECTED PROBLEMS INVOLVING ENERGY PRODUCTION AND WATER SUPPLY IN THE SOUTH ATLANTIC-GULF STATES

by

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INTRODUCTION

The first of a series of speakers on a topic being discussed in parts has a number of advantanges. The audience is fresh, alert, and responsive. The speaker can assume that whatever he omits will be covered by others to follow. Any overlap will not be noted unitl it occurs. In many ways, the first speaker can set the tone for the entire session. As I presented my last conference paper at 5:30 on a Friday afternoon, this seems an opportune time to claim each advantage.

Energy production relates to water supply in many ways. Energy is consumed in obtaining and distributing municipal and industrial water. Energy production becomes more costly and may even have to be curtailed if the water otherwise used in generating hydroelectric energy or cooling thermal electric plants is instead assigned to other uses. Improper disposal of fuel residuals often permits the waste products of combustion to be washed into streams and makes water supply more costly. Conservation measures that reduce energy use also reduce the water used in energy production. Fuel residuals and waste heat from energy production and use are major sources of water pollution. The coordination required to properly manage energy and water resources creates many implementation problems because of the changes required in the separate institutions established for what once seemed to be two independent functions. The scope of this paper is confined to the first three relationships: energy use in water supply, water use in energy production, and the effects on water supply of improper disposal of energy residuals.

The nature and relative importance of the various energy-water relationships varies from place to place. This paper emphasizes problems in the eight South-Atlantic-Gulf states east of the Mississippi and south of Virginia and Tennessee inclusive. These states are an energy importing region. Most of the area is in flat coastal plain. Many rivers in the humid climate have enough flow for some hydroelectric power generation but nowhere near enough to meet the total needs of the region. The coastal areas have little coal or oil production (even though speculation is growing over the offshore oil deposits), but coal is found in some upland areas. Since alternative energy sources are scarce and cooling water is relatively abundant in areas of low population density, nuclear power production is relatively more important than in most other regions.

Within the scope as defined, this paper will outline some major energy-water problems and then proceed to a systematic evaluation of priority research needs with respect to three of them.

MAJOR PROBLEMS

We can begin our list of major problems with one that is becoming an important political issue in metropolitan Atlanta. From the 1930's through the 1960's, the Southeastern states were the site of the construction of more than their share of large reservoirs by the Corps of Engineers and the Tennessee Valley Authority. Electrification was a major social concern during those years, and hydroelectric power was a primary purpose when most reservoirs were constructed. Today, population growth is causing many cities to look for additional water, and large firm supplies require reservoirs. As few good reservoir sites remain and new reservoir construction is now environmentally unpopular, it has become necessary to consider the possibility of shifting use of existing storage from production of hydroelectric power to providing additional municipal and industrial water. Such a shift may be desirable at a time of energy shortage because other production technologies can be substituted to provide energy but not water.

For a second problem, municipal and industrial water must be conveyed from its source to its place of use and be treated to meet health standards before it is distributed to the public. A great deal of energy is consumed in pumping (cities are usually located at an elevation higher than either ground or surface supplies) and treatment (moving water through the aeration, filtration, and sedimentation processes and producing the needed chemicals). Pumping is required to maintain pressures in municipal delivery systems and for fire fighting. Most coastal plain communities and rural users pump groundwater. Cost analysis is important in determining the optimum water delivery system design configuration, and the recent changes in the relative cost of energy are changing the least cost configuration. Furthermore, energy shortages lead to more frequent outages, interruptions in water delivery, and investment in alternate systems for emergency use.

Third, major energy requirements for pumping and treatment also exist for wastewater disposal. The more sophisticated treatment processes required for greater environmental protection use more power. The much-discussed land disposal of wastes requires pumping to sites more remote than the conventional treatment plants. Energy use in wastewater treatment is one of the more significant relationships between energy and water in the Southeast but one more properly addressed by one of the papers to follow.

Fourth, as urbanization becomes more intense, more localities are subjected to strong developmental pressures in their municipal watershed. Even if all sanitary wastes are treated, pollution associated with runoff from streets and other surfaces where wastes collect between rains (the non-point sources) make urban runoff less suitable for municipal supply. Treatment becomes more costly and requires more power. A new supply will be more distant and require more power to obtain. Treatment of the nonpoint source runoff before it enters the stream will likely be even more costly and power consuming, but may be justified by the resulting environmental enhancement. Many of the most troublesome pollutants to treat are fuel residuals deposited on the ground surface after incomplete combustion.

Fifth, thermal-electric generation requires a great deal of cooling water, and generating plants tend to increase stream temperatures. Warmer temperatures aggrevate downstream pollution problems, and water quality management agencies often respond by raising or more strictly enforcing minimum flow requirements. The net effect is to reduce the availability of water for alternative uses.

ANALYSIS OF SELECTED PROBLEMS

This list of energy-water problems could no doubt be extended, but this is a convenient point to shift to analyzing selected problems in greater depth; and a convenient analytic technique quite familiar to this audience is that developed by Dr. Warren Hall. The procedure provides a framework for the systematic examination of each problem for needs for identification research to define the goals and objectives of problem solution, inspiration research to define a list of viable alternatives, feasibility research to determine which alternatives can accomplish the desired goals, consequences research to define the effects of each feasible alternative so that the most desirable can be selected, and monitoring research to devise systems for recording whether selected measures are performing as desired.

Feasibility has six aspects. The technical question is whether implementation of the alternative will really solve the perceived problem. The economic question is whether the alternative will really produce benefits in excess of costs. The environmental question is whether the alternative will induce unacceptable adverse environmental consequences. The financial question is whether money is available to pay for the alternative. The social question is whether the public will respond to the alternative in a manner effectively contributing to the goals and objectives. The political question is whether the alternative will achieve the required political support and whether it conforms to existing laws.

Each of the six aspects of feasibility must also be covered in the information gathered for comparing consequences to select from among the feasible alternatives. The institutionalized optimization process, however, has emphasized technical design criteria and the economic objective of maximizing net benefits. The other considerations have been used more in deciding whether or not a fixed plan should be implemented than in formulating its design. The recent trend, however, has been toward bringing environmental considerations into planning through environmental impact assessment and social considerations through public participation.

TRADEOFF BETWEEN POWER AND WATER SUPPLY

One energy-water problem deserving analysis is the advisability of changing reservoir operating schedules so as to reallocate existing reservoir storage from hydroelectric power generation to water supply. The objectives to be used in evaluating such a change are those outlined in the Principles and Standards established by the Water Resources Council.[1] The primary tests would be whether the additional water supply benefits exceed the power benefits foregone and whether the change can be executed within relevant environmental and social constraints. The environmental constraints are not likely to be too severe in a situation where no new construction is involved, but some problems are caused by rapid or excessive drawdowns. The social constraints are likely to be more limiting because of the agreements and cost sharing arrangements among interest groups which would have to be modified. The situation seems to be one in which no identification research to define goals and objectives should be necessary.

The alternatives for balancing hydropower generation with water supply include:

(1) Develop new water supplies independent of existing reservoirs.

(2) Convert from power generation to water supply at existing reservoirs and develop an alternate generating source to make up the deficiency.

(3) Operate the existing reservoirs more efficiently to supply both power and water from the same facilities.

(4) Maintain both power and water supply from the reservoirs by diverting storage from some other purpose or purposes.

(5) Enlarge the reservoirs.

(6) Develop or expand downstream holding facilities so that water used to generate power can be stored until needed for water supply.

(7) Recoordinate the power network so that power can be generated on the time schedule in which water must be supplied. If water is to be released for downstream supply, it can be run through the turbine to generate power, but the power will be unuseable without compensating adjustments in the timing of generation elsewhere. The major drawback of letting water supply needs dictate the patterns of power generation is that the flexibility in starting and stopping which is a chief advantage of hydroelectric generation is eliminated. Pumped storage may be added to restore some needed flexibility.

This list of alternatives seems reasonably complete without inspiration research to develop more, and the details for implementing most of them are fairly well known.

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[1]Federal Register, September 10, 1973, v. 38, no. 174, pp. 24778-869.

Alternatives 3, 4, and 7 are not technically feasible in situations in which the amount of water needed is large compared with the amount used for other purposes. When the amount needed is relatively small, alternative 3 is widely used. The techniques for ascertaining technical feasibility are, however, probably well enough in hand so that further research is not needed on this score.

The feasibility issues are largely financial, social, and political. Financial commitments, detailed in legally binding cost sharing agreements, are made at the time of facility construction, and a change from power to water supply requires an adjustment. Even when public benefit can be demonstrated, study is needed to define the legal limitations to and the implications of adjustments, the rights of the injured parties (those depending on the power), and equitable rules for reimbursement. Opening the possibility of future reservoir use changes also has social feasibilty implications as hydroelectric investments will lose of their long-run dependability. Private investment by power companies or others anticipating long-run reliance on a facility may become harder to obtain.

The consequences research needs are more in the technical, economic, and environmental areas. The technical research is needed to develop more efficient rules for reservoir and power system operation. The economic research is needed to develop better information on the effects of drawdown on recreation visitation and benefits and information on the economic impact of periodic water and power shortages. The environmental research is needed on the environmental implications of reservoir surface fluctuation. The economic and environmental consequences research is of higher priority than the technical as it provides critical inputs for deriving more realistic functions for use in developing more efficient operating rules. The needed research into financial, social, and political consequences should be addressed first in terms of the feasibility questions outlined above.

ENERGY USE IN WATER DELIVERY SYSTEMS

The second problem that I would like to discuss is the use of energy by water delivery systems. Both water treatment plants and water distribution networks have been designed to balance the cost of other system elements with the cost of energy in terms of the prevailing price structure. For example, the pipe sizes used in a water distribution network are selected to minimize the sum of pipe and pumping costs. The probability, however, is that the prevailing price charged for energy is well below the total marginal social cost of producing it, particularly when environmental externalities and the eventual diminishing of nonrenewable fuels are considered. The low price provides a financial incentive to overuse energy, and the design of current water supply systems has largely responded to this incentive. Now that energy costs are beginning to rise relative to other prices, it is necessary to consider how the operation of current systems and the design of future systems should be changed.

As was the case for the first problem discussed, the goals and objectives to be pursued are well defined and consist largely of maximizing net water supply benefits. Alternatives include:

(1) Use more chemicals or other non-energy inputs in the operation of existing water treatment plants in order to reduce energy use.

(2) Design new water treatment plants so as to reduce energy use.

(3) Employ larger pipe sizes in water distribution networks.

(4) Employ more efficient layouts in water distribution networks so that a given level of service can be provided by a less expensive arrangement of pipelines and pumps.

(5) Adjust the time schedules for water treatment and pumping so that more of the total energy requirement occurs at times other than peak energy use periods. This will either require additional or more efficient use of existing water storage tanks.

(6) Incorporate energy considerations into the policies for extending water distribution systems into rural areas.

(7) Induce a reduction in water use by a price increase or other appropriate means.

While this list provides a fairly complete range of options, inspiration research is needed to define several of them sufficiently specifically to become operational. The options for reducing power use in treatment plant design and operation are not well known. Inspiration research could also be helpful in defining alternatives for inducing a reduction in water use.

The minimum population density at which it becomes advisable to extend water distribution systems to rural areas depends in part on energy considerations. Rural users supplying their own water are more likely than a community distribution system to pump their water and generally have less efficient pumps, but the extra energy used by small individual systems becomes more than compensated, at some population density, by the extra energy required by a system employing more pipe per customer.

Feasibility issues vary among the alternatives. More energy efficient treatment systems and delivery networks can be designed, and the technical feasibility issue is largely one of how much energy can be saved in this manner. Technical feasibility limitations obviously place an upper limit to the energy savings that can be effected.

The alternative of using storage to alter treatment and pumping schedules so as to make greater use of off-peak power requires an economic feasibility evaluation. The study should concentrate on a detailed analysis of how the costs (as opposed to the price) of energy varies with the total load on the generating system. From such information, it would be a routine matter to determine the storage requirements for various pumping or treatment schedules and make cost estimates for ascertaining whether the idea has economic merit.

The other needs for technical, economic, environmental, or financial studies relate more to developing better methods for forecasting consequences than for determining feasibility. On the other hand, several important social and political feasibility questions need to be resolved.

The primary feasibility issue with respect to the first four alternatives is whether it is possible to achieve optimum energy use in water supply in a situation in which the price is less than the true marginal social cost. Since it is to a water utility's advantage to design and operate a system that makes more than the socially optimum use of energy if price is less than cost, some compensating combination of other incentives and regulatory measures will have to be designed and implemented. The needed feasibility research would be to explore the political factors that influence the likelihood of a given set of incentives being adopted and the social factors that influence the response to those that are. Similar social and political feasibility assessments are needed on bringing rural users into water distribution systems, courses of action when optimum delivery systems cross jurisdictional boundaries, and the possibilities for inducing water conservation.

The greatest consequences research need is to determine the true marginal social cost of energy. What is the current cost? How is it likely to vary over the design life of water treatment and distribution systems? What cost is appropriate for use in the design of systems with long lives? In many cases, the curves of system cost plotted against some design decision variable (pipe size for example) are close to flat over a wide region. One might favor alternatives on the side requiring less energy use; however, this usually means larger capital investment and hence less flexibility in responding to unanticipated future situations. It is easier to stop buying energy than to salvage a buried pipeline. A comprehensive model of economic interrelationships and related environmental impacts is needed for the consequences assessment.

With respect to the envrionmental consequences of the alternatives, the first five alternatives largely involve internal system design and do not affect the environment much. The sixth and seventh can have substantial influences on land development patterns, and these consequences need to be explored.

The major financial issue is the best way to pay for a system that deviates from the least cost design because of such considerations as energy and the environment. More explicitly, equitable rules are needed for drawing the dividing line between user financing and an external subsidy to pay for features in the public interest.

MUNICIPAL WATERSHED PROTECTION

The last of the three problems that I have chosen for analysis is the conflict between urban development and the use of runoff from the developed area for water supply by downstream communities. Atlanta is not atypical of many urban areas in that as the city expands, many small communities are unable to protect their municipal watersheds against urban development and thus become forced into a metropolitan-wide water supply system that is generally larger and more energy intensive. Even communities that protect their original supply have no way to expand the system to accommodate their own growth. Communities on a major river downstream from a larger metropolitan area are also affected. As urban development extends nationwide, the energy required to pump water from distant pristine sources becomes greater. A hard look needs to be given to using local urban runoff for water supply.

The major issue with respect to goals and objectives is that of appropriate public health safeguards. Many more kinds of pollution are found in urban than in rural runoff; many of these are not easily treated; and some may not even be known. The fundamental question is one of acceptable risk. A very high level of safety can only be achieved by very high economic and environmental costs. The economic question is how high a level is justified. The financial question is for how high a level are people willing to pay. This last question suggests one possible source of empirical data for the needed identification research.

The alternatives for a community faced with urban development in its municipal watershed include:

(1) Import water from more distant rural sources.

(2) Import drinking water from the more distant rural sources but use urban runoff for yard irrigation, fire fighting, industrial cooling, etc.

(3) Take urban runoff from streams and treat it to be suitable for municipal use.

(4) Treat urban runoff before it enters the stream to a quality equivalent with rural runoff.

(5) Induce a reduction in the potency of the wastes picked up by urban runoff. In the context of this paper, particular empahsis needs to be given to energy residuals.

Definition of the alternatives for importing water involves standard engineering procedures, but inspiration research may be helpful in defining new creative designs for implementing a separation of drinking from other water distribution, treatment of urban runoff for municipal use, treatment of nonpoint runoff before it enters the stream, and reduction of the concentration and potency of the wastes picked up by urban runoff. Possibly, new methods could be developed for keeping urban surfaces cleaner and thereby reducing the waste load acquired by the runoff. The range of alternatives would include new techniques for cleaning urban surfaces on a regular basis or measures to reduce the amount of wastes materials that accumulate on these surfaces in the first place. Much more work is also required in developing working methods for collecting and treating urban runoff.

The feasibility questions with respect to the treatment of urban runoff are largely economic and financial. Such treatment is required to achieve the water quality goals specified in recent legislation, but it is not clear that society will be willing to pay the costs or provide the energy required. The suggested feasibility research procedure would be to estimate the costs for collecting and treating various kinds of nonpoint pollution, examine the consequences of such treatment by category, determine if the benefits justify the expenditure, and explore the possible cost sharing arrangements for likely approaches.

The feasibility of measures to induce cleaner land surfaces in urban areas cannot be evaluated until the approaches are more explicitly defined. The primary energy-oriented issues are whether motor vehicle design can be modified to reduce the deposit of fuel residuals on road surfaces and whether modifications of combustion processes and other air pollution control methods can materially reduce the fallout of polluting combustion products. The feasibility studies should concentrate on the technical question of whether any designs can be found that will accomplish these objectives at a reasonable cost.

Until the feasibility of the other alternatives are more fully explored, the only priority consequences research is with respect to the alternative of importing water from distant rural sources. The specific research needs are largely those already outlined in the section of this paper on obtaining water supplies from existing storage facilities.

CONCLUSION

This paper has sought to outline and provide some notion of the relative priorities for the research needed to achieve more efficient energy use in water supply for the South Atlantic-Gulf states. Many of the same needs and priorities probably also apply to other parts of the United States. Certainly, this type of systematic evaluation is important if research into the energy-related aspects of water supply is going to solve the aspects of the overall problem worrisome to the general public and its political leadership.

MANAGEMENT - CONSERVATION - REUSE AND RECYCLING

by

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INTRODUCTION

The National Water Commission Act requires that the reuse of wastewater be considered as an alternate means of helping to meet future water demands. The potential usefulness of such reuse was projected in 1968 by the U.S. Water Resources Council. For 1980 it was projected that municipalities will withdraw 34 billion gallons per day and return 23 billion gallons per day, or approximately 68 percent. Industry (excluding mining and thermal-electric cooling uses) is expected in 1980 to withdraw 55 billion gallons per day and return 50 billion gallons per day, or approximately 91 percent.

Water has always been used and reused. The hydrologic cycle (described in the first chapter of the Old Testament book of Ecclesiastes) is one of reuse. Cities, towns and industries draw water from surface streams and discharge wastes into the same streams which, in turn, become the water supplies for downstream users. According to the National Water Commission (1971), one-third of the nation's population currently depends on municipal withdrawals from streams containing, on the average, one gallon of previously used water out of thirty gallons of flow. The Commission also stated that as much as one gallon out of five of municipal water supply has been used before.

Reclamation measures would save much water that is now wasted. Manufacturing processes can often be altered to cause less pollution and water in industrial plants can, in some cases, be recycled. Pollution control measures now require the treatment of municipal wastewater which is to be reused. The treated wastewater can be considered an additional water resource, the use of which for lower grade purposes than drinking can result in substantial savings of clean water supplies.

Water reclamation is by no means a cure-all for water shortage problems, but the reuse of treated water can be a great assist through the recharging of aquifers (where the withdrawn water is not used for human consumption), and by meeting many irrigation and industrial needs. The resue of treated effluents is most suitable in cases where large volumes of water are used and the wastes are not too heavily contaminated.

INDIRECT REUSE OF WASTEWATER

Indirect reuse of wastewater occurs when water, which has already been used one or more times for domestic or industrial purposes, is discharged into fresh surface or groundwater and then used again in a diluted form.

Although waste treatment measures effectively reduce the quantities of pollutants entering such receiving waters, pollutants do not pass through the treatment units. Fortunately, natural purification enhances the treatment of effluents. The degree of natural purification is dependent, among other things, on such factors as dilution, character of the waste and time. Notwithstanding, before the diluted effluents can be used for potable water supplies, still further treatment is required. Examples of the operations used are storage, coagulation, sedimentation, filtration and disinfection.

DIRECT REUSE OF WASTEWATER

Direct reuse involves the planned and deliberate use of treated wastewater for some purpose as irrigation, industrial use, recreational use, the recharging of aquifers and drinking.

Agriculture

The use of sewage effluent as an agricultural water resource is a common practice. However, the quality of the reused water is important for the health of the workers in contact with it and for the particular application for which it is used. Trace elements which are toxic to crops can be a problem -- boron for example which is highly toxic to citrus.

Industry

Industries conserve water by recycling within plants. Municipal wastewater effluents have been used as cooling water.

A two-year study of petrochemical wastewater recycling is being made by Union Carbide with the project partially supported by $231,000 in EPA funding. The total cost of the investigation by the company in search of recycling techniques for its Ponce, Puerto Rico plant will be $550,000. The first step will be the construction of a small pilot unit at the company's South Carolina-West Virginia Technical Center. Union Carbide has already spent $10 million on a combination aerobic, anaerobic treatment system for the Ponce complex. The aim of the new studies is to refine the work further so that the plant can recycle most of the 1,500 gallons per minute of wastewater back into the production units.

Recreation

The use of treated wastewater for filling lakes to be used for boating, fishing and sometimes swimming is relatively new. Some have been in existence for ten years. At one California location municipal wastewater is treated by the activated sludge process, fed into a lagoon, chlorinated and spread on a natural bed of sand and gravel where it passes through several hundred feet of horizontal filtering. The water then flows into manmade lakes which are used for boating and fishing. At Lake Tahoe advanced waste treatment processes produce a very high quality effluent that is used in Indian Creek Reservoir for boating, swimming, fishing and irrigation.

Municipal Reuse

Municipalities can use well treated effluents for many nonpotable purposes. Some of these are: (1) street flushing; (2) watering golf courses and public parks; and (3) underground injection to repel salt water intrusion.

Supplementing potable supplies with treated wastewater has been successfully practiced, but drinking water should preferably come from a clean supply.

ECONOMICS OF REUSE

The major costs of both water supply and waste treatment are in the distribution system, plant structure and interest on borrowed money. Only a quarter of the cost of water supply and waste disposal can be attributed to treatment. Part of the cost of water reclamation can be charged to pollution control, but the benefits derived may well exceed the cost of obtaining it.

POLITICAL AND SOCIAL CONSTRAINTS

In the past water supply and waste disposal have often been managed by separate divisions of local government. This has today been changed in many cases. At any plant the water quality at the intake is affected by the pollution from upstream, while the wastewater effluent may affect downstream communities. Management on an area basis is a step in the right direction. Present day wastewater management systems, however, will need to be revised if wastewater reuse becomes common.

Advanced measures of pollution control and wastewater reuse require enforcement of regulations and reliable treatment plants and operators. The shortage of trained operators is a world-wide problem. When a wastewater treatment plant is producing a product for reuse, its operation will have to be top flight. Otherwise, an adverse economic impact will result.

HEALTH RISKS

One of the primary public health considerations for the proper sanitary treatment and disposal of municipal wastewater has always been the prevention of communicable diseases caused by enteric pathogenic microorganisms or diseases caused by toxic substances. Those who plan the reuse of wastewater must be fully aware of potential health hazards, and precautions must be observed.

SUMMARY AND RECOMMENDATIONS[1]

For purposes, such as irrigation, industrial cooling and processing, the watering of golf courses, and the provision of recreational and landscaped lakes, wastewater can be, and has been, used safely after suitable treatment.

Water uses should be graded according to the degree of purity required and allocated in such a way that water of high quality is not used for purposes that can tolerate a lesser degree of purity. By grading and reusing effluents for low-grade purposes, great savings can be made in the use of potable water.

However, when the intentional direct or indirect reuse of wastewater is planned, the following conditions should be insured:

(1) Water quality standards appropriate to the reuse should be formulated and rigidly enforced.

(2) As a guide to governments wishing to formulate national standards, international agencies such as the World Health Organization should develop reuse standards for various purposes, including food preparation and the watering of agricultural crops.

(3) Full knowledge should be maintained of each water source, whether a natural body of water or wastewater, so that treatment may be adequately designed to allow for possible fluctuations in quality, account taken of potential health risks, and adequate safeguards taken to insure the safety of workers and consumers.

(4) Laboratory facilities should be adequate for monitoring and testing purposes appropriate to the proposed water use. For certain complicated test procedures, involving special skills and equipment such as are needed to identify viruses or organic trace materials, it may be sufficient to provide facilities on a regional or area basis.

(5) Reuse systems should be designed by qualified engineers experienced in chemical coagulation, high-efficiency filtration, carbon adsorption, reverse osmosis, and ion exchange, appropriate combinations of which make it possible to reduce nearly all contaminants in wastewater to concentrations found in natural unpolluted sources. Operators and supervisors of these systems should be highly competent.

(6) The safe disposal of sludges, slurries, and brines, which may be highly dangerous to handle, should be taken fully into account both at the design stage and in operation.

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[1]Excerpted (with the express permission of the World Health Organination) from "Reuse of Effluents: Methods of Wastewater Treatment and Health Safeguards", World Health Organization, Technical Report Series, No. 517, Geneva, 1973.

Existing natural sources of drinking water in several parts of the world already contain industrial and municipal wastewater in proportions that may approach 100 percent in periods of low flow. The degree to which this unintentional and indirect reuse affects existing sources should be determined and appropriate measures should be taken, particularly in critical areas, to insure the safety of drinking water.

Further research is required in the following areas, in which the present state of knowledge is known to be insufficient:

(1) The potential long-term health effects of trace materials and residues remaining after conventional water treatment.

(2) The improvement of methods of identifying, measuring, and monitoring chemical and microbial pollutants. Rapid identification of bacteria and viruses is required, and there is a need for a means of economically monitoring chemical pollutants by simple field tests.

(3) The development and improvement of treatment and separation processes suitable for use in many parts of the world.

(4) The practicability and cost of dual water systems for first and second class waters. Dual systems may become a necessary feature of water management in the near future in some areas, and investigations should be undertaken concerning health hazards and their avoidance.

The World Health Organization should encourage the standardization of present analytical methods.

Water supply, waste disposal, and water reuse are intricately interrelated activities, usually affecting more than one population group and several geographic areas. Where applicable, the establishment of regional multipurpose authorities having control of both water resources and water treatment may be the best solution to the management of these activities.

Water reclamation and reuse may be the most practicable solution to water shortages, and are likely to be forced on governments in certain areas with increasing urgency. They present no insurmountable technical problems, although more knowledge will lead to economies and greater reliability. Reclamation is a practical solution to water scarcity in most conditions, provided that adequate precautions are taken in the design and operation of systems to protect the health of the individual and of the community.

The potential for reuse of treated municipal and industrial wastewater is high and the outlook is encouraging. At present the technology of reuse provides important savings; approved technology should yield significant gains in water management and conservation.

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CRITICAL ENERGY-WATER ISSUES RELATIVE TO THE ENVIRONMENT

by

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My objective is to introduce the topic of critical issues in the energy-water area as pertain to the environment in the South Atlantic-Gulf, Lower Mississippi, Tennessee region. The states included in this region are Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee. It goes without saying that my task is quite difficult, if for no other reason than only because there is so much variation in the water resources within the region and the physical variation of the region itself.

One encounters states or areas in the region where primary focus may be on water resources in the coastal zone as well as areas which are concerned predominantly with interior river basins. Some streams are highly developed, whereas others are utilized to a lesser degree. One must deal with very large rivers such as the Mississippi as well as the smaller headwater rivers found in the mountains and the Piedmont and all sizes in between.

Obviously, my remarks will reflect my own personal experiences, research, and work in the region; but there are several issues which are more or less common to the entire region. Hopefully, these introductory remarks will provide the intended catalyst for further discussion of energy-water issues relating to the environment in the region.

The theme of this year's UCOWR Annual Meeting is "Energy, Environment, and Water Resources," a timely and challenging theme I am sure you all will agree. I am quite aware of the diversity of energy sources and fuels including coal, oil, gas, water, nuclear, etc. A utility official recently cited an additional potential fuel that seems to be present all around us, not in dwindling supply but in geometrically increasing supply. He was referring to the paper which forms all of the environmental reports, license applications, studies, reports to regulatory agencies, etc. It was not stated how many megawatts capacity this could support.

A great deal of effort is going into investigating the energy-water-environment area by the various energy production companies and agencies. A lot of money is being spent; and much manpower from utilities, trade associations, regulatory agencies, the academic community, research and development groups, and consulting firms is being devoted to this topic. Mention was made to me recently that, to get a certain power generation facility on line, it required the utility to touch base with over seventy agencies from the local to the federal level. Obviously, much good comes from this as well as much exasperation and duplication. This in itself is a problem area frequently cited.

I am aware that much energy is consumed in our region and in the nation in forms other than electrical energy. My focus, however, will be on production of electrical energy, as this seems to impact or has the potential to impact upon our water resources much more directly throughout the region. While other activities, e.g., current and prospective exploration for and production of oil and gas offshore and coal mining, can or do impact on our environment and our region's water resources, I only mention them in passing. They, too, to a great extent, are related to the production of electrical power and are linked to its demands. Likewise, there is a very clear linkage between the capacity to generate electrical energy and the availability of fuels such as coal, oil, and gas. For example, if a hydropower facility goes off line, there can be much activity devoted to finding more oil or gas to provide the lost peaking power capacity from other facilites in a system.

Clearly, the great bulk of electrical energy in our region in the foreseeable future will be from thermal (fossil-fired or nuclear) generating facilities. A variety of new technologies may or may not prove feasible, and the time at which they would become operational must be very questionable. In our region, the Southeast in general, nuclear generating capacity in operation, under construction, or announced is much greater in proportion to our population or area than in other regions of the nation. Clearly, many important issues involving the energy-water-environment interface will relate to thermal electric power generation.

There are a number of energy-water-environment issues, problems, topics, etc. Many of these have been fully or at least extensively discussed and argued in the literature and at numerous specialty technical conferences. This meeting need not be a forum for rehashing them. I would much prefer to simply mention or acknowledge a few in passing and move on.

One of these is thermal discharges which can cause some problems or changes in lakes and streams, alone or due to temprature-dependent interactions. We need not delve too deeply into this at this meeting. A great variety of predictive models and approaches for studying thermal plumes and effluents from thermal generating facilities exists. Most of these tend to emphasize the hydrodynamic and physical transport aspects as opposed to overall environmental effects. Perhaps that would be too much to expect from a single tool or technique and could be subject to misuse in oversimplifying complex systems.

As streams or reservoirs are artificially warmed, changes will surely occur in aquatic species, numbers, diversity, productivity, etc. Some of these changes are very subtle and are not, or might well not be, visible to the average person or maybe to most "water resources" practitioners. But they may have far-reaching effects on the aquatic community, very localized or extensive depending on the situation. The question is, how "bad" are the changes if indeed they are deemed to be bad? Are the effects acceptable in the altered water resources system? What are the energy-water-environment tradeoffs; and what are the associated costs and benefits, tangible and intangible? We need solid, definitive information on which the public(s) or their representatives can make wise and sound decisions.

The domain of technical or scientific dogma is more comfortable than the sometimes fuzzy and always frantic real-world environment where alternatives are proposed and their associated merits ascertained and values sought. The goal, difficult as it may be, is synthesizing and integrating things and determining the best mix for a specific situation or class of situations.

Another problem being faced by many at the energy-water-environment interface is fish impingement and entrainment. This is a tough and very visible issue. How many fish of various species will be killed by intake and discharge structures, going through the generating facility or condenser, etc.? How many would have made it to maturity anyway? Of course, we have to put costs on this. For example, assume that a certain percentage of a reservoir would be circulated through a generating facility annually. This is estimated to contain a certain number of tiny fish, and a certain number are estimated to be killed in excess of those that would not have survived anyway. A replacement value is sought, perhaps the cost of a hatchery providing a fry-sized fish. Multiplication can yield a damage or environmental cost of sorts. If this should happen to exceed our gross national product, for example, some assumptions would have to change to yield a more "reasonable" figure. This has been cited simply as an example of what we face. It may be that the commercial or sport fishing interests might not have even noticed any effects of the losses; maybe they would have. Experts can argue all sides of this and other energy-related questions with abundant evidence and data.

Another problem is the matter of water quality changes in impoundments and conventional hydropower facilities. One could get a variety of environment-related problems. This topic has been treated at length; and some techniques have been developed to predict, with varying degrees of success, the effects of power impoundments and cooling lakes as well as engineering measures or modifications to decrease adverse effects. One can get into complex situations in a single reservoir or lake and even more when one encounters a series of hydropower reservoirs along a river.

The effects on water quality of operating pumped-storage hydropower facilities is a challenge that looms before us. There could be some far-reaching effects that might develop and be identified as more and more go on line in the near future. A number of such generating facilities are in operation, under construction, announced, or being sited now in this region. There are a variety of principal configurations with the upper pool connected to a flowing river, an impoundment, or an off-stream lower pool. Each type possesses its own peculair environmental factors or features.

In this region, there is limited potential for additional conventional hydroelectric generating facilities. As mentioned above, there are a number of pumped-storage facilities in operation or planned to provide some of the needed additional peaking power, which is probably the major value of hydropower in systems in this region today.

As the "energy crisis" has come upon us, we have heard much more of the virtues of dams and impoundments for power generation. There is one somewhat controversial mainstream dam project which will inundate thousands of acres of land but will generate only a small fraction of the energy that a particular planned pumped-storage project will with a surface area of only a few hundred acres. One utility official recently indicated that, if they impounded all the rivers in their entire service area for conventional hydropower, it would meet their projected increased demands for only the next eleven months.

Hydroelectric power generation was a major project purpose back in the "early days" of water resources development. Then purposes such as recreation came along which have led to decreased pool flucturations, etc. The "system" was somewhat responsive to changing demands and the needs of society. Now the energy crisis has arrived, and more tradeoffs will be required. Perhaps there will be an increased utilization of exisiting facilities for power and a decreased emphasis on recreation. Growing populations and economic development are calling for more water supply utilization from energy-producing hydro facilities. The situation becomes tighter as we look into the future.

We in the academic community have, in my opinion, a very heavy responsibility to acquaint our students, the leaders and decision makers of tomorrow, with the complicated tradeoffs involved. We must make sure they are aware of the constantly changing needs and desires of society as relate to water resources. It used to be that these changes manifested themselves over maybe a generation or at least a number of years. Today, they can be evident in months or maybe even days. If the oil is shut off, do you or they want a full recreation pool or electric lights? We who are shaping the decision makers of tomorrow and the technical advisers to decision makers even sooner must see that they are prepared to deal with complex energy-water-environment issues and the tough tradeoffs. This will involve more than simply the water resources "professionals," but this will be discussed later.

It has been said that at least certain areas of our region are in good shape compared to other parts of the nation electrical energy wise and should be in an even better posture in the not too distant future as facilities now under construction get on line. We face a challenge as to how we use this relative abundance of energy. We can use it wisely so the effect on our environment, direct and indirect, will be minimal or acceptable through planned, selective, orderly growth or in unbridled economic development and urban sprawl. Land use may be the key. The old cliche "water and related land resources" may have more meaning than ever before with energy being the catalyst that brings land, water, human, and all other resources into intimate contact as never before.

Perhaps the major impact of energy and water as pertains to the environment will not be from power generation, per se, but how we use the energy that we will have. Included are factors such as what sort of industry we bring in or allow to come in, how our cities and rural areas develop, the size of the population in the region, water-related recreation development, etc., i.e., the things that are made possible or precluded by having energy, either an abundance or a tight supply relative to other regions and even elsewhere in the world.

Utilities are in the business of generating and supplying electrical energy. Recreation, water supply, etc. are very welcome and desirable sidelines that go along with power production. As needs for water supply, recreation demands, and other factors cause more constraints on power generation, the utilities could be in a real squeeze. The energy they produce affects the environment in many ways. One of these is the visual impact of a very low water level in power-producing reservoirs and the ramifications on recreation. I would like to get into aesthetics and visual impact, but am trying to stay with the water environment.

A publicly owned system may be able to reallocate water from its reservoirs much more easily than a private utility whose charter or mission is to generate and supply electric power. It is, of course, expected that even they (the private utilities) will generate their power and utilize our resources in an environmentally responsible and socially responsive manner. Everyone is willing to adjust and be good neighbors or good corporate citizens as long as it does not signficantly and adversely interfere with their primary mission(s). This observation applies to all industry and agencies, public and private, power-related or not.

There are a great number of other energy-water-environment issues and problems. Included would be effects of radioactive releases, within or in excess of limits, on streams, reservoirs, and the aquatic community as well as public water supplies. The management of nuclear wastes from power production is another issue. Leaks in engineered long-term storage or other storage methods being used or under consideration could affect surface and groundwater resources. Removal of particulates from stacks at coal-burning generating stations can create potential sources of adverse effects on our water resources and the environment.

Now that we have narrowed our focus considerably to electrical energy generation, perhaps we can concentrate even more on an issue that is of common interest in the region. There are a variety of actual and potential environmental issues relative to power generation and water. Perhaps none is of greater import today than the topic of how to handle or manage condenser cooling water from thermal generating facilities, nuclear and fossil-fired. Alternatives include once-through cooling with river water, cooling ponds, multipurpose cooling lakes, and off-stream cooling, either closed cycle or cooling prior to discharge.

The U.S. Environmental Protection Agency (EPA) has taken a rather strong posture in this region which tends to favor and encourage off-stream cooling, e.g., cooling towers and other systems, as opposed to lake cooling without any cooling prior to discharge. Once-through systems on rivers would seem to be a thing of the past for today's and tomorrow's large generating facilities.

This action has caused the utilities, or many of them, to back off on planned or already constructed lake sites. There will definitely be more cooling towers and fewer lakes, strictly for cooling of "multipurpose," in the near future. Various sources differ as to whether this is a short- or long-term situation. But the utilities are not likely to waste what they consider to be good existing lake cooling sites if they have to install cooling towers or other off-stream cooling devices. At least for now, they are holding them and locating on river sites in the hinterland.

As would be expected, sources differ as to the merits of lake cooling or once-through cooling versus off-stream cooling. One can get a somewhat different picture as to total water consumption, costs, environmental effects, etc. from regulatory agency, power industry, and off-stream cooling equipment manufacturing personnel.

Fewer multipurpose cooling lakes means less potential for flow augmentation and other beneficial uses downstream. It also means less reservoir-type water-related recreation. It has many other implications, some favorable and some unfavorable. One's affiliation, e.g., power industry, regulatory agency, etc., tends to affect what one considers to be "favorable" and "unfavorable."

We certainly cannot have an indiscriminate proliferation of cooling ponds or multipurpose cooling lakes. The potential for recreation benefits drops off as more and more lakes are built. Whereas there can be potentail recreation, water supply, and other benefits from multipurpose cooling lakes, there are none for cooling towers and minimal potential at best for strict cooling ponds.

Damming up rivers and streams certainly affects the diversity of our region's water resources. We need some reservoirs, and we need some free-flowing streams. We need cold-water fisheries as well as more warm-water fisheries. Different people in the public have different preferences and desires. The variety of needs of the public(s) has to be considered as decisions are made about our water resources and how they will be utilized for power production. The implications relative to land use, public participation, and tough tradeoffs are again inescapable.

Off-stream cooling, as in all other forms of environmental protection or control, requires energy. You either lose energy or have to build a bigger generating facility to get the same energy output for consumers. This requires more energy to run the cooling towers and might consume more water. Another effect is that more fuel is consumed, and tight capital funds are expended.

Utilities in the region seem to be going along with regulations for off-stream cooling, for the most part due to the need to get scheduled new generating facilities on line and avoid prolonged delays of indeterminate length due to negotiations with regulatory agencies. Retro-fitting of certain existing generating facilities as now required may be another ball game. I do not see how very many really productive existing facilities are going to be shut down in the face of our energy problems. There is, then, the potential or prospect of the utilities' adopting a different posture relative to retro-fitting existing facilities as compared with equipping new facilities with off-stream cooling.

As mentioned previously, there is probably a current tendency to scatter new thermal generating facilities around on rivers where adequate water is available for cooling tower makeup and blow-down. These consumptive water uses can represent an appreciable proportion of the flow, or at least the low flow, in a river. This applies to fairly good-sized rivers as well as to smaller ones. I heard of one site under very serious consideration with projected consumptive use for towers in excess of the historic low flow of the stream. And this was a major stream.

In a certain area, let us assume that there are now so many thermal plants with "X" megawatts total generating capacity. There will be consumptive losses for cooling whether one uses towers, ponds, once-through cooling, multipurpose lakes, or whatnot. Some people are becoming concerned. Look on into the future over a reasonable planning horizon. In so many years (8, 10, 12, it makes little difference), there will be more thermal plants with "2X" megawatts of capacity using or consuming a lot more water for cooling. On a few more years, more thermal plants with "4X" megawatts capacity using much more water. This is not that many years hence. It is within the lifetime of most of us here. We and the water resources professionals produced by our universities will have to cope with this.

The potential exists, then, for cooling water requirements to have a major impact on the quantity of flow in our region's rivers, whether or not off-stream cooling is required or encouraged in the long term. The implications on the quantity and quality of our water resources and the multitude of beneficial uses made of them are indeed signfiicant if not staggering.

Consider some hypothetical river in our region. Let us assume that the Federal Power Commission requires a certain minimum release from a reservoir on the river. Upstream from the reservoir, there are now two thermal generating facilities with cooling towers which consume, say, a total of twenty percent of the seven-day, ten-year low flow of the river. In ten or twelve years, there may be four generating facilities consuming a total of fifty percent of the low flow. In another ten or twelve years, what do we have? What if the minimum releases from the reservoir cannot be met or can be met only with "excessive" drawdowns in the drought period? What about other users of water above and below the reservoir? If we do not already face challenges of this nature today around the region, they could certainly develop. While the effects may be more pronounced or develop sooner in smaller rivers, they could ultimately face users of water resources on even the largest streams.

I have heard it said that what water is evaporated or consumed by cooling in one basin will return as more rainfall in another basin and that everything will tend to even out. I have a feeling that there could be some severe localized if not regional problems, however. This is a topic which has received much discussion and warrants further consideration.

I have previously alluded to the tendency to scatter thermal generating facilities as reservoirs, thought by utilities to be able to accommodate or support several facilities, are not now being used to the planned extent.

There are some serious questions regarding the matter of scattering or concentrating energy production facilities. There has been and is still consideration of "energy complexes" with multipurpose hydropower and cooling lakes, several nuclear generating facilities, maybe a nuclear fuel reprocessing plant, etc. Current requirements which discourage lake cooling have tended to decrease near-term prospects for such energy centers. Supposed excessive warming of too much of the lakes' surface area or volume, national security overtones from concentrating energy production facilities, potential danger to the public from having so much nuclear activity concentrated, and other factors have been mentioned.

There are some obvious benefits from concentrating energy production facilities. Economies of scale might enter the picture. Regulation and environmental control might be more easily accomplished. There could be less transport of spent nuclear fuels around the countryside. Other advantages could be cited. As in any other matter of consequence in the energy-water-environment matrix, there are no simple generalized answers.

There is a very real linkage between energy-water-environment matters and economic considerations. The costs of environmental control, generating equipment, construction, fuel of all types, etc. have increased greatly in recent years. These increases are being passed on to the consumers. Many persons consider that energy in general, including electrical energy, has been underpriced in the past. Cheap energy is a thing of the past. As the total social cost of all forms of energy tends to be more effectively incorporated into all goods and services, we are likely to see changes in consumption patterns develop. Many of these will impact, directly and indrectly, upon the environment and our region's water resources.

Today money is tight whether it be for building generating facilities, municipal wastewater treatment plants, and everything else in the private and public sectors. Interest rates are high, funds are impounded, and a lot of people are nervous about their investment decisions. It has been stated that a five percent increase in the capital cost of a new thermal generating facility for off-stream cooling is reasonable. When you add on the increased cost for making the generating facility larger to cover the energy used in cooling plus other operation and maintenance costs, this can mount up. We may have to choose whether to put cooling towers throughout a service area or to be able to build another energy generating facility. Again, we encounter tradeoffs. In a tight-money environment, they become even more difficult to make.

Mention has been made on several occasions of tradeoffs and decisions facing us here in the region relative to energy-water-environment matters. I have also said that the "professionals" should not and cannot make the decisions alone. This gets us to one last topic -- public participation and citizen involvement. Like water resources development, energy production is or should be in response to legitimate social needs. At the outset, I hope you will not confuse the usual stereotype public hearing with effective, meaningful public participation.

In my mind, the public can participate in energy-water-environment matters in two major areas: (a) by determing how much energy will be needed; and (b) by getting involved in the selection of sites and technologies utilized to produce the needed energy.

The doubling time for electrical generating capacity has been maybe seven to ten years and dropping recently. With energy conservation measures being advocated and a population growing at a declining rate, you heard about doubling times of maybe ten or twelve years or longer. It is a possibility that there will be shifts from other types of energy to electrical as the oil scare permeates the system. This could tend to counter those factors which might have led to a declining rate of growth in electrical generating capacity. There should be a shift in usage of energy in general including electrical as the public decides not only how much energy they can and will use directly but indirectly as well through consumption of all goods and services.

They, the public(s), are the ultimate decision makers and will, or certainly could, decide how much energy is to be produced. This will, in turn, impact significantly on environmental factors associated with energy production. A question to be raised is whether those decision makers in both the public and private sectors are really and sufficiently aware of this, are properly considering this, and to the appropriate extent. Can the mechanisms of today and tomorrow work to get this input to the right place here in our region?

The second point, i.e., alternate sites and technologies, requires a bit more comment. We must have an informed, rational, constructive, involved, educated public or publics. Along with this, we must also have sensitive and perceptive technical people and water resources professionals who can function in an environment calling for effective, meaningful public participation. There is a real challenge to us in the universities, as well as those technical personnel in agencies and utilities, to educate the public so they can make meaningful, constructive, informed inputs in considering alternate sites and power production technologies. This is a long-term give-and-take proposition that should be worthwhile to energy-producing agencies and utilities as well as the public in achieving more acceptable, socially responsive, and responsible energy development.

In order for us to obtain informed, constructive public input in the alternate sites and technologies area, the effort must be initiated early in alternative definition phase (with one viable alternative always being to do nothing). The effort must be continuous through the multiple evaluation and screening phases and on to final implementation.

A public that is not informed and not involved in such matters may have little choice but to object and intervene. But if they have been a real part of the process, they have a better feel for why the energy production facility is needed, why it is going where it is, and why the particular technology is to be utilized. This would be a highly desirable end result, and there are some success stories. To achieve them, there must be a real commitment on the part of both the agency or utility and the public(s) or their representatives to deal openly and in good faith.

The public is going to continue to require energy. The question is how much and what kind. And the energy has to be generated or produced somewhere. It cannot all come from "somewhere else" and impact on "someone else's" environment and water resources.

I could continue to discuss or introduce these and other issues relative to the energy-water-environment situation in the South Atlantic-Gulf, Lower Mississippi, Tennessee region. In closing, I would call to your attention and emphasize several common thoughts which have appeared in my presentation as well as others at this meeting.

Some of the are: (a) the need for improved power plant siting techniques and procedures; (b) the great importance and implications of land use considerations; (c) the urgent need for more effective and meaningful public participation; (d) the necessity of looking forward and planning in a comprehensive manner to control our own destiny more in the region; (e) the fact that land, water, energy, environment, people, economics, etc. are all realted and inseparable; (f) that our mechanisms and institutions must be able to accommodate the challenges we face or to adapt; and (g) the tough tradeoffs we are all going to be called upon to make relative to energy, water, and the environment.

INSTITUTIONS AND POLICIES AFFECTING ENERGY, ENVIRONMENT, WATER

by

Ronald M. North
University of Georgia

The energy, environment, water interrelationships are intuitively apparent but most difficult to comprehend in their real world complexity. If energy, environment and water (including land) are considered jointly and fully by our institutions and policies, there is a great risk of stalemate in the development of better institutions and policies and in the general economy. However, the larger risks of stalemate are from the generation of conflicting and competitive institutions and policies in our great haste to save and protect or to exploit our favorite resource. I think we need to look upon the three resources considered here - energy, environment and water - as a disaggregation of the older more general concept of "land." The traditional concept of land embodied all the resources attached to, stored in or emanating from the land, including the rights thereto.

The first disaggregation of land was into the two concepts of land and water, sometimes referred to now by water interests as "water and related land resources." We also treat minerals and forests as special aspects of land just as we are inferring today that energy and environment are special aspects of land. I am bringing this concept of land to your attention because land use is basic to any consideration of institutional and policy questions. Land use, land ownership and land control are the issues for this workshop on energy, environment and water.

If we consider the three crises of our generation chronologically they would include: first, the great water concerns of the 1950's; second, the environmental concerns of the 1960's; and third, the energy concerns of the 1970's. I do not wish to claim any clairvoyance, but we could very well generate a minerals or timber or food crisis in the 1980's. However, it seems more likely that a general land crisis will develop, given our emerging concern for and sensitivity over land use planning.

Perhaps you are asking by now why one would introduce a fourth dimension to the three already complex dimensions of energy, environment and water--the assigned topics for this conference. We cannot adequately consider the subsets without considering the set. In the case of any discussion of institutions and policies, we must look at the more unifying concept of land from which our existing energy, water and environmental institutions and policies have been derived and with which any new policies will either conflict or complement.

The basic meaning of "institutional" is that which is highly organized. This may include a set of elementary principles which are recognized and authoritative or an established law, custom or practice. It may also include an established society or an organization to promote art, science or a specific course. Policy is defined as government or the science of government, but this usage is now rare. The second definition (prudence and wisdom in the management of affairs, sagacity, shrewdness) is important, but like the first, it is not part of our current usage. The third and fourth definitions of policy are those we accept and understand today. The third says that policy is management or procedure based primarily on material interest, rather than on higher principles. The fourth suggests that policy is a settled course adopted and followed by government or an organization or an individual.

If we develop a working definition of the institutional, policy aspects of energy-environment-water relationships we might define institutions as those established policies and organizations we take for granted and policies as today's operating procedures, committees and commissions. We now can look at some institutional and policy issues specific to energy, environment and water in the southeast (the South Atlantic Gulf, Lower Mississippi, Tennessee river basins).

The situation we now have by definition and inference is that our institutions are being attacked by our policies. The basic strategy is to discover or create a crisis, then policy and committee our institutions to death.

Permit me to outline briefly some of the basic institutions which have shaped our policies on water-energy-environment issues:

(1) ownership-private, public, res commes, res nullis;

(2) eminent domain - a private ownership restraint in favor of land (water-energy-environment) use for public purposes when necessary and with compensation;

(3) policy power - a further restraint of private rights which may abuse other private or public rights, source or regulation, licensing, zoning, etc;

(4) taxation - affects use, development, transferability of resources;

(5) expansion - economic growth, increasing gross national product.

The policies which have developed within these institutions have been chiefly those affecting agriculture, transportation and energy. We have supported cheap food, cheap shipping, cheap water and cheap energy policies for many years. We have heavily subsidized these aspects of our economy both by direct grants of lands and monies and by indirect grants of tax relief, employee training, eminent domain power and "favored status" taxing and regulation. These protectionist and subsidization policies, as they became institutionalized, have each generated their own crisis in their own time. In addition to the individual problems of transportation, agriculture, water and energy, all of these sectors of the economy have impinged heavily and often adversely on the environment. In fact, it was the uncontrolled excesses of government and private development of our water, energy and land which led to the National Environmental Policy Act of 1969, "Earth Day, 1970", reaffirmation of citizens rights and standings, and the thousands of legislations, rules and regulations affecting and noticeably slowing all of the traditional development and growth institutions. The cheap water policy bore the frontal assault with attacks on "dam building", "channelization" and "industrial pollution".

The Southeast was particularly vulnerable to this attack on the water resource and growth institutions. The Southeast had an abundance of such institutions as TVA, the Corps, the SCS, state and local economic development departments, public utilities and industries, all with projects completed, under construction or planned to either provide cheap water and energy or to take advantage of its availability. There was even the publication of a briefly popular but unscholarly publication called The Water Lords by Ralph Nader Associates. The report dealt generally with industrial exploitation and governmental license in the use of water resources, although it was specically drawn from industrial development cases in the Savannah River Basin and Coastal Georgia. Florida had the famous Miami International Airport-Everglades case as well as the Cross Florida Barge Canal. The Gulf states had their own Tennessee-Tombigbee delays and offshore oil, water and energy development problems. South and North Carolina both faced environmental restraints on hoped for development by B.D.A.S.F. (a chemical conglomerate) and TVA (the Upper French Broad).

The questions of energy, water and environment which now confront us in the Southeast are heavily biased toward the institutional-policy complexities. One purpose of this paper is to suggest the kinds of institutional-policy questions UCOWR member-universities may address in their teaching, research and advocacy or service programs. The water-energy-environment related problems in the Southeast may be listed as those of:

(1) continued structural development in the river basins (reservoirs, locks, industries and effluent disposal systems;

(2) development of coastal and/or deep water refineries or ports;

(3) offshore oil and mineral exploration and mining;

(4) coastal zone management, including land reservations, land use planning and control, groundwater-salt water interface management and control and residential-tourist developments;

(5) development and siting of hydro, fossil and nuclear power generation facilities;

(6) energy distribution systems including the possible development of utility corridors and underground systems to alleviate the massive land and resource wastes, inefficiencies and property abuses of today's helter-skelter, unplanned lives;

(7) state and local government organization to deal effectively with land-water-energy-environment and questions raised by federal and industrial interests, viz., how can the southeastern states organize to adopt a position or their own master plans for water and energy development projects in response to the existing random project by project positions forced on them by federal and private interests;

(8) shaping the state's own destinies through the use of land-water-energy relationships to develop state goals for economic development, environmental quality and social prerequisites.

Each of you can add to or delete from this shopping list of problems facing the Southeastern river basin states. However, my purpose is to relate these problems to the institutional and policy conditions necessary to deal with these and associated problems.

I would like to remind you of some of the new institutions and national or citizen policies which are requiring new state policies to deal with them. In the absence of effective state policies, only chaos and crisis responses can be expected in our land, water, energy and environmental development. In the absence of a definitive study, may I mention that to my knowledge only Mississippi has made any serious effort to deal with the questions of water rights or to solve the serious economic uncertainties of existing riparian doctrines in the Southeast. Likewise, Florida has the only statewide example of legislation dealing with land use planning. Georgia has an embryonic state Heritage Trust Foundation to provide some identification, development and protection of natural and historical areas. Largely, we are still depending on understaffed, fragmented agencies, bureaus, commissions and common-law grievance provisions to deal with the new order of expensive food, expensive transportation, expensive energy, declining land reserves, declining environmental reserves and more expensive privacy.

What new institutions or policies should we be researching, developing or supporting to enhance our land-water-energy and environment? This shopping list is not intended to be specific in details nor on priorities, but rather to suggest the new institutions which are developing with or without the university and scientific inputs. Briefly, our institutions must be restructured in the Southeast to permit:

(1) increased citizen participation at earlier stages of project planning, viz., at the conceptual stage where priorities are set and relative needs balanced;[1]

(2) increased provisions for and acceptance of recycling of resources;

(3) development of the public trust doctrine of land, water, energy and other natural resources either through public ownership, easements, zoning, user taxes or more stringent limitations on private property;

(4) increased emphases on public access to natural resources and related non-price allocation systems such as reservations, lotteries and permits;

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[1]A local case in point occurred recently in Athens where a largely secret (blue ribbon committee) plan for a new airport was defeated 5 to 1 while a new city park and extensive bike paths were favorably supported when both sets of projects were to be more than 75 percent federally financed.

(5) increasing demands for more quality of life indicators such as net products discounted for environmental degradation and less emphasis on gross expansion (gross product) as evidenced through decreasing support for subsidized industrial development, through mixed income housing and more mini-towns containing jobs and bedrooms (the reverse of present zoning practices);

(6) increasing application of local cost sharing and user charges on all federally financed projects as resistance to higher federal and local taxes mounts along with larger governmental committments to programs, regulations and employees;

(7) increased watershed, river basin and regional or statewide land use planning and the institutionalizing of such organizations.

These new policies and institutions are expected to develop in response to the increasing scarcities of water, food, energy and environment as both technological and institutional solutions to abundance become more expensive and as people adjust to the less subsidized, more expensive amenities and necessities. Many people actually welcomed the energy crisis as a relief from the competition of maintaining 70-80 mph on the interstates, automobiles that wouldn't fit garages and half-acre lawns requiring weekly trimmings.

The result of all this is that the water resources research, planning, development and construction organization (including universities) will need to direct more of the public's resources to the development of policies, operating procedures and institutions which focus more on broader social goals such as environmental and general welfare and less on specific, special interests such as water for flood control or navigation or energy per se. We will also need to look more carefully at non-traditional alternatives for water and related energy development, especially for complenentary designs and combinations which optimize several goals as both water and energy supplies shift from largely stock sources (reservoirs, aquifers, fossil deposits) to flow sources such as stream recycling and solar fueling.

Water resources professionals have been very successful in developing supporting institutions such as the concept of flood control by structural measures and organizations such as irrigation districts, flood control districts and conservation associations since about 1900 to meet 20th century needs. They should be just as successful if the same efforts are devoted to the restructuring of these institutions and their policies to meet present and 21st century needs, especially those institutional mechanisms which will allow us to consider consequences and to select from available technologies. In the future water resources projects which increase energy consumption, limit energy production potential or degrade the environment will be a disservice to society. We should not wait for our policies on energy and environment to kill our institutions on water and land but restructure them quickly for compatability.

DISCUSSION REPORT

James C. Warman
Chairman
Auburn University

Maynard M. Hufschmidt
Reporter
University of North Carolina

Discussions in the workshop are presented in this report as they developed from four papers presented under the following titles:

(1) SELECTED PROBLEMS INVOLVING ENERGY PRODUCTION AND WATER SUPPLY IN THE REGION, by L. Douglas James, Georgia Institute of Technology.

(2) WATER MANAGEMENT AND CONSERVATION: THE ROLE OF WATER REUSE AND RECYCLE, by William H. Morgan, University of Florida.

(3) CRITICAL ENERGY-WATER RESOURCE ISSUES RELATED TO THE ENVIRONMENT, by Benjamin C. Dysart, III, Clemson University.

(4) INSTITUTIONS AND POLICIES AFFECTING ENERGY, WATER AND THE ENVIRONMENT, by Ronald M. North, University of Georgia.

The remaining undeveloped hydroelectric power potential is small in relation to demand. Its development will raise important land use and environmental issues. Existing developed hydroelectric power is increasingly being considered for conversion to other higher value water uses, for example, water supply and water-based recreation near population centers such as Atlanta.

In the Southeast fossil and nuclear fuels will be the major source of electric power in the foreseeable future. Although water resources in the Southeast were considered generally abundant in relation to demands, this will not be so in the future given the enormous water cooling needs of planned thermal power plants. Cooling towers and/or cooling lakes result in evaporative losses that will present increasingly serious problems -- locally in the upper reaches of the typical long narrow river basins and also, perhaps, regionally. Two important issues were raised:

(1) The current policy of the U.S. Environmental Protection Agency to press for cooling towers instead of reliance on in-stream cooling using man-made lakes imposes high cost and local adverse environmental impacts plus the likely increased evaporative losses from towers. On the other hand, sole reliance on cooling lakes and use of streams for cooling degrades streams and uses large land areas for the sizable lakes required. Research in specific southeastern settings is needed on the technical, economic and environmental questions.

(2) Power plant siting should be regulated on a state and regional basis with concern for land and water use and economic and environmental impacts. Utilities which plan and build plants need to have the now cumbersome permit and approval process simplified. Local and state agencies and the general public need to see the entire picture of power expansion and siting of plants rather than being given only a project-by-project opportunity to react. The project environmental impact statement process is not adequate to provide the regional overview.

Coal mining is the major industry in some sections of the Southeast. Major issues between strip mining and deep mining, including tradeoffs in safety, cost and environmental degradation, take on a different cast in the humid Southeast than in the semiarid Southwest. Reclamation and revegetation of strip mine areas is feasible in the Southeast -- failure to accomplish it is a policy or management deficiency that could be resolved through strict controls and imposition of severance taxes on coal to cover the cost of renovation.

Electric energy generation, offshore development of oil and transportation and refining of oil are energy-related problems facing the Southeast. Attendant policy issues remain an important area for research.

Almost all of the southeastern states share the common coastal zone problem. In planning for Coastal Zone Management under NOAA (and in N.C., S.C. and Ga., the Coastal Plains Commission), institutions and regulations are being developed which should provide a basis for dealing with emerging energy-water issues.

TWO IMPORTANT GENERAL FINDINGS

(1) The reaction to the energy crisis in Washington has once again demonstrated that, in the rush to adapt an overall national approach to solution of problems, important regional differences are overlooked. Whether this relates to power plant siting, strip mining vs. deep mining, or use of cooling towers vs. cooling lakes for electric generating plants, national policies and prescriptions may need to be modified to fit specific regional situations. Certainly this is true with respect to the Southeast. This fact emphasizes the importance of research on the specific items where regional differences are significant due to climate, topography, resource endowment, patterns of land use, and level and nature of economic development.

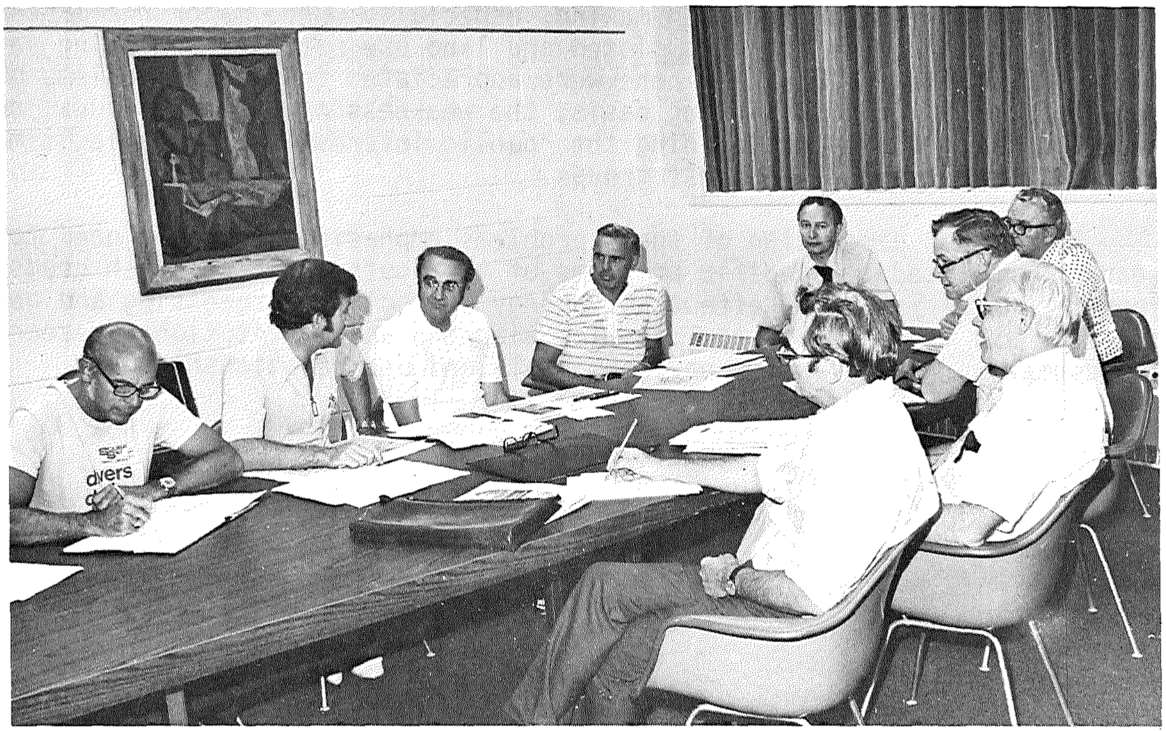
(2) The crucial importance of developing institutions at the local, state and regional levels to deal effectively with energy-water-land-environmental problems and issues was stressed. On the regional scale, the problem of building effective institutions for coastal zone management was identified.

At the state level, the need was discussed for effective land use laws, regulations and agencies to deal with power plant siting, oil-mineral (phosphate) extraction and processing, and control of urbanization including second-home development in mountain and coastal areas. Some states, such as Florida, North Carolina and Georgia, have made sound beginnings, but much more is needed.

At the sub-state regions, the development of the multi-county, Council of Government, or regional planning agency was noted as a positive trend; but, these have only begun to be useful -- and often yet only in metropolitan areas.

There was recognition of the need for effective and real public participation in planning and decision making, especially where major resources such as land and water are being committed and land use patterns are being set for the future. The difficulties here were appreciated including problems of getting people involved on a continuing basis, the weakness of the traditional public hearing, the problems of defining the "public interest," and the legitimate role of special and general interest groups.

Throughout discussion of these problems emphasis was on the need for research pinpointed to specific problems of the Southeast. Research needs ranged from technical issues of effects of energy extraction, processing and generation on water and land quality to economic, planning and institutional research in the context of energy-water-environmental-land use relationships.



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REGIONAL WORKSHOP

III - SOURIS-RED-RAINY, UPPER MISSISSIPPI, GREAT LAKES, OHIO

ENERGY PRODUCTION AND WATER SUPPLY

by

Merwin D. Dougal
Iowa State University

INTRODUCTION

Electric energy requirements in this region -- the Souris-Red-Rainy, Upper Mississippi, Great Lakes, Ohio River Basins -- have followed the national trend in large part. A six to seven percent annual increase has resulted in a doubling of power production every 10 to 12 years. Water is one of the primary factors of production in the generation of electric energy. It is the primary factor in hydroelectric plants. Since the bulk of electric energy is produced in steam-electric systems (fossil fuel or nuclear plants), large amounts of water are needed for condenser cooling purposes. Smaller amounts are needed for boiler feed or makeup and for periodic blowdown purposes.

This presentation will concentrate on the general aspects of energy production and water supply. Subsequent speakers will dwell on the management-conservation, pollution-environment and institution-policy aspects of the national and regional energy problem. The general availability of the water resource will be outlined first, the overall population and economic level of development considered second, and the water needs for energy summarized in the third section. The multi-region area of the nation considered in this workshop fortunately has an ample supply of water. This beneficial resource provides several alternatives in meeting future water requirements for energy production. Environmental controls will dictate in large part the cost of water-supply and cooling-water requirements, and the resultant cost to the consumer, in this area.

AVAILABILITY OF THE WATER RESOURCE

With the exception of the Souris-Red-Rainy Basin area, the remainder of this multi-region area receives a bountiful supply of water.[1] Although periodic droughts temporarily deplete the surface streamflow and annual runoff, the long term picture is bright. In addition, the physical magnitude of the Mississippi, Ohio and Great Lakes system provides a tremendous quantity of water for all beneficial water-user groups: energy production, water supply, water quality, control, watershed management, navigation,

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[1]The Nation's Water Resources, the first National Assessment, U.S. Water Resources Council, Washington, D.C., 1968.

recreation, fish and wildlife enhancement, irrigation, and related flood plain management activities.

The average annual precipitation varies from 16-20 inches in the Souris-Red-Rainy Basins to 40-48 inches in the upper Ohio River Basins. (Figure 1) The average annual runoff (as streamflow) varies from 1 inch to more than 20 inches in these same basins, with most of the region experiencing more than 5 inches. (Figure 2) In addition, groundwater is available in appreciable quantities, both from surficial aquifers in the glaciated central region and from bedrock aquifers in the sedimentary rocks. (Figure 3)

The average annual natural runoff from each of these basins is listed in Table 1, as extracted from the 1968 National Assessment.[2] These values show that there are substantial quantities of water available for energy production, if it can be shared equitably with the other beneficial uses.

POPULATION AND ECONOMIC FACTORS

Projections of both population and economic growth have been made by several federal agencies, primarily under the auspicies of the Water Resources Council.[3,4,5] The 1968 National Assessment shows only one population projection for the conterminous United States, increasing from 195 million in 1965 to about 340 million in 2000 and 468 million in 2020. This approximated the relatively high population growth rates of the period 1959-1965, or a value of 1.6 percent per year. Recent trends show the effect of modern birth control methods and a changing social-economic picture, and lower projections are being considered. The National Water Commission introduced four projections into its economic studies for the year 2000: 264 million, 279 million, 299 million and 318 million. Related changes in electrical demand should also be introduced, but the 1968 assessment data will be used in this summary.

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[2] The Nation's Water Resources, the First National Assessment, U.S. Water Resources Council, Washington, D.C., 1968.

[3] Ibid.

[4] Water Policies for the Future, Final Report, U.S. National Water Commission, Washington, D.C., 1973.

[5] Upper Mississippi River Comprehensive Basin Study, Appendix M, Power, U.M.R.C.B.S. Coordinating Committee, Washington, D.C., 1970.

[6] Water Policies for the Future, Final Report, U.S. National Water Commission, Washington, D.C., 1973.

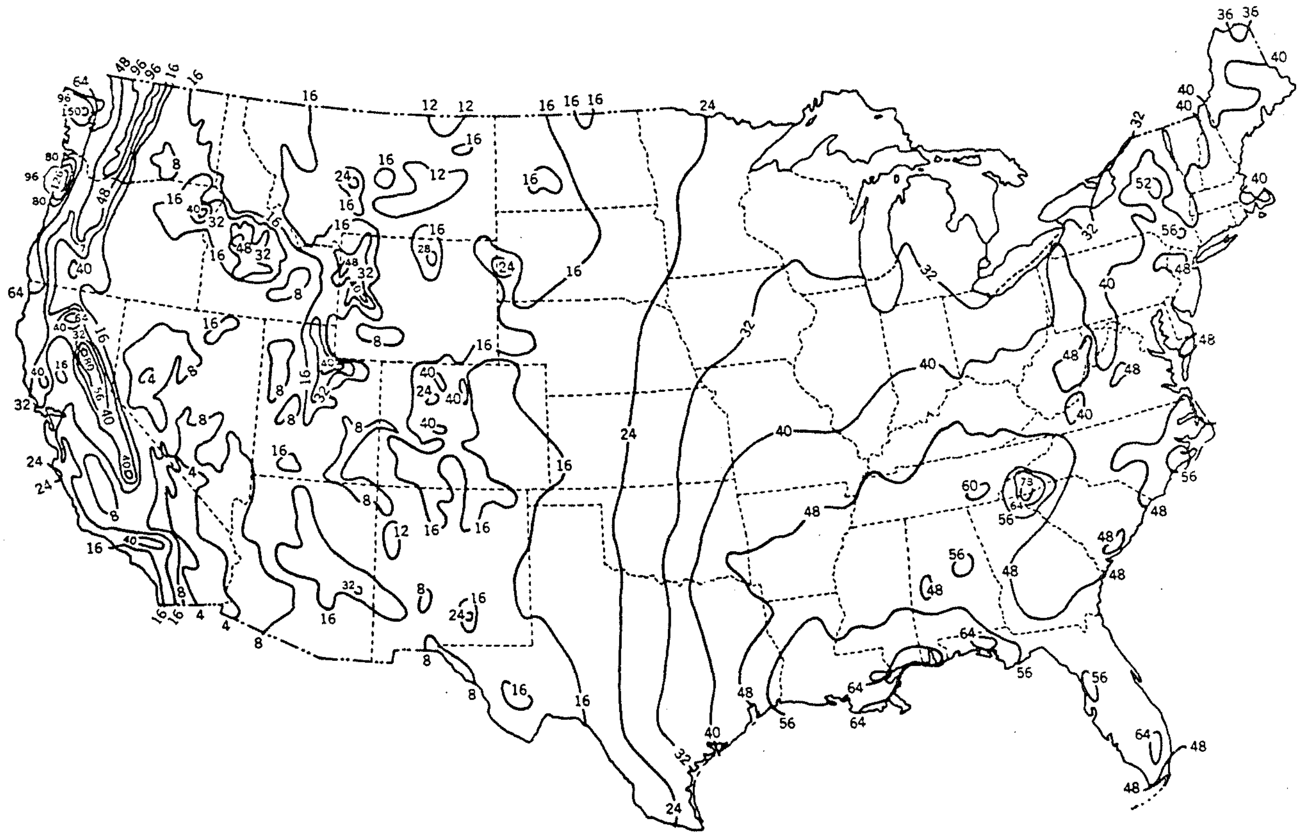

Figure 1

AVERAGE ANNUAL PRECIPITATION IN THE UNITED STATES
(from Linsley and Franzini)

Figure 2

AVERAGE ANNUAL STREAM RUNOFF IN THE UNITED STATES, IN INCHES
(from Linsley and Franzini)

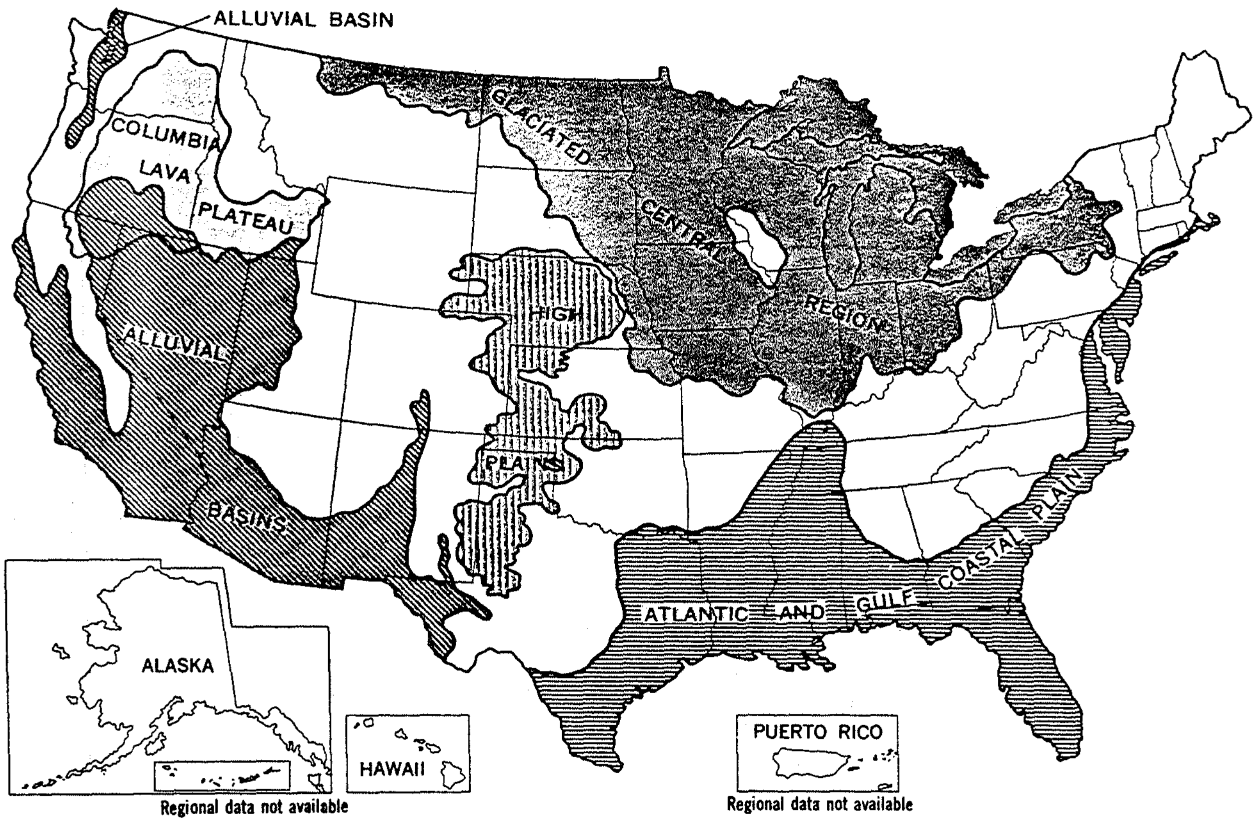

Figure 3

POTENTIAL AREAS OF LARGE GROUNDWATER RESOURCES IN THE UNITED STATES
(after Water Resources Council, First National Assessment)

TABLE 1

AVERAGE ANNUAL RUNOFF

Basin	Average Runoff, bgd	Average Runoff, million ac-ft per year
Souris-Red-Rainy	6.2	6.9
Upper Mississippi	65.	73.
Ohio	125.	140.
Great Lakes (land area only)	63.2	70.8
Great Lakes (total outflow, Lake Ontario)	153.	171.

Population data contained in the 1968 assessment are listed in Table 2. If the lowest rate of population increase is experienced (relative to the National Water Commissoin Study), then the 2000 population projections might be lowered by 20-25 percent. This will have a corresponding impact on electrical energy demand.

Additional economic factors should enter into determining the demand for water. Water needs will depend on two major variables: (1) demands for products and services obtainable from or with water; and (2) the cost of using alternative sources and processes for meeting such demands. Technological changes and potential innovations make long-rage forecasting difficult; this applies to all beneficial uses including the energy production category.

Projected water demands as extracted from the 1968 National Assessment are tabulated in Tables 3, 4, 5 and 6. A summary of the projected growth of utility generating capacity in the United States, as listed in the report of the National Water Commission is shown in Table 7. Forecasts made by the California Institute of Technology show that with a zero population growth, a 50 percent decrease in the present rate of growth in individual income and wealth, and a 50 percent reduction of the experienced rate of increase in energy demand, the national consumption of electricity will still triple by 1990. This compares with a quadruple effect in Table 7.

It should be emphasized that a substantial portion of the nation's population, commercial and industrail capacity are located in these basins included in this workshop discussion. The data listed in Table 2 show that 32 percent of the nation's population resided in this workshop area, as of 1960. A decrease to 27 percent is forecast by 2020, with the additional increase occurring in southeastern, southern, and western states. However, a 50 to 100 percent increase in the region's population by 2020 is the general range of the several forecasts.

WATER AND ENERGY PRODUCTION

Electric power production must satisfy residential, commercial, industrial and agricultural farm needs in this multi-regional area of the nation. This energy production will utilize substantial quantities of water if future demands increase at the rates experienced in the past several decades.

The organization of the power industry in the region consists of a mix of investor-owned utilities, public (non-federal), a few federal (arsenal locations), and cooperatives. In the Upper Mississippi River Basin, for instance, about 90 percent of the total generating capacity is by investor-owned utilities, 5 percent municipal and 5 percent in rural electric cooperatives, and only a minor amount in the federal sector (Rock Island Arsenal). The municipal systems are quite small in terms of the regional totals -- one-half have their own generating equipment and others actually purchase their power requirements. The cooperative consist of some who have generating and transmission systems, with the others involved solely in distribution systems. Some regions are largely rural, served by a large number of small systems, while the dense metropolitan area of Chicago, for

TABLE 2

POPULATION PROJECTIONS

Basin	1960 actual	1980	2000	2020
Souris-Red-Rainy	652	791	1,023	1,368
Upper Mississippi	11,759	15,180	20,004	26,766
Ohio	18,793	23,498	30,742	41,241
Great Lakes	25,474	33,171	43,293	57,640
Totals	56,678	72,640	95,062	127,015
Percent of national	32.2	29.8	28.2	27.2

Type of use	Used 1965	Projected requirements		
		1980	2000	2020
Withdrawals				
Rural domestic	14	16	17	21
Municipal (public-supplied)	36	49	82	124
Industrial (self-supplied)	98	150	212	297
Steam-electric power (fresh)	200	500	1,100	1,700
Agriculture:				
Irrigation	24	200	562	576
Livestock	19	21	29	40
Total	391	936	2,002	2,758
Consumptive use				
Rural domestic	14	16	17	21
Municipal	11	16	26	35
Industrial	7	8	10	12
Steam-electric power (fresh)	2	4	10	20
Agriculture:				
Irrigation	24	150	402	416
Livestock	19	21	29	40
Total	77	215	494	544

TABLE 3

U.S. WATER RESOURCES COUNCIL, PROJECTED WATER REQUIREMENTS, SOURIS-RED-RAINY REGION, MGD

Type of use	Used 1965	Projected requirements		
		1980	2000	2020
Withdrawals				
Rural domestic	203	143	132	130
Municipal (public-supplied)	1,103	1,770	2,760	4,000
Industrial (self-supplied)	1,664	2,800	5,300	10,000
Steam-electric power	4,800	9,500	21,500	25,900
Agriculture:				
Irrigation	95	110	200	280
Livestock	314	477	695	956
Total	8,179	14,800	30,587	41,266
Consumptive use				
Rural domestic	101	94	85	76
Municipal	162	258	403	580
Industrial	58	98	184	346
Steam-electric power	61	166	373	607
Agriculture:				
Irrigation	83	95	170	240
Livestock	305	392	563	775
Total	770	1,103	1,778	2,624

TABLE 4

U.S. WATER RESOURCES COUNCIL, PROJECTED WATER REQUIREMENTS, UPPER MISSISSIPPI RIVER REGION, MGD

Type of use	Used 1965	Projected requirements		
		1980	2000	2020
Withdrawals				
Rural domestic	300	350	415	490
Municipal (public-supplied)	1,791	2,330	3,320	4,900
Industrial (self-supplied)	8,606	11,600	15,900	23,200
Steam-electric power (fresh)	17,400	27,300	45,200	61,200
Agriculture:				
Irrigation [1,2]	24	102	352	685
Livestock	134	129	194	258
Total	28,255	41,811	65,381	90,733
Consumptive use				
Rural domestic	200	250	290	340
Municipal	230	300	430	620
Industrial	410	550	770	1,100
Steam-electric power (fresh)	138	350	775	1,190
Agriculture:				
Irrigation [1,2]	24	102	352	685
Livestock	132	129	194	258
Total	1,134	1,681	2,811	4,193

[1] WRC projections differ.
[2] Requirement for normal years; dry year requirements may be up to 45% higher.

TABLE 5

U.S. WATER RESOURCES COUNCIL, PROJECTED WATER REQUIREMENTS, OHIO RIVER REGION, MGD

Type of use	Used 1965	Projected requirements		
		1980	2000	2020
Withdrawals				
Rural domestic	274	257	292	347
Municipal (public-supplied)	3,622	5,030	6,900	9,500
Industrial (self-supplied)	9,069	16,700	33,000	66,000
Steam-electric power (fresh)	12,000	25,700	56,100	114,700
Agriculture:				
Irrigation	75	110	170	230
Livestock	79	96	132	183
Total	25,119	47,893	96,594	190,960
Consumptive use				
Rural domestic	100	85	103	125
Municipal	502	702	953	1,304
Industrial	362	728	1,400	2,800
Steam-electric power (fresh)	95	184	467	898
Agriculture:				
Irrigation	68	95	140	190
Livestock	72	87	120	167
Total	1,199	1,881	3,183	5,484

TABLE 6

U.S. WATER RESOURCES COUNCIL, PROJECTED WATER REQUIREMENTS, GREAT LAKES REGION, MGD

Type of Plant	1970 (actual) Capacity	1970 (actual) % of Total Generation	1980 Capacity	1980 % of Total Generation	1990 Capacity	1990 % of Total Generation
Hydroelectric-conventional	51.6	16.4	68	9.4	82	5.4
Hydroelectric-pumped storage	3.6	0.3	27	0.8	70	1
Fossil steam	259.1	80.5	390	60.9	558	43.5
Gas-turbine and diesel	19.2	1.4	40	0.9	75	0.8
Nuclear	6.5	1.4	140	28	475	49.3
TOTALS	340	100	665	100	1,260	100

Notes: (1) The projections are premised on an average gross reserve margin of 20%.
(2) Since different types of plants are operated at different capacity factors, this capacity breakdown is not directly representative of share of kilowatt-hour production. For example, since nuclear plants are customarily used in baseload service and therefore operate at comparatively high capacity factors, nuclear power's contribution to total electricity production would be higher than its capacity share.

Source: U.S. FEDERAL POWER COMMISSION (1972). The 1970 National Power Survey. U.S. Government Printing Office, Washington, D.C. pp. I-18-29.

TABLE 7

PROJECTED GROWTH OF UTILITY ELECTRIC GENERATING CAPACITY, IN THOUSANDS OF MEGAWATTS
(from National Water Commission final report)

example, is served essentially by one system. Also industrial (non-utility) generation should be noted. This amounts to an additional 10 percent, based on the total supplied by the various utilities. Because of the economic advantages of scale, automation of much equipment, general power needs, better efficiencies, etc., we are seeing a trend to larger units and other technological innovations including nuclear, mine-mouth, steam-electric and unit train concepts.

The following components of electric power supply are recognized in this area:

(1) Hydroelectric plants
- (a) Run-of-the-river
- (b) Storage
- (c) Pumped storage

(2) Fossil-Fuel steam electric plants
- (a) Coal-fired
- (b) Gas or oil fired

(3) Nuclear power plants

(4) Gas turbine and diesel plants

Hydroelectric generation has been important in the Great Lakes Basin for many years, especially in the outflow channels from the Great Lakes and the St. Lawrence River system. Development and allocation of the water resources for hydropower use has been a joint effort between the United States and Canada in this border area. Additional development of hydroelectric facilities in Canada also has been significant. However, the generation, trasmission and use of this electrical energy is exceedingly complex because of regional interties. The metropolitan areas of New York City and surrounding municipal and industrial complexes are served partially by this northern hydropower system. Suffice it to say that in the United States there is little potential for additional hydroelectric installations, on a practical and/or environmental basis. Some additional development can be made in Canada, but the amount which might be delivered to the Great Lakes region is believed to be small. Many older and smaller hydroelectric plants in the region will in all probability be phased out as larger scale steam-electric (fossil fuel or nuclear) plants are added to the total system. One very old hydroelectric plant is the Union Electric Plant on the Mississippi River at Keokuk, Iowa, constructed in 1913, with a capacity of 125,000 kw. This decline in hydropower is unfortunate, in that the hydropower concept has many desirable attributes -- a renewable resource at no direct purchase cost, no air or thermal pollution, quiet operation, no fuel stockpiling and associated transportation and water pollution problems, ability to start quickly to handle peak loads, etc.

There are several pumped-storage hydroelectric plants in this multi-regional area.[7,8] The Taum Sauk pumped storage project of the Union Electric Company, St. Louis, Missouri, is an example which has a stated capacity of 408 mw. Others have been constructed in the Great Lakes and Ohio River Basins. These pumped-storage projects have offered a substantial economic advantage in meeting peak loads in systems where load factors are low. With interties, these economic advantages are not so great. The trend toward higher transmission voltages has made the movement of large amounts of electric power over long distances more practical.[9]

There are numerous small diesel plants in the multi-regional area, primarily in small to medium size communities. The gas turbine is a recent innovation used for peaking and emergency power. Both constitute a small part of the total generating capacity. The City of Ames, Iowa, for example, has added a gas turbine unit a few years ago. The future outlook of these is clouded, however, because of the rapid curtailment in the supply of natural gas to the upper Midwest.

Therefore, the multi-regional area relies heavily on steam-electric plants to generate the major portion of electrical energy. These include both fossil fuel and nuclear plants. More and more dependence is being made on nuclear power, evidenced by the number of applications and plants under construction. This is also documented in several federal reports (including Figure 4-3-1, 1968 assessment). Water requirements for condenser cooling will be substantial for this level of future demand.

The light-water reactors increase waste heat discharges and cooling water requirements, up to 50 percent more than fossil-fuel plants.

WATER REQUIREMENTS FOR GENERATING ELECTRICITY

Water requirements can be placed in two major categories:[10,11] the total withdrawal requirement for cooling, and a consumptive (evaporative)

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[7] Water Policies for the Future, Final Report, U.S. National Water Commission, Washington, D.C., 1973.

[8] Upper Mississippi River Comprehensive Basin Study, Appendix M, Power, U.M.R.C.B.S. Coordinating Committee, Washington, D.C., 1970.

[9] "The Role of Water in the Energy Crisis", Proceedings of a Conference, Nebraska Water Resources Research Institute, Lincoln, Nebraska, 1973.

[10] Upper Mississippi River Comprehensive Basin Study, Appendix M, Power, U.M.R.C.B.S. Coordinating Committee, Washington, D.C., 1970.

[11] "Iowa's Water Resources Program", Special Report on Progress and Needs, Iowa Natural Resources Council, Des Moines, Iowa, 1973.

use portion. Lesser amounts required for boiler-feed makeup and for periodic "blowdown" do not appear to be appreciable. The consumptive losses in general amount to 1 to 2 percent of the total cooling requirement: 1 percent for once-through cooling, 1½ percent for cooling ponds, and 2 percent for evaporative cooling towers and spray ponds. There would be little or no external requirement for water for dry or closed cycle towers where water evaporation is avoided.

This indicates that alternative cooling methods exist for releasing heat without causing adverse or undesirable environmental impacts.

The National Water Commission,[12] as well as other agencies,[13,14] have evaluated and summarized the cooling water requirements for various types of steam-electrical generating facilities. Table 8 lists the summary of the National Water Commission.

A modern 1,000 megawatt (mw) fossil fuel steam-electric plant would require about 1,150 cfs. at full capacity, or 832,600 acre-feet per year. A 1,000 megawatt nuclear plant (at 33 percent efficiency) requires about 1,900 cfs. for a 15° F. water temperature rise across the condenser, an average rise for the usual 10-20° F. range used in practice. One of the larger nuclear units constructed in the Midwest is the Cordova plant of the Commonwealth Edison Co. and the Iowa-Illinois Gas and Electric Company, located on the Mississippi River and having a production capability of 1,400 mw.[15]

The projected water requirements for steam-electric power generation are listed in Table 9, as summarized from the 1968 assessment for this multi-regional area. These estimates show about a ten-fold increase in total condenser cooling water requirements by the year 2020. How much these estimates might be reduced because of lower population growth rates, related stabilized economic patterns, energy conservation measures, etc., is difficult if not impossible to predict. (See Appendix A for typical water requirements.)

Comparison of the data in Table 9 with the average runoff from Table 1 exhibits one interesting fact. The total estimated cooling requirements in each basin approach in magnitude the average runoff of that particular basin. Of greater importance is the consumptive use portion. Comparison of the 2020 consumptive use with streamflow shows that about one percent of the average runoff must be allocated to the energy category. The estimates for stream (or lake) withdrawal were made prior to the enactment of the Water Quality Act of 1972. In view of the "no discharge" provisions of this federal legislation, and the limitations on temperature permitted under the water quality stream

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[12]Water Policies for the Future, Final Report, U.S. National Water Commission, Washington, D.C., 1973.

[13]Upper Mississippi River Comprehensive Basin Study, Appendix M, Power U.M.R.C.B.S. Coordinating Committee, Washington, D.C., 1970.

[14]"The Role of Water in the Energy Crisis", Proceedings of a Conference, Nebraska Water Resources Research Institute, Lincoln, Nebraska, 1973.

[15]"Iowa's Water Resources Program", Special Report on Progress and Needs, Iowa Natural Resources Council, Des Moines, Iowa, 1973.

Plant Type	Thermal Efficiency (Percent)	Required Input per kw-hr (Heat rate)	Total Waste Heat (Required input minus kw-hr heat equivalent)[2]	=	Lost to Boiler Stack[3] (etc.)	+	Heat Discharged to the Condenser	Cooling Water Requirement (Cubic feet per second per megawatt, of capacity)[4]
Fossil fuel	33	10,500	7,100		1,600		5,500	1.6
Fossil fuel (recent)	40	8,600	5,200		1,300		3,900	1.15
Light water reactor	33	10,500	7,100		500		6,600	1.9
Breeder reactor	42	8,200	4,800		300		4,500	1.35

[1] Not using cooling towers.
[2] The heat equivalent of one kilowatt-hour of electricity (kw.-hr.) is 3,413 British thermal units (B.t.u.)
[3] Approximately 10 to 15 percent of required input for fossil fuel.
Approximately 3 to 5 percent of required input for nuclear.
[4] Based on an inlet temperature in the 70°s F. and a temperature rise across the condenser of 15° F.

Source: KRENKEL, Peter A et al. (May 1972). The Water Use and Management Aspects of Steam Electric Power Generation, prepared for the National Water Commission by the Commission's Consulting Panel on Waste Heat. National Technical Information Service, Springfield, Va., Accession No. PB 210 355.

TABLE 8

HEAT CHARACTERISTICS AND COOLING WATER REQUIREMENTS FOR VARIOUS TYPES OF STEAM ELECTRIC GENERATING PLANTS, WITH HEAT VALUES IN BTU PER KW-HR (from National Water Commission final report)

TABLE 9

PROJECTED WATER REQUIREMENTS FOR STEAM-ELECTRIC PLANTS AND ASSOCIATED POWER PRODUCTION, 1965-2020 IN BILLIONS OF GALLONS PER DAY FOR UTILITY-OWNED PLANTS

Year and Category	Souris-Red-Rainy	Upper Mississippi	Ohio	Great Lakes
1965 Condenser cooling requirement	0.200	6.800	17.400	12.000
Stream withdrawal	0.200	4.800	17.400	12.000
Consumptive use	0.002	0.061	0.138	0.095
1980 Condenser cooling requirement	0.500	17.400	41.000	25.800
Stream withdrawal	0.500	9.500	27.300	25.700
Consumptive use	0.004	0.166	0.350	0.184
2000 Condenser cooling requirement	1.100	34.000	73.600	58.200
Stream withdrawal	1.100	21.500	45.200	56.100
Consumptive use	0.010	0.373	0.775	0.467
2020 Condenser cooling requirement	2.100	55.100	119.500	116.000
Stream withdrawal	1.700	25.900	61.200	114.700
Consumptive use	0.020	0.607	1.190	0.898

standards, lower values for stream withdrawal can be expected. The implementation of spray cooling ponds at the Cordova, Illinois, nuclear plant, located on the Mississippi River, under the provisions of the state and federal criteria, shows that this trend is supported under the current emphasis on environmental enhancement.

OTHER CONSIDERATIONS

Several additional water requirements should be mentioned in this discussion. First, navigation needs must be included in any study of future energy production. Tremendous quantities of coal and fuel oil delivered by barge to plants located on the major waterways or the Great Lakes. This brings into new focus such factors as improvement of navigation locks and dams, channelization and dredging, harbor and terminal facilities, year-round navigation, and deeper channels (increasing from 9 to 12 feet, for example).

Second, coal gasificaiton or liquefaction may become a necessity, either economically in terms of transportation optimization or to reduce the sulfur content prior to plant consumption. Coal mining and processing is a large industry in this multi-regional area. The coal reserves in states within this workshop sutdy are are listed in Table 10. This information shows that about 35 percent of the total remaining reserves are in this multi-regional area we are discussing. These reserves include bituminous, subbituminous, lignite, anthracite and semianthracite coal resources. The 1968 assessment states that recoverable reserves are based on 50 percent of the total remaining reserves. It should be noted also that, as of 1960, only 4 percent of the original reserves had been extracted, and 96 percent of the original reserves still remained unused. Water demand for mining extraction, such as dust control, coal washing and fire protection also must be included.[16,17]

Water needs in land reclamation of surface-mined areas also should be considered.[18,19] Supplemental irrigation may be necessary, particularly for initial seeding and cover establishment and during drought periods. Associated water quality and environmental problems will be discussed by other participants on the workshop programs.[20]

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[16]"Water Demands for Expanding Energy Development," Circular 703, U.S. Geological Survey, Washington, D.C., 1974.

[17]"Feasibility Study of a New Surface Mining Method, Longwall Stripping," EPA-670/2-74-002, U.S. Environmental Protection Agency, Washington, D.C., 1974.

[18]"Water Demands for Expanding Energy Development," Circular 703, U.S. Geological Survey, Washington, D.C., 1974.

[19]Restoring Surface-Mined Land, Mis. Publc. No. 1082, U.S. Department of Agriculture, Washington, D.C., 1973.

[20]"The Effects of Strip Mining Upon Navigable Waters and Their Tributaries," A Discussion and Selected Bibliography, University of Pittsburg, Graduate Center for Public Works Administration, Pittsburgh, Pennsylvania, 1972.

TABLE 10

COAL RESERVES OF STATES IN THE STUDY AREA,
MILLION SHORT TONS, AS OF 1960

State	Date of Estimate	Total estimated original reserves	Remaining reserves, 1960
Illinois	1953	137,329	136,381
Indiana	1953	37,293	34,997
Iowa	1909	29,160	28,446
Kentucky	--	72,318	67,026
Michigan	1950	297	205
Missouri	1913	79,362	78,788
Ohio	1960	46,488	42,384
Pennsylvania	1928	97,898	70,882
Tennessee	1959	1,912	1,900
Virginia	1952	12,051	10,487
West Virginia	1940	116,618	103,880
Totals		630,726	575,376
U.S. Totals		1,719,964	1,660.290
Percent of U.S. in region		36.7	34.7

SUMMARY

The multi-regional area included in this workshop -- the Souris-Red-Rainy, Upper Mississippi, Ohio, Great Lakes Basins -- has tremendous water quantities available for beneficial use. The only water-deficient area is the far northwestern sector -- the Souris-Red-Rainy Basin area. The other three basins contain the two major rivers of the Midwest and the Great Lakes system. The latter has a water surface of 95,000 square miles and a huge related volume of water in storage. The entire area has a total annual runoff of about 350 billion gallons per day, or 391 million acre-feet per year.

The area currently contains about 32 percent of the total population of the 48 conterminous U.S. In addition it contains a greater percentage of the commercial and industrail sectors -- most of all the steel production, for example, and up to 50 percent of national production in other key manufacturing categories. Therefore, forecasts for water demand contain large increases for industrial and energy production.

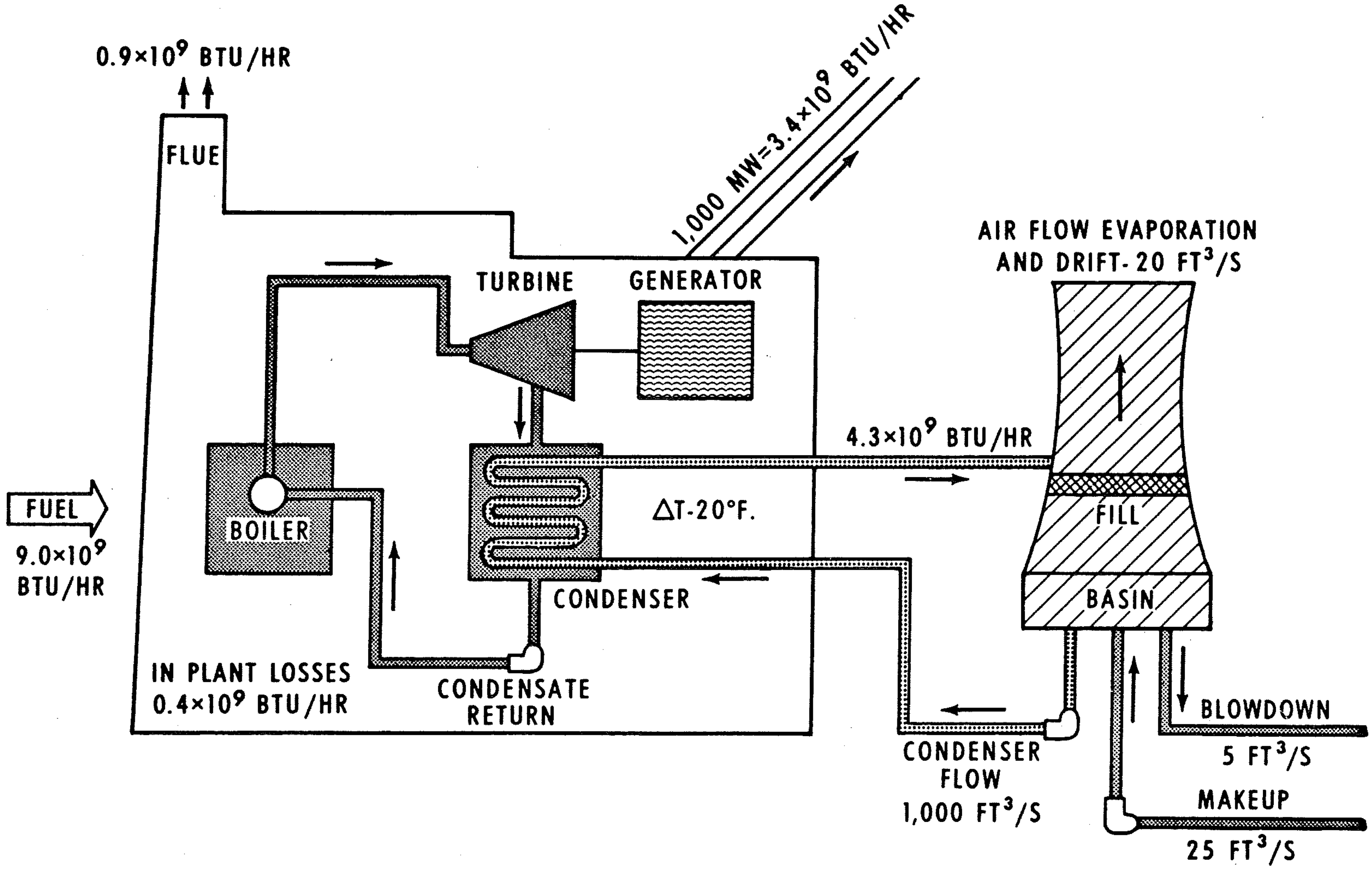
Water requirements for energy will primarily be for cooling. Total cooling water requirements will approach the magnitude of the average annual runoff of these four basins. However, the consumptive requirements will only be one percent of the total cooling demand. Withdrawals from the surface water (and groundwater) may be large, but are within the area's total water resource availability.

The major problem in meeting the water needs for energy production in this area is how to release the waste heat discharge without causing undesirable environmental impacts. Cooling towers, cooling ponds or spray canals, or one-through cooling systems are reasonable, practical methods.

The first method is the most costly, results in twice the consumptive amount of water in evaporation, but minimizes the impact on the environment. Fortunately, an increase from one to two percent of evaporative loss, in terms of total cooling water requirements, can easily be met. Therefore, water quality and environmental considerations will determine the economic costs of energy production.

Other factors also loom large in this energy picture. Water needs must be determined for coal gasification or liquefaction, coal transport (navigation or pipe slurry), and in reclamation activities.

Other technological innovations which are being explored for future use may lessen the impact of the current energy program. However, many are still in the laboratory experimental stages. Perhaps energy conservation should be an equally hopeful objective for our nation's citizens. Unfortunately, most discussions of this alternative offer little encouragement. All of these alternatives will become increasingly important if the nation's natural resources are to be most effective managed and used on a long-term basis.



APPENDIX A

HEAT BALANCE DIAGRAM OF TYPICAL 1,000-MW
FOSSIL-FUELED THERMAL-ELECTRIC PLANT
(from U.S.G.S. Circular 703)

CRITICAL ENERGY WATER ISSUES IN THE OHIO RIVER - GREAT LAKES BASIN

by

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and

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INTRODUCTION

Although this paper is intended to be one of the overview manuscripts concerning the Souris-Red-Rainy, Upper Mississippi, Great Lakes and Ohio regions, the authors are addressing their comments primarily to the Illinois area. Many of the issues are relevant to the entire area; we hope that differences among regions and additional issues will be covered in the discussion periods.

This paper considers energy and water relationships and deals with the management and conservation of water resources in a humid area. Energy conversion processes place major demands on water resources. Projected increases in energy-related water demands are dramatic; however, these water demands will have to compete with expected increases in water requirements for other industries, municipalities and agriculture. In addition, our society appears to be placing an ever increasing value on minimizing man-made disturbances to water courses. This new environmental ethic places a great demand for using water resources as "natural" waterways. In view of these large, growing and often conflicting uses, it will be increasingly important to effectively manage water resources through practices such as conservation and reuse.

A 1967 report, Water for Illinois: A Plan for Action[1] readily determined that there is an abundance of water for man's use to 2020. The total resource was equal to about 43 bgd, while the 1965 usage was about 16 bgd. The largest use of water withdrawal for the future was projected to be for power generation activities. However, at that time once-through cooling systems were assumed, and as a result the projected consumptive water losses were not expected to present a major problem. Consequently, most experts felt that there were no major critical issues; permits for water withdrawal were not recommended, etc. The findings in this report are typical for much of this area since there are large quantities of fresh water in the Great Lakes and Upper Mississippi regions, as well as in the Ohio River basin region.

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[1]Illinois Technical Advisory Committee on Water Resources, Water for Illinois: A Plan for Action, 1967.

However, in 1974 the situation is changing. The same inventory of water supply is present--in fact we have had too much the last two years--but the resource remains the same. Society's increasing demand for energy and simultaneously a clean environment is placing a heavy strain on the present energy delivery system; and, due to limited supplies of oil and gas, other fuels are being considered. For example, plans are being considered for converting coal to high BTU synthetic natural gas, low BTU gas for electricity generation and liquid fuels. These conversion processes consume large quantities of water. Hydrogen atoms are removed from the water for forming the respective fuels. The destruction of water becomes a vital factor as we look downstream into the future. In addition, large amounts of cooling water are required. All sorts of estimates are being made concerning the total water requirements for coal gasification and liquefaction. Unless recycling and reuse become an intimate part of any planning process, society before the year 2020 may be facing another critical issue, and that will be the lack of water.

DEFINITIONS

The management of water resources is taken to be the control of the utilization of water resources systems. A management decision, for example, might specify allowable withdrawal(s) of water.

Conservation of water is the practice of minimizing the level of water withdrawal from water courses for meeting a specific objective(s). There are two ways to minimize water withdrawals: water reuse and decreasing the water requirement for the specified objective(s).

Water reuse is taken to be the practice of using spent water from a given use as the water supply for a given use. Two categories of reuse are defined by Hendricks and Bagley[2]. Sequential reuse is taken to be the use by one activity of spent water from a different activity, while recycle reuse is taken to be the reuse by a given activity of its own spent water. Examples of sequential reuse on different scales are: (1) process waste water reused as cooling water within an industrial plant, and (2) municipal waste water reused as cooling water by an electric power plant. Examples of recycled reuse are: (1) in an industrial process using boiler blowdown water after treatment as makeup water for the boiler, and (2) municipal effluent reused as that municipality's water supply. As can be seen from the examples, water reuse activities can be on different scales.

The second way to minimize water withdrawals, that is, by decreasing the water requirement, can be effected by modifying industrial processes or by decreasing domestic use behavior. For example, increasing water prices can be used to decrease residential and industrial use levels.

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[2]Hendricks, D. W. and J. M. Bagley, "Water Supply Augmentation by Reuse," Proceedings, American Water Resources Association, No. 7, 1969.

WHY CONSERVE WATER?

The purpose of water resources management is to provide the greatest benefit to society from utilizing water resources. In the past, in the eastern region of the United States, extensive management of water use has been viewed as unnecessary since water has been assumed to be abundant. For example, as we mentioned earlier, in Illinois in 1965, the total water availability was approximately 43 billion gallons per day while the total water usage was only 16.3 billion gallons per day. The consumptive usage, that water not returned to the water resources directly, totaled only 1.1 billion gallons per day.[3]

This picture of future water resources demands, however, is obsolete due to at least three reasons:

(1) A drastically changing characteristic of the water-use picture is the impact of the changing world energy situation. Increases in the number of domestic energy conversion facilities are expected as a result of "Project Independence" and a desire to use domestic energy sources. Energy conversion facilities place major demands on the water resources. Both nuclear and fossil fuel steam electric generation plants place large demands for cooling water. In addition, a new industry is being considered for converting high-sulfur coal found east of the Mississippi River to low-sulfur liquid and gaseous fuels. For example, several processes are being considered for converting coal to a gas substitute for natural gas. This gas, mainly methane, can be formed using coal and hydrogen from water. In addition to this "consumptive" water requirement, such processes also require large amounts of cooling water. A typical coal gasification plant might withdraw from 5,000 to 20,000 gallons per minute of which some 4,000 to 15,000 gallons per minute would be lost to the system. Water is chemically consumed and lost to the atmosphere from cooling. Water requirements for one facility being considered, which is 4-5 times larger than a plant producing 250 million cubic feet of gas per day, would require for consumptive purposes a water supply of approximately 100 mgd. This equals 4 percent of the 7-day 10-year low flow of the Illinois River, or 0.3 percent of the 7-day 10-year low flow of the Mississippi River or the Ohio River where both border Illinois. For cooling purposes, 2,830 mgd, or 120 percent of the 7-day 10-year low flow of the Illinois River would be required.

(2) The recently articulated demand for "using" water in its "natural" state is derived from a new environmental "ethic." There are at least two implications. First, it is more and more desirable to minimize the total withdrawal of water from natural waterways for use. The minimal withdrawals provide minimum disturbances to the existing flow and in addition provide for minimal levels of waste waters returned. Evidence for this type of new competing demand can be found by examining cases in the Eastern part of the United States where efforts to site new conversion facilities have been blocked successfully by environmental pressures. The second result of the environmental ethic is that more and more restrictive effluent standards are being implemented. This generally implies higher levels of waste treatment required.

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[3]Illinois Technical Advisory Committee on Water Resources, Water for Illinois: A Plan for Action, 1967.

Both environmental considerations place pressures for water conservation and water reuse. Consider first a user's internal cost given by the cost of pumping raw water from a water course, treating the water for use, using the water, treating it for return to a waterway and transporting it back to the waterway. By restricting the level of water use in a process by a conservation measure the actual cost of the process may increase; on the other hand, the cost of procuring the raw water, treating the waste water and transporting it should decrease. Water reuse has essentially the same effect. The user incurs a cost for treating waste waters before either sequential reuse or recycled reuse. However, this cost is partially offset by the decreased costs for procuring raw water and transporting and treating final effluent. As effluent requirements become more stringent, these savings make reuse more attractive. Thus, a water user is likely to incur both additional costs and offsetting savings due to conservation measures.

Consider also, however, the cost to society, or external costs, of damages due to envrionmental degradation. Conservation measures reduce environmental damages, and these savings must be added to the user's internal saving mentioned above. Therefore, as higher and higher values are placed on reducing environmental damages, conservation and water reuse become more and more attractive.

(3) In addition to increases in water demands for municipal use and industrial uses, in the near future it may be desirable to increase drastically the amount of water available for agricultural irrigation. Irrigation furing critical dry spells could produce a significant increase in the crop yield in the Midwest.[4]

In summary, the increasing demand for water for all uses combined with the increasing damages due to withdrawing water for use and the increasing cost of treating waste water demonstrate the importance of evaluating conservation and reuse capabilities for regions east of the Mississippi River.

CURRENT WATER USES

For the state of Illinois in 1965, about 5 bgd were used by municipalities and about 11 bgd by industry. Currently, very little water is being used for agricultural irrigation. Eighty percent of the industrial withdrawal is used for power generation, seven percent for steel rolling and finishing, and thirteen percent for other processes. Industrial water withdrawals are given in Table 1.

In our area, water is needed for transportation through movement of barges on the Mississippi and Ohio rivers and shipping on the Great Lakes. Water is needed in these systems to maintain the movement of cargo. This usage does not suggest much opportunity for conservation, as the water is constantly being reused by the next vessel. This form of transportation conserves energy considerably. The critical problem areas here involve the contamination of this water by large volumes of movement.

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[4] "Withdrawal of Water by Industry in Illinois, 1970-71," by Schnepper, Evans and Neill, Illinois State Water Survey Circular No. 115, 1973.

TABLE 1

WATER WITHDRAWAL BY INDUSTRY IN ILLINOIS[5]

	Percent	Total MGD
Power Generation	79.6	8,775
Primary Metal Industries-Steel	8.9	972
Agricultural Food & Machinery	3.7	403
Chemicals and Allied Products	2.1	229
Coal Mining	0.3	32
Petroleum and Coal Products	0.8	89
Other	4.7	520
	100.0	11,020

[5] "Withdrawal of Water by Industry in Illinois, 1970-71," by Schnepper, Evans and Neill, Illinois State Water Survey Circular No. 115, 1973.

Other uses of water are for recreation and the dilution of man's wastes. However, based primarily on the national policy, much of this misuse of water resources is being eliminated. We do not foresee complete elimination, but much higher quality water will be in our streams and lakes as we learn and work towards protecting them.

In the production of oil, industry is now using water in a secondary recovery process in order to extract additional oils from the storage reservoir. This becomes a "consumptive" water use, and, in certain areas of the region, amounts to very substantial water losses. Every barrel of oil removed requires an equal amount of water. This water is then lost for future use.

WATER REUSE POTENTIAL

Water reuse potential is determined by technical, economic and social considerations. Technical considerations include treatment requirements to make a waste water suitable for reuse and conveyance requirements for moving the waste water to the water supply point for the following use. Treatment requirements generally include demineralization to prevent the accumulation of salts. Blending reuse water with raw water can also be used to maintain acceptable quality levels. Economic considerations include the costs for treatment or blending and the costs for conveyance. Social considerations include equity issues, such as those accompanying the recycle reuse of municipal waste water for municipal water supply.

Past studies considering water reuse have centered around arid or semi-arid regions in the Western part of the United States. In these regions it is frequently necessary to augment existing water supplies for uses such as municipal, industrial and agricultural. Reusing waste waters appears an attractive alternative when compared to importing water over large distances which may be prohibitive in cost.

Water reuse was demonstrated to be economically and technically feasible in a recent study for San Antonio by the Alamo Area Council of Governments.[6] Two extreme solutions for meeting water demand for 2000 were evaluated: no reuse and complete or 100 percent reuse. The no reuse or conventional solution is based on the importation of surface water. Since the complete recycle solution was only 10 percent more costly than the conventional solution, the study concluded that the two solutions are comparable. Furthermore, the study indicates that the actual least costly solution is likely to be a combination of partial reuse and partial conventional supply. This implies the blending of a quantity of demineralized waste water with a quantity of conventionally supplied water. This study assumed direct treatment of raw waste water by physico-chemical processes. It should also be noted that this study also initiated the development of a methodology using mathematical modeling and analytical techniques for investigating and evaluating recycle reuse. The study demonstrates the feasibility of water reuse in lieu of importation for San Antonio.

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[6]Alamo Area Council of Governments, Basin Management for Water Reuse, for the Environmental Protection Agency, February, 1972.

A study for the Salt Lake City area of Utah considered water reuse for municipal, industrial and agricultural purposes.[7] This study considered costs for transporting water and costs for reducing the biochemical oxygen demand and the total dissolved solids of waste water. A mathematical optimization procedure was suggested for evaluating reuse systems. Example solutions demonstrate the potential future feasibility of sequential reuse of municipal and industrial effluents for irrigation water and of treating a supply of irrigation return flow and river water for blending with additional river water for use as municipal supply.

These studies demonstrate the potential for water reuse in areas where water supply augmentation is necessary for meeting municipal, industrial and agricultural demands. This same reuse potential exists in areas with more abundant water supplies where due to limited local supplies or due to environmental goals it may be desirable to reuse water.

CRITICAL ISSUES

In the past, man's development of energy producing facilities has been dependent upon the economic aspects. More recently, the environmental consequences have been introduced. Today, we must consider the source of energy and how to make maximum use of it. The water molecule is a source of energy, as well as a medium for producing energy.

In terms of conservation and management, we need to carefully evaluate our water resources to protect them for the future, as well as to utilize them wisely. Or, in other words, we need to optimize energy and water usage together.

Several specific issues are as follows:

(1) The primary water use in the Ohio River Basin - Great Lakes region is for cooling water for power plants. Therefore, an evaluation of water reuse potential should emphasize reusing wastewater discharges for cooling water and reusing cooling water discharges. Attention should also be given to quality requirements for cooling waters.

(2) Since the primary use of water is for cooling purposes, we should review the systems that produce the excess heat to see whether or not the excess heat might be used for beneficial purposes.

(3) Instead of building larger and larger power plants, we might consider the construction of small units which might be submerged below the ground level and used by industry and people in the near vicinity. This would provide a use for the low-grade excess heat, eliminate large losses in transmission of electrical energy and eliminate some of the hazards of a large complex system, which could severely tax a regional system if it failed. A nearby system for the use of the excess heat would reduce the loss of water in the system.

(4) Coal conversion facilities in Iowa, Illinois, Indiana, Kentucky, Ohio, Pennsylvania and West Virginia could decrease drastically the amount of water available for other purposes. The "consumptive" water use,

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[7]Hendricks, D. W. and J. M. Bagley, "Water Supply Augmentation by Reuse," Proceedings, American Water Resources Association, No. 7, 1969.

in particular, would increase due to such facilities. For one type of coal refinery being considered, 100 mgd would be consumes; this amounts to about 9 percent of the present consumptive use in Illinois. Efforts are needed to reduce the consumptive water requirements.

(5) Another major issue involves the atmospheric effects of a large coal conversion plant. Multiple large cooling towers and ponds would serve as a large water reservoir for atmospheric processes. This would increase the fog conditions, snowfall, and most likely, rainfall near the plant. In addition, the release of moisture to the atmosphere could have an effect on global climates. And, how large a source can one develop before a detrimental atmospheric effect is crucial?

(6) Another issue that needs to be explored further is that of whether or not hydroelectric power production in the Great Lakes is being done with maximum efficiency. The total hydro production of electricity is small compared to other sources, but the relationships of peak electrical demands, pump storage and total energy utilization should be carefully reviewed.

(7) Does the humid East need a water permit system to control water withdrawals and use and to protect the water resources for other users?

(8) Should transportation by barges be encouraged as a means of conserving energy?

(9) What water quality requirements are there for each water use, and what are the waste water characteristics?

(10) What increases in agricultural production are possible through irrigation, and what are the water needs?

CONCLUSION

While we expect to have sufficient water supplies to meet out physical needs in the next two decades, including projected energy-related water demands, we should still consider water conservation practices in order to maximize the aggregate benefit. The management of the resource becomes critical as competing demands for water use increase.

POLLUTION IN THE ENVIRONMENT

by

Leonard B. Dworsky
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A written paper was not received.

CRITICAL ENERGY-WATER ISSUES: INSTITUTION-POLICY

by

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INTRODUCTION

In October 1973 the Nebraska Water Resources Research Institute sponsored a conference entitled, "The Role of Water in the Energy Crisis". The Proceedings[1] from this conference provide an excellent introduction to the topic of this paper, namely - Institution-Policy as a critical energy-water issue. In particular, Engelbert's paper cites three basic propositions which focus upon the institution-policy issue:

(1) Political-social aspects of water-energy relationships have been greatly neglected both in research and development.

(2) The failure to comprehend and project energy-water relationships in broader social settings is producing unfortunate political consequences. Political infighting on specific issues causes loss of perspective upon broader issues.

(3) New analytical approaches must be fashioned for dealing with the social parameters for energy-water relationships. It is necessary to recognize energy-water relationships as major vehicles for shaping social change.[2]

These concepts provided by Engelbert will serve as a framework for this paper. Emphasis will be placed upon suggesting certain new approaches (analytical and otherwise) for working with the institution-policy component of the energy-water issue.

In contrast to certain fossil fuels, there is no shortage of figures which demonstrate the nature of the energy problem facing this country at present. Dr. Michael C. Noland, Midwest Research Institute, has provided a concise summary regarding energy.[3] In the United States, we consume 350 million BUT/capita/year. This quantity of energy translates into an annual per capita consumption of 1300 gallons of oil, 110,000 cubic feet of natural gas, and 2-1/2 tons of coal. Furthermore, this demand for energy is not

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[1] "The Role of Water in the Energy Crisis", Proceedings of a Conference, Nebraska Water Resources Research Institute, Lincoln, Nebraska, October 23-24, 1973.

[2] Engelbert, Ernest A., "The Political-Social Aspect of Energy-Water Relationships", in Proceedings, The Role of Water in the Energy Crisis, pp. 19-37, October 1973.

constant but growing. During 1967-1972, the growth in energy was nearly 5 percent per year.[4] At this rate, the consumption of energy will double every 15 years. Given this growth condition, the energy crisis requires a two-pronged attack. First, it is imperative to develop new energy sources for both the long-run and short-run. In the former case, it is essential to concentrate upon alternate energy sources (in place of fossil and possibly nuclear fuel). Secondly, it is of critical importance to develop guidelines and politices which will act to retard the growth of demand for energy.

The critical issue of institution-policy and energy-water interaction is the absence of effective institution and policy means to properly focus upon the problem. Energy-water is a relationship characterized by a rich admixture of public and private entities. There are many constituencies represented in the decision-making arena. For example, prior to the establishment of the Federal Energy Office there were almost 70 different federal agencies bearing some responsibility for energy problems.[5]

Energy and water are so closely interwoven that consideration of one without the other will only lead to suboptimal analysis and decision. It is clear that water as a life-sustaining commodity must be available or be provided if life is to survive in a given geographical area. Now and in the future, the energy budget for a particular geographical region may be as limiting for life support as the water budget in the past. Research is required which will explore the nature of the energy-water relationship. Instituion-policy mechanisms must be provided which will enable the public to have a greater sense of the choices facing them in the last years of the 20th century. These choices will relate to the quality of life and character of the living space throughout our country.

BRIEF SURVEY: REGIONAL CENTERS

In February 1974 letters were sent by the author to the Water Resource Centers, River Basin Commissions, and State Environmental Agencies in the Souris-Red-Rainy, Upper Mississippi, Great Lakes, and Ohio regions. These letters requested information upon critical institution-policy issues as related to water and energy. The respondents provided extremely useful insights into how instituion-policy is perceived at their individual vantage points as well as usbstantive observations related to specific problem areas. Topics and issues identified included the following:

(1) The extent to which extension of the Great Lakes commercial navigation season will aid in efficient water-based transport of fissil fuels to ameliorate the energy crisis in winter.

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[4]Auer, Peter L., "An Integrated National Energy Research and Development Program", Science, Vol. 184, No. 4134, April 19, 1974, p. 296.

[5]Ibid.

(2) The identification of areas in the Great Lakes Region, including submerged lands under the Great Lakes, for development of natural gas reserves.

(3) Streamlining present procedures for planning construction and operation of electrical power plants in the Great Lakes.

(4) Development of energy sources which are not in the specific basin but adjacent to it.

(5) Growth in energy demand has led to increased thermal discharge. This issue of heated waste effluent was cited by several respondents. The EPA proposed guidelines of March 1974 call for no discharge of waste heat. However, this guideline must be coupled with Section 316(a) of P.L. 92-500 which permits either EPA or an authorized state to grant a less stringent discharge. This administration flexibility offers a wide range of policy choice. One critical factor is how does EPA or the authorized state determine whether or not a proposed heat effluent will be harmful? One may envision some very subtle changes in the aquatic ecosystem caused by altered thermal environments. The results of these subtle changes may not manifest themselves until some point in the future. What is the acceptable level of risk that will be associated with thermal discharges?

(6) One state agency expressed concern over anticipated cuts in federal funding designed to assist the state in both water pollution control and comprehensive water and related land use planning.

(7) Land use policy and regulations were identified as being important policy aspects of energy-water. In particular, land use planning and power plant siting regulations are closely related.

(8) While major attention has been provided to the question of determining acceptable and tolerable waste heat discharges to receiving waters (as indicated in (5) above), concern is now being expressed that the environmental impact of the intake structures may cause more harm than the waste heat discharge. For example, fish being killed by striking the input screens.

(9) The Federal Water Resources Planning Act, P.L. 89-80 through section 201(b) charges River Basin Commissions with the responsibility for coordination of federal, state, interstate, local and non-governmental plans for the development of water and related land resources in its area. Consequently, as reported by one respondent, it is felt that River Basin Commissions have a responsibility for energy programs when ever water and related land resources are involved.

From this brief report upon the responses received from basin commissions, water resource research institutes, and state environmental agencies, within the specified region, one sees a diverse set of policy issues perceived by those action groups.

INSTITUTION-POLICY: PROBLEM ISSUES

The energy crisis may be understood as a sequence of dilemmas which tie together energy-environment-economic policies. This sequence has been outlined as follows:

> The growing economy in the United States and other industrailized nations has resulted in exponential economic growth. The exponential growth of energy consumption has closely followed the trend in economic growth. The present demand for energy exceeds indigenous supplies. Industrialized nations are dependent upon foreign fuels. At present, a technology gap exists which limits our capability to utilize other than fossil fuels. The upper bound on foreign fuel prices is the cost of substitute fuels to supply the next marginal unit of fuel demand.[6]

As energy use increases, the volume of waste products from energy production of consumption begin to exceed the ability of natural environmental processes to absorb these waste products (heat, CO_2) without severe degradation.[7] There are many uncertainities associated with the impact upon the earth ecosystem resulting from the continued and expanding release of large quantities of heat and CO_2. In the long run, it may turn out that the "greenhouse effect" from the CO_2 may be more serious in its influence than the heat release.[8]

The present institutional mechanism operative in the socio-economic system examines alternative solutions for the issues presented above primarily from the persepctive of immediate and very short-range futures. However, in White's view a first requirement to deal with the energy crisis is to revise these institutions to allow an improved interaction between the economic marketplace, research and development, and the long-term interests of society. Each of these segments represents different constiuencies and goals and each segment has different response characteristics.[9] Milton Katz, argues in a similar fashion when he states that the primary criteria utilized in decision making in power production has been cost efficiency from the perspective of enterprise - i.e., the private companies, local government agencies, and national units (TVA) that actually build and manage power generating facilities.[10] In Katz's view, the decision-making process may be altered to accommodate the needs of other criteria -- especially the criteria of comprehensive assessment where the advantages/disadvantages for society as a whole are considered. The change required as suggested by

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[6] White, David C., "The Energy-Environment-Economic Triangle", in <u>Technology Review</u>, Vol. 76, No. 2, December 1973, p. 19.

[7] Ibid.

[8] Ibid.

[9] Ibid.

[10] Katz, Milton, "Decision-Making in the Production of Power", <u>Scientific American</u>, Vol. 224, No. 3, September 1971, p.191.

Katz is to implement technology assessment as a component of the decision-making process. Technology assessment is basically utilization of advanced analytical techniques to design many alternative means to achieve a desired objective. The assessment would include consequences of alternative courses of action insofar as they can be perceived or predicted.[11] While Professor Katz's suggestion is rational and attractive in its simplicity, its implementation may prove to be most difficult.[12]

Russell Train addresses institution-policy issues of energy and water by stating that the energy crisis is part and parcel of an overall environmental problem facing our citizens -- we are experiencing the classic symptoms of the strains that occur when an organism begins to exceed the carrying capacity of its habitat. In Train's view, we are moving into an age of resource shortage. By choice or necessity we are going to have to learn to live within our limits.[13] To accomplish this task of living within our limits, we must move to strengthen the institutions and processes of government. Specificially, we must improve their capability to assess problems and programs -- not simply in isolation but in terms of their interrelationships and not simply in the short-run but over the longer span of 10 or 20 or 30 years.[14] In the long-run, we must develop the technological means to live off "energy income" rather than "energy capital" (winds, sun, tides, geothermal rather than finite fossil fuel).[15]

The issue of alternative energy sources (energy income) is a critical one for our society and the world as a whole. The decision to utilize alternative energy sources would logically follow from a recognition of the limits of fossil fuel resources plus the undesirable consequences associated with fossil fuel combustion (i.e., the CO_2 greenhouse effect). One set of policy guidelines leading to alternative energy sources would be as follows:

(1) Exhaustion of fossil and nuclear fuel reserves should be delayed as long as possible.

(2) A satisfactory living environment should be maintained both for man and for other creatures on this planet.

(3) An upper limit on total energy consumption should exist.[16]

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[11]Katz, Milton, "Decision-Making in the Prodcution of Power", Scientific American, Vol. 224, No. 3, September 1971, p. 191.

[12]Yaffee, S.R., "Factors Affecting Innovation in Water Quality Management: Implementation of the 1968 Michigan Clean Water Bond Issue", OWRR Project No. A-054, MICH, University of Michigan, 1973.

[13]Train, Russell E., "The Quality of Growth", Science, Vol. 184, No. 4141, June 7, 1974, p. 1050.

[14]Ibid.

[15]Ibid.

[16]Grimes, Dale, "Alternative Sources of Energy", paper presented at Edison Foundation Science Institute, Bozeman, Montana, March 1974, p. 1

Grimes classifies alternative energy sources into two categores:

(1) Statistically available which includes direct solar, wind, and tides.

(2) Steadily available which indlues satellite solar, hydropower, sea thermal gradient, and geothermal.

For the regional workshop, wind may be the most interesting alternative energy source with capability for implementation within areas of the regional workshop. In fact, the Wisconsin Senate received a detailed systems analysis of a possible wind generator network in October 1973. This study proposed a system which would supply an average annual output of 7.4 GW (Giga Watt) by extracting .25 percent of the available wind energy over the affected area. Some of the generating stations would be floated off-shore in Lake Michigan and Lake Superior while others would be tower-mounted straddling interstate highways.[17] The electricity generated at the wind station would be utilized for the elctrolysis of water and the hydrogen obtained therefrom would be used as a secondary fuel source. The challenge of alternative sources of energy poses not only technical problems but also institutional-policy problems. The public is constantly bombarded with the fact that the petroleum industry is a very capital intensive industry. If alternative energy sources were to threaten to make such investments redundant or obsolete, one may only speculate as to the pressures from financial quarters which would be brought to bear upon the decision makers considering alternative energy sources. However, it should be pointed out that the National Science Foundation is sponsoring research on wind generated power at a special facility presently under construction at Sandusky, Ohio on the shore of Lake Erie.

This section of the paper has identified the nature of energy-water problems in terms of instituion-policy issues. A specific example where these issues have been joined is the state of Florida.[18] Six thousand (6,000) people/week are migrating into the state of Florida. The state's consumption of electricity is increasing at the rate of 11 percent/year. Many citizens in Florida are concerned that soon they will be short of energy, clean water and air, attractive cities, and uncrowded beaches. They either are or soon will be living beyond the carrying capacity of their state. The state of Florida has projected three "alternative futures" for energy consumption as a function of three different projections of per capita energy demand and population growth. The high growth case projects extension of past trends, i.e., increased per capita energy consumption plus increased population growth. The other extreme is a low growth case where the is no per capita increase in energy consumption and a marked decline in the rate of population increase. The results are as follows:

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[17]Grimes, Dale, "Alternative Sources of Energy", paper presented at Edison Foundation Science Institute, Bozeman, Montana, March 1974, p. 26.

[18]Carter, Luther J., "An Energy Policy Emerges in a Growth State", Science, Vol. 184, No. 4134, April 19, 1974, p. 302-304.

	Year	1000 Megawatt Electric Generating Plants	Comments
Case A (High growth)	2000	129 (1/2 nuclear) (1/2 fossil fuel)	$72\text{-}10^6$ tons/coal/yr 3-100,000 dead weight ton tankers would deliver oil every day
Case B (Low growth)	2000	2	+50 miles of transmission lines

The third case is between these two extremes. The institution-policy process in Florida is identifying alternatives and the implication of these alternatives for the public. Under the provision of the Florida Environmental Land and Water Management Act of 1972, the state may soon adopt a growth policy containing a set of strategies including critical areas, enforceable land use planning, impact fees, and new growth in an area to be determined by the "carrying capacity" of the area. While there are significant political and administrative roadblocks still to be overcome prior to adoption of these strategies, the Florida example may be a useful guide to what needs to be done elsewhere.

INSTITUTIONAL MECHANISMS

The thrust of this paper is that energy-water interrelationships have created the need for broader more comprehensive analysis than performed historically. A valid question is whether or not existing institutional structure and policy processes are satisfactory to provide for this enhanced analytic perspective. In terms of the regional workshop, the Great Lakes stands out as an example of where past institutional structure and process have been criticized for failure to meet social needs. Accordingly, it is appropriate to identify certain of the suggestions which have been made for revision of the instituional system for management and utilization of the Great Lakes. Application and relevance of these ideas to other regional areas would have to be made by those with direct knowledge of the specific region.

The National Water Commission recommendation for improvement of institutional arrangements indicates that the missing link appears to be a mechanism for providing overall policy guidance to integrate the tasks being done by separate agencies.[19] Craine stated that many of the shortcomings of the

[19]"Water Plicies for the Future", National Water Commission, Final Report to the President and the Congress of the United States, Washington, D.C., June 1973, p. 433-434.

present institutional arrangements in the Great Lakes may not lie in the agency itself but rather in the institutional system or lack thereof in which the agency has been expected to operate. A vital aspect of institutional design is the explicit prescription of linkages between agencies which are vital to system operation.[20]

Specific proposals for institutional improvement in the Great Lakes are well documented.[21] In my view, the theme for these sources which would be most fruitful in terms of the institution-policy issues of energy-water is articulated by Professor Craine. Craine suggests two levels of geographic agencies. One, a basin-wide policy agency would be created which would establish primary policy controls. Second, an agency would be created to perform geographic integration in such subbains or regions of the Great Lakes Basin as problems and demand for public action indicated. The overview policy group would operate throughout the basin, much as the International Joint Commission (IJC) does today, and the others would be formed as needed within geographical areas requireing attention.

In contrast, one may consider the idea of establishing Regional Energy Commissions.[22] These commissions would have primary responsibility for energy policy formation and implementation. However, as previously indicated energy policy should not be separated from land use, water use, and other vital planning activities. Accordingly, one may question whether or not creation of Regional Energy Commissions would adequately address the problem.

OBSERVATIONS

Energy-water interrelationships are clearly complex and pervasive. The decision horizon needs to be divided into the short-term or near-term and the longer term. The former time period may include the years up to 1985-90; in contrast, the long-term planning/decision horizon would be the years after 1985-90. The provision of firm energy to meet demand requires significant lead time in order to move from concept-to design-to decision-to construction and finally-to operation.

A series of near-term water-energy policy problems have been identified in Souris-Red-Rainy, Upper Mississippi, Great Lakes, and Ohio Basins. However, the most important task in my view is not the specific choice made for any

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[20] Craine, Lyel E., "Final Report on Institutional Arrangements for the Great Lakes", A report prepared for the Great Lakes Commission, March 15, 1972.

[21] "A Proposal for Improving the Management of the Great Lakes of United States and Canada", Canada-United States University Seminar, 1971-72.

[22] Noland, Dr. Michael C., op. cit., p. 12.

one or even all of these current policy problems. Rather the most important task is devising improved capabilities -- analytic and others -- to investigate and project consequences of particular policy choices. These consequences should be identified in environmental, economic and social, and political domans. The analysis capabilities should stress the interrelationships of policy choices not their assumed independence.

The second -- equally important task -- is to modify our institutional structures in a way which will enable these units to effectively utilize the information prepared by the improved analysis capabilities. The River Basin Commissions provide a component of this revised institutional structure. These groups can certainly provide the overall energy-water policy guidance from the basin-wide perspective. Yet the diversity of most basins will require the specific focus of a unique agency to tie together activities within a specific geographical focus. Accordingly, the two-tier approach suggested by Lyle Craine for the Great Lakes Basin should -- in my view -- be developed to the point of operational testing. For example, one might consider the southern half of Lake Michigan as a geographical focus including Milwaukee, Chicago, Gary and portions of the state of Michigan. A new agency could be created for this region to focus upon the interrelationships between existing activities in the four separate states. Here the overall policy guidance set by the Great Lakes Basin Commission would be monitored, implemented, and coordinated by this new unit in the specific geographical region of interest.

Until the recent past, this country and the region designated by this workshop have not had to consider energy as a limited resource. This fact has been part of the way of life of this country for over 200 years -- namely, if there is a problem we can solve it -- we have or can obtain abundant resources for all out citizens. Technology will provide the fix to whatever the problem is that confronts us. Political-social aspects of energy-water relationships have not been examined because historically there was no reason to undertake such research. Neither resource was considered limiting and even if there were a shortage of water in a particular region, technology through diversion/transmission could overcome that problem. Now, in certain quarters, there is recognition that both water and energy are limiting resources. Furthermore, it is recognized that the previous mind-set which viewed our society as boundless in terms of basic resources must change. Consequently, new institution processes and procedures must be developed to enable the public to consider the future in terms of our recognition of resource constraints. The concept of technology assessment is certainly a step in this direction; however, means must be developed to consider not only the hard science/engineering alternatives but the political/social/economic/environmental impacts of these alternatives as well. The range of issues to be considered will range from the very specific, such as the allowable change in water temperature within a 1000' radius due to heat discharge, to the very diffuse, such as should cities continue to expand at their fringes or should policy be developed and implemented which penalizes such growth and encourages investment back within the cities where the provisional infrastructure is already established. Means must be developed to communicate to the public the areas of uncertainity that exist in terms of knowledge about consequences from policy choices.

These consequences are not limited to economic consequences but include environmental, social, political consequences as well. The institutional mechanism must open up to allow for a more complete interplay between the economic marketplace, research and development, and the long-term interests of socieyt. One effective and perhaps non-threatening way to accomplish these objectives is through a mixture of advanced computer models designed to simulate physical-biological futures which are derived for alternative policy choices coupled with political-social models aimed toward indicating realistic responses to the alternative futures resulting from the physical-biological models. This is an example of form following function in the sense that institutions evolve as a result of present demands which are themselves resultants of very basic decision choices which may have been taken years ago.

Energy-water choices structure interrelationships which have a profound impact upon our socieyt. Historically, energy has been viewed as a boundless resource to be harnessed for mankind's benefit. Recent developments underline the wisdom of considering energy resources as limited; and consequently, alterting our energy processes such that our energy consumption is energy "income" as opposed to energy "capital". In my view, this change in orientation toward resource utilization will necessitate alternative institutional forms that will assess the broad implications (however imperfectly) of alternative futures throughout the regions of this workshop. Innovative means include but are not limited to Delphi Techniques, Computer Simulation models, gaming-simulation models need to be employed in order to examine alternative futures in their broader aspects. Unless these and other techniques are utilized, traditional emphasis or short-run economic decision making will dominate institution-policy decisions. A series of very sub-optimal decisions regarding energy-water issues will in all likelihood further contribute to the serious energy crisis which already exists not only in this country but throughout the industrialized and developing world.

DISCUSSION REPORT

Robert Stiefel
Chairman
Ohio State University

Thomas G. Bahr
Reporter
Michigan State University

Dr. Dougal from Iowa State presented a paper on water supply problems related to energy. He pointed out that rainfall, runoff, evaporative water loss, groundwater reserves, and population distribution were features common to the region. Industrial growth within the region is also high - more than 32 percent of the industry of the country located in this area and the demand for energy will be exponential. In the discussion it was pointed out that UCOWR has not addressed itself to alternative futures relating to the effect of water resource development on national population distribution strategies. It was suggested that one means to accomplish this coordination might be for UCOWR to work with the science advisory panel of the House Public Works Committee.

Various power production sources in the region were discussed. It was concluded that the water resource needs relating to energy in the region were those most closely associated with cooling water for steam electric facilities. Consumptive use of water for steam electric generation is generally low, but the release of heated effluents poses potential problems. Thus a major problem in the region relates to the management of heated water discharges. These are problems of water quality, not water quantity. It also was mentioned that groundwater may afford possibilities for power plant cooling water in certain parts of the region.

Dr. Glen Stout presented a paper on water demands for energy and stressed the need for conservation and reuse schemes. Sequential reuse and recycled reuse were mentioned which led to a discussion of the question of why conserve water in a seemingly water-rich region. Although the environmental ethic certainly has an effect on the decision to reuse water, there are other more pragmatic reasons. For example, less withdrawal of water for energy will, in turn, create less demands for treating water after it is used. Savings on treatment costs could be considerable. Water for navigation was mentioned as an important water use for the region and in general is considered to be an energy conserving means of transportation. Water for the dilution of waste was mentioned, but in view of the Great Lakes as sinks for waste material, this use for water can no longer be seriously considered.

The management of water supply considering the secondary spinoffs, especially related to population distribution, appears to be a high priority problem area for the region. Power plant siting, for example, will have profound effects on population distribution and the distribution of industry and other energy-consuming elements of society. The group strongly recommended that power plant sizing and siting should not be left up to the utility engineers but rather should be a multidisciplinary effort because of its vast importance.

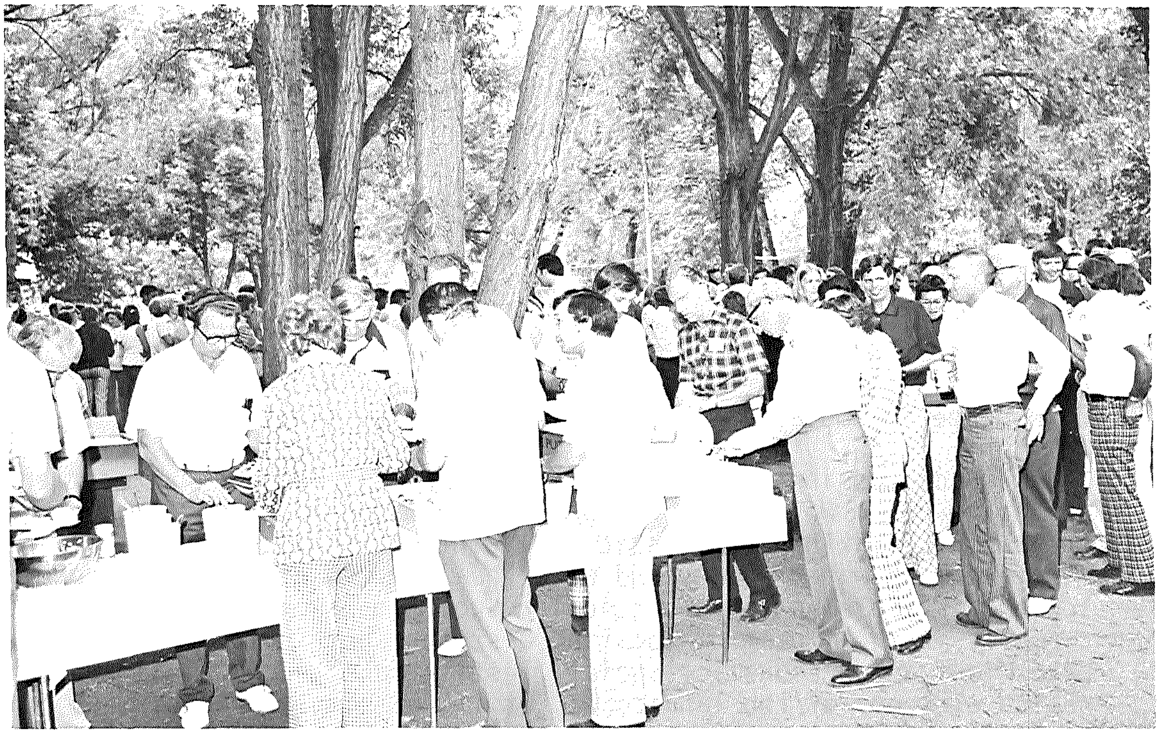
Dr. Leonard Dworsky presented a discussion on regional concerns of water for energy. Reaffirmed was the lack of information and adequate documentation of damage caused by heated discharge from steam electric power plants. It was pointed out that effects of waste heat may be difficult to determine in the short term since many of these effects are chronic in nature.

Dr. Jonathan Bulkley discussed a number of institutional problems related to water and energy. It was stated that we are probably living beyond our carrying capacity as it relates to energy. We should be living off our energy interest rather than our energy capital! There is a critical need to revise our institutions to accommodate the necessary changes that will, no doubt, take place in society with future water-energy problems.

The discussion of this workshop eventually focused on recommending that any approach to water resource problems related to energy should be geared to the theme of taking a wholistic viewpoint of the alternative futures in the management of water supply and water quality. What are the tradeoffs to society in implementing a particular supply management scheme? What, for example, is the impact of locating a steam-electric facility on the shore of Lake Michigan on economic, social, institutional, ecological and public health elements of the landscape? It is not simply a problem of determining the effects of this scheme on water quantity or quality.

It was also mentioned that universities, through the representative regional structures, should work more closely with the Basin Commissions. These commissions play an important role in shaping recommendations of the Water Resources Council and their subsequent budget recommendations to the President.

In summary, the group reaffirmed the need for water centers to assist in research programming for the Office of Water Research and Technology. Stressed was the value of the regional approach in developing programs that can effectively respond to problems by harnessing the talents inherent in an inter-institutional effort. The group recommended that the research programming should be such that projects are developed in response to regional problems and that research should be geared and followed through with the users of the research in mind. Major emphasis should be placed on taking a wholistic or total systems look at the consequences of alternative water management schemes, and it was urged that the OWRT not focus too narrowly on water problems, especially as they relate to energy.

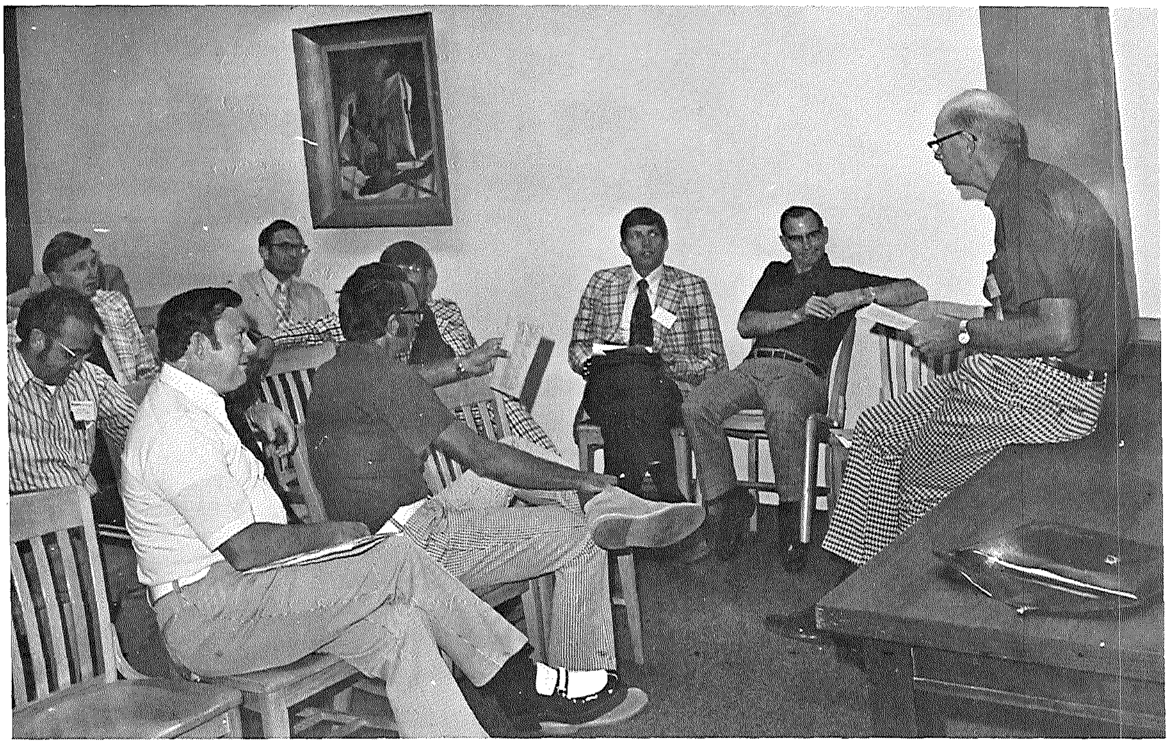


Steak Fry at Logan Canyon

Banquet

REGIONAL WORKSHOP

IV - MISSOURI



Missouri River Basin Workshop in session

OPPORTUNITIES FOR ENERGY DEVELOPMENT IN THE NORTHERN GREAT PLAINS

by

Dale O. Anderson
North Dakota State University

One of the greatest, if not the greatest, challenges facing the Northern Great Plains states in the next decade is to provide an acceptable level of natural resource development and economic growth consistent with a quality environment and social well-being. We can achieve this goal through adequate comprehensive planning and effective decision making. Such planning assumes a fundamental knowledge of biological, physical, social and economic know-how necessary to achieve a political solution. The development of the coal energy industry in the Northern Great Plains presents each of us in research, education, planning and decision making with a unique challenge to perform.

The growth in energy demands along with the demand for clean energy has focused attention on the lignite and subbituminous coal deposits of the Northern Great Plains. Montana, North Dakota and Wyoming all have extensive coal resources. The Fort Union coal beds, which underlie a large area of northeastern Wyoming, southeastern Montana and wester North Dakota, appear to offer the greatest potential for development. (Figure 1) The Fort Union reserves account for 40 percent of the total United States coal reserves and as much as 90 percent of the low sulfur reserves.[1] Total Fort Union reserves have been estimated at 1.3 trillion tons. Given the present state of technology and demand for energy, it is estimated that more than 60 billion tons predicted to be available in the tree states are economically strippable.[2]

HISTORICAL COAL DEVELOPMENT

Commercial mining of lignite has been underway in North Dakota and the Northern Great Plains region for nearly a half century. Much of the early coal mining in North Dakota was accomplished through deep underground mines. This type of mining created problems associated with the surface

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[1]Bureau of Mines, "Strippable Reserves of Bituminous Coal and Lignite in the United States," Information Circular 8531, U.S. Department of the Interior, Washington, D.C., 1971, p. 3.

[2]Graff, S.L. and Matson, R., "Montana's Coal Resource Situation," The Mining Record, Volume 83, No. 13, 1972, p. 4.

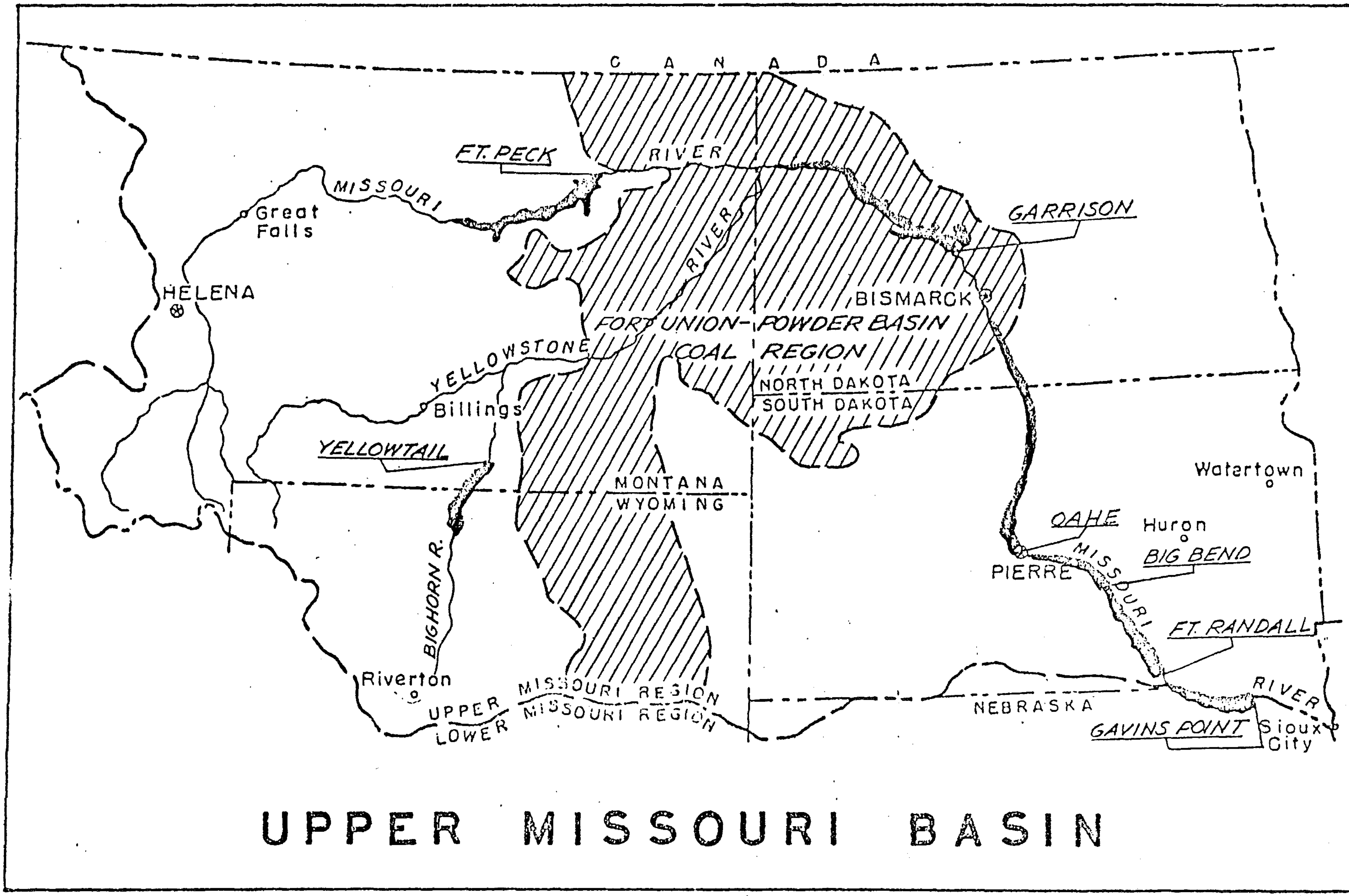

Figure 1

FORT UNION - POWDER BASIN COAL REGION OF WYOMING, MONTANA AND NORTH DAKOTA use of the land above a mine. In many areas of North Dakota where underground mining has taken place in the past, the surface of the land has collapsed, causing intermittent depressions rendering the land unproductive for most uses.

Strip mining of coal has replaced underground mining in North Dakota. Commercial mining of lignite in North Dakota is concentrated in Mercer and Oliver counties which is from 50 to 75 miles northwest of Bismarck. Most of the coal production from current mining is used to fuel steam-electric power plants located near the mines. A smaller amount is being shipped to eastern and midwestern coal-fired plants to be mixed with local coal that will not meet existing environmental regulations.

Strip mining is a high volume earth moving operation with overburden being removed by electric powered drag lines. The largest drag lines are approximately 35 cubic yards in capacity. The coal is hauled from the mine to the point of processing through the use of 100 cubic yard bottom dump carriers.

The strip mining process is illustrated by the series of diagrams in Figure 2. Although a coal seam outcrops in some areas, the depth of the overburden in most areas is at least 90 feet and in some instances as much as 150 feet. The coal seam ranges from 10 to 25 feet. The rule of thumb, followed by most coal companies to determine the economic feasibility of mining a particular area, is a ratio of coal to overburden of 1:10. That is, they must be able to extract at least one foot of coal for each ten feet of overburden removed.

An examination of the strip mining procedure illustrated by Figrue 2 will show that in the process of removing the overburden from the coal seam the most productive soil ends up at the bottom of the spoil bank. Thus, restoring vegetative growth to the surface of the spoil banks is a long and difficult process. The success varies considerably. A law passed by the 1973 North Dakota Legislative Assembly requires that at least two feet of top soil be replaced and the land be returned to its natural productivity. The effectiveness of this law in achieving productive spoil bank reclamation is not known at this time.

FUTURE COAL DEVELOPMENT PLANS

Plans for extensive development of the Fort Union Coal reserves are proceeding rapidly. Coal production in Wyoming, Montana and North Dakota for 1972 was 4,240,000; 8,220,000; and 6,540,000 tons respectively. By 1980, it is projected by the mineral resources group of the Northern Great Plains Resource Program that the production will increase to 28,800,000 tons for Wyoming; 40,640,000 tons for Montana; and 18,470,000 tons for North Dakota. Future plans for Fort Union Coal appear to call for increases in mine-mouth generation of electrical power, gasification and liquefaction to meet demands for electrical power, natural gas and other fuels.

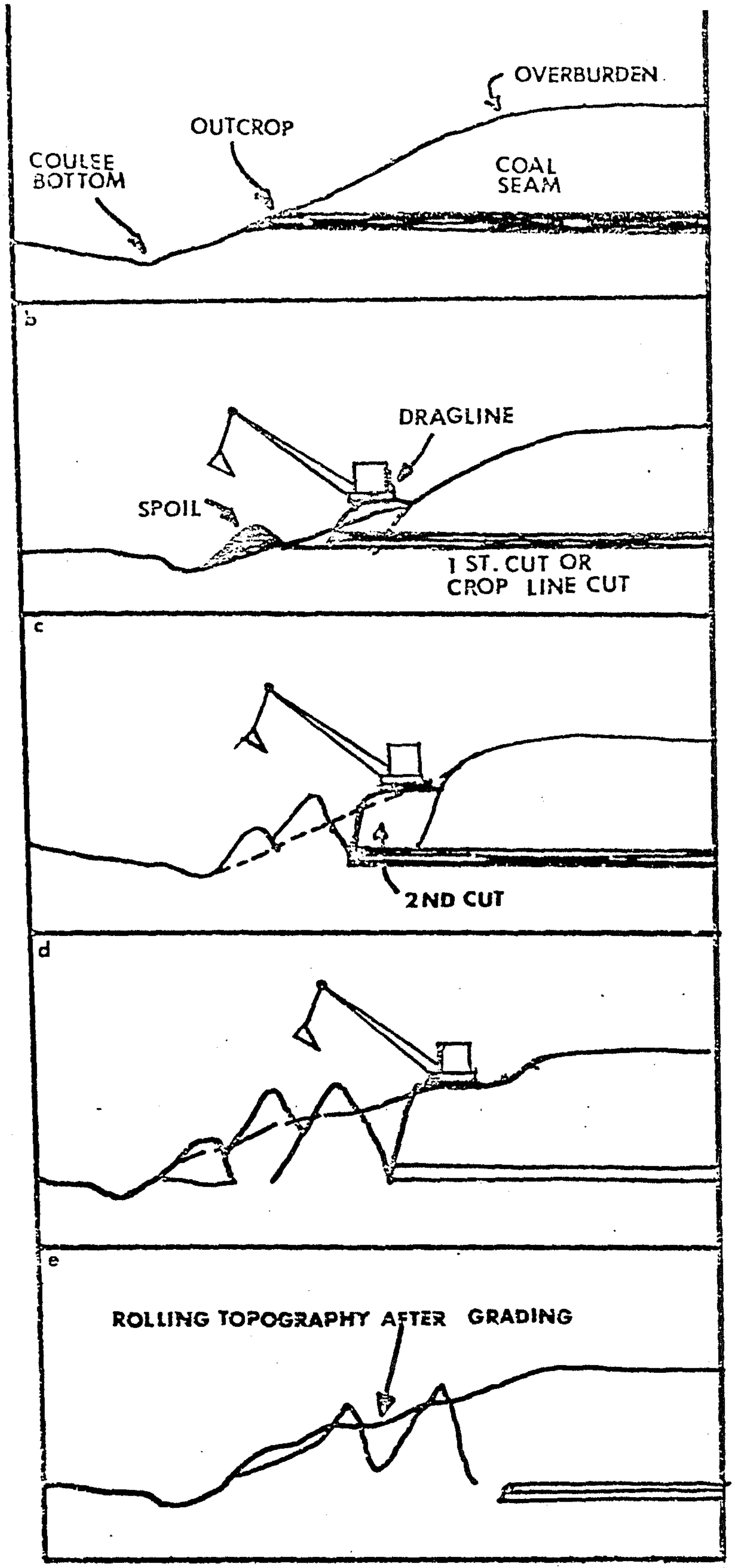

Figure 2

CROSS SECTION OF A NORTH DAKOTA LIGNITE FIELD
ILLUSTRATING THE STRIP MINING OPERATION

Source: Bond, Peter, "Spoil Bank Restoration," Conference on Mining and Power Production, Interium Report Number 5, Little Missouri Grassland Program, North Dakota State University, Fargo, North Dakota, 1973, p. 36-40.

Most attention in the past year has focused on gasification plant proposals. The gasification plants would combine coal and water to form a synthetic natural gas which would be transported by pipeline to markets mainly outside of North Dakota and the Upper Midwest. Present estimates indicate that each plant would consume 10-12 million tons of coal and 17,000 acre-feet of water per year. Each plant, designed to produce 250 million cubic feet of gas per day, would require an initial investment of approximately $700 million. The plant, its coal mine and pipeline distribution facility would employ about 1,050 workers.

The land area disturbed by a gasificaiton plant would vary, depending largely on the coal production per acre. It is expected that the plant would require 2,200 acres. Based on projected production for one area, approximately 500 acres of land would be disturbed annually in mining the coal required by one plant. The company plans to begin the reclamation process of disturbed land and have it back in production within three years.

Although coal gasification remains somewhat speculative, several major companies are proceeding with specific plans to establish plants in North Dakota. For example, the Michigan-Wisconsin Pipeline Company and the North American Coal Corporation jointly announced that the coal corporation had dedicated 1.5 million tons of lignite reserves in western North Dakota to the Michigan-Wisconsin Pipeline Company for future gasification. The pipeline company filed a request for water rights with the North Dakota State Water Commission totaling 375,000 acre-feet annually. The water is to be diverted from Lake Sakakawea (impoundment created by the Garrison Dam on the Missouri River). The State Water Commission, after a number of public hearings, granted the Michigan-Wisconsin Pipeline Company a water permit for 17,000 acre-feet annually to authorize the development one gasification plant. In granting the permit, the State Water Commission attached 18 conditions to which the Michigan-Wisconsin Pipeline Company must conform. Other companies announcing plans to develop coal gasification plants in western North Dakota include El Paso Natural Gas Company and Natural Gas Pipeline Company of America. In addition, several firms have announced plans to sharply increase the electric generating capacity of the region.

OPPORTUNITIES ASSOCIATED WITH COAL-ENERGY DEVELOPMENT: SOCIO-ECONOMIC IMPACTS

While it can be stated generally that the three states are seeking ways to stimulate economic growth and therefore favor development of the coal resources within their borders, the contemplated development raises serious reservations. Indeed, there are existing factions within each of these states that are opposed to any substantial coal-energy development.

There is little doubt that local areas, the three states as a whole or even the region will receive considerable economic benefits from the development of the Fort Union coal resources. However, it is clear that the real costs of developing these resources -- depletion of resource stocks, environmental disruption, if not actual damage, loss of existing economic activities that will be displaced by coal developmnet, cost of providing the numerous public facilities and services that will be required to accommodate the population influx that will accompany the development -- will be borne by this region. On the other hand, the principal beneficiaries from development of the region's coal resources will be those individuals who benefit by either lower cost or more reliable sources of energy.

Since the final markets for most of the coal or products made from the coal are located outside of the region, development issues center around the question of whether the region will be compensated for the unavoidable costs associated with development and whether reasonable action will be taken to avoid unnecessary environmental damage.

The following section discusses a portion of a comprehensive study being conducted by the North Dakota State Water Commission to evaluate alternative development levels for southwestern North Dakota. The study analyzes four alternative levels of development. These levels are defined in Table 1. The impact of these different levels of development on employment and population will be discussed.

This area of the Great Plains is basically agricultural, is losing population at a significantly faster rate than the remainder of the state and employment opportunities are declining.

The economic impact on direct and indirect employment was estimated for two water uses -- coal gasificaiton and coal-fired steam electric power generating plants. The impact of other water uses such as irrigation, municipal water, flood control and recreation was not estimated. It was assumed that there would be no change in direct employment for these uses of water and consequently no appreciable change in employment would occur. Irrigation is the only other water use which would affect direct employment in the area. It was assumed that irrigation development would not affect basic employment in agriculture. However, employment in the supply intrastructure for agriculture would be affected somewhat. It was assumed that the total change would be negligible given continued advancement in technology and growth in farm size on dryland.

Direct employment for steam electric power was established at 105 full-time jobs for mining and plant operation of a 500 megawatt facility. (Table 2) This included 50 employed at the plant while mining provided 55 jobs. Direct employment for the coal gasification plant producing 250 MMSCFD was 1,056 jobs. (Table 2) This provided 300 full-time jobs in the mine and 756 full-time jobs at the plant.

Given the direct employment for coal gasification and power generating plants, total direct employment was calculated for the scenarios of development. The number of new jobs created by gasificaiton and power ranged from 15,985 in the low development scenario (Level I) to 51,702 under the high level development scenario (Level IV). The total employment for steam electric power ranged from 1,201 jobs under Level I to 7,350 jobs under Level IV. Concurrently, the coal gasification process generated 14,784 jobs assuming Level I development and 44,352 assuming Level IV development would occur.

TABLE 1

SPECIFICATION OF ALTERNATIVE LEVELS OF ENERGY DEVELOPMENT FOR SOUTHWESTERN NORTH DAKOTA

Development Level	Coal Gasification Plants	Power Generation
	(Number)	(Megawatts)
Level I	14	5,720
Level II	14	10,000
Level III	28	20,000
Level IV	42	35,000

TABLE 2

DIRECT EMPLOYMENT CREATED BY COAL GASIFICATION AND STEAM ELECTRIC POWER GENERATION FOR FOUR ALTERNATIVE LEVELS OF DEVELOPMENT

Item	Plant and Mine Employment	Levels of Development			
		I	II	III	IV
	No. of Jobs	No. of Jobs	No. of Jobs	No. of Jobs	No. of Jobs
Steam Electric Power	105	1,201	2,100	4,000	7,350
Plant Employment[1]	(50)	(572)	(1,000)	(2,000)	(3,500)
Mine Employment	(55)	(629)	(1,100)	(2,000)	(3,850)
Coal Gasification	1,056	14,784	14,784	29,568	44,352
Plant Employment[2]	(756)	(10,584)	(10,584)	(21,168)	(31,572)
Mine Employment	(300)	(4,200)	(4,200)	(8,400)	(12,600)
Total Direct Employment		15,985	16,884	33,768	51,702

[1]Based on a 500 megawatt plant and employment factor of 0.10 jobs per megawatt.

[2]Based on a plant size of 250 MMSCF per day production capacity and coal requirements of 10,000,000 tons annually.

Indirect employment for the four levels of development was based on an indirect to direct multiplier of 2.23;[3] in other words, volume throughout the economy to employ 2.23 supporting people as indirect employment. This change in employment would be expected after the economy was once again back in equilibrium at a considerably higher level of economic activity.

Applying the multiplier value of 2.23 to direct employment provided the estimates of indirect employment for each development scenario summarized in Table 3. The level of indirect employment ranged from 35,647 employees at Level I to 115,295 employees if development occurred at a magnitude consistent with Level IV. Therefore, the total change in employment is projected to be 51,632 at the lowest simulated level of development and 166,997 at the highest level.

The employment level in the 14 southwestern North Dakota counties in 1970 was about 55,000. Therefore, development at the lowest level would increase employment by an amount almost equal to the 1970 employment level, assuming the impact was confined to the 14-county area. A broadening of the impact zone of influence would decrease the employment impact in the southwestern North Dakota area.

The impact of coal development on total population was estimated by applying a ratio of total population/employment to the total population changes. A ratio of 2.71 projected for 1980 was utilized in developing population changes.[4] Estimates of changes in total population ranged from 139,923 persons, assuming Level I to 452,652 persons, assuming Level IV. In other words, an increase in direct employment of 15,985 jobs in Level I would increase population in the area by 139,923. The magnitude of the employment change would be reduced as the employment impact is broadened beyond the 14-county area.

VALUE OF WATER

Although it is true that life depends on water, society does not usually act as though water had equal value to life itself. The reason is that the supply of water far exceeds the amount required to sustain human life. In practice, water is used extravagantly. The standard explanation for treating water so carelessly is that it costs too much to do otherwise--a reason that seems to contradict the idea that water is our most valuable resource. Obviously, water value is a complex subject.

Value estimates are useful only if they contribute to better decision making about water allocation. In deciding upon the allocation of water among competing uses which have a similar effect upon the water resource, a comparison of water value per unit of water used indicates the direction such an allocation should proceed.

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[3] Dalstad, Norman, et al., Economic Impact of Energy Development Patterns in North Dakota, Department of Agricultural Economics North Dakota State University, Unpublished Report prepared for the Northern Great Plains Resources Program, 1974.

[4] Ibid.

TABLE 3

DIRECT, INDIRECT, TOTAL EMPLOYMENT AND
TOTAL POPULATION CHANGE ASSOCIATED WITH THE
DEVELOPMENT OF COAL GASIFICATION AND STEAM ELECTRIC
POWER GENERATION FOR FOUR ALTERNATIVE LEVELS OF DEVELOPMENT

Item	Level of Development			
	I	II	III	IV
Total Direct Employment	15,985	16,884	33,768	51,702
Total Indirect Employment	35,647	37,651	75,303	115,295
Total Employment	51,632	54,535	109,071	166,997
Total Population Change	139,923	147,790	295,582	452,562

A consistent definition of "use" of water is essential for comparable measures of the value of water in different uses. But, defining water use is difficult because the users of water differ greatly in the way that they use water. Some users have no measurable effect on the water and hence several users can use the same unit of water at the same time or in sequence, for example, fish, navigation and recreation. Others, such as agricultural uses or coal gasification, consume much of the water that is used and it is not available for any subsequent uses.

The West River Study being conducted by the State Water Commission in North Dakota has developed an estimate of the economic value of water for use in coal gasification, steam power generation and agriculture. The estimated values of water per acre-foot were $306.45 when used in the coal gasification process; $308.97 when used in steam power generation; and $97.52 for irrigated agriculture, assuming prices representing 1973 average crop prices received by farmers and 1971-72 prices received by farmers for livestock.

The comparison of water values in alternative uses will become increasingly important in the future as a growing demand must be satisfied with a limited natural supply of water and values in use increase. The opportunities for net gains by better allocations will be much greater. Economic values provide the best general indication of the basic worth of water as long as appropriate attention is provided to protection of environmental values. The values for water developed in the West River Study provide a basic framework for water allocation.

SUMMARY

The magnitude of coal development in the Northern Great Plains during the next 20 years will be extensive. We must endeavor to provide an acceptable level of natural resource development and economic and social well-being while assuring the maintenance of a quality environment. This goal can be achieved through adequate comprehensive planning. Such planning assumes a fundamental knowledge of biological, physical, social and economic know-how necessary to achieve a political solution. In many cases the necessary fundamental knowledge presently available is not adequate to formulate rational decision making. In other cases, appropriate information readily available has not been disseminated to the users. Therefore, substantial research and education programs must be initiated and carried out to make it possible for public and private decision makers, as well as the general public, to reach national decisions on coal development in the Northern Great Plains which will have a major impact on future generations.

WATER AND CONSERVATION IN THE MISSOURI RIVER BASIN

by

Hyde S. Jacobs
Kansas State University

The Missouri River Basin - biggest of the nation's 18 major river basins - embraces 513,000 square miles in the United States, 328 million acres in ten states.

Rainfall in half the basin averages less than 16 inches annually, and less than 12 inches in much of the basin. Population is low. Although the region contains 15 percent of the nation's land, it supports only 4½ percent of its people.[1] Consequently, per capita runoff, 6,400 gallons per person per day, exceeds that in the upper Mississippi, Ohio, North Atlantic, and six other major basins. Irrigation is important so per capita use of water is high: more than 3,300 gallons per day per person in the upper basin and 2,900 gallons per day in the entire Missouri River Basin compared with the national average of 1,600 gallons per day.[2,3]

Much of the land in the basin is arable and devoted to crops, range, and pasture; a third of the total acreage is in crops and the soils are generally deep and fertile. Nitrogen is the fertilizer most needed but phosphorus and potassium also are needed, especially in the eastern soils of the region and under irrigation.

Notwithstanding the dry climate, flood losses are estimated to be higher in the Missouri River Basin than in any other major basin.

The Missouri River Basin is an area of contrast. Annual rainfall ranges from 45 inches at the southeastern tip of the basin to less than 10 inches in Wyoming. Water lost annually from open-pan evaporation varies from 65 inches in Kansas to 26 inches in Montana, and rainfall is sporadic. An actual example is instructive. At Tribune, Kansas, annual rainfall averages 17 inches per year; open-pan evaporation 65 inches in April through September; half the annual precipitation is received on the 9 days having

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[1] A Framework Plan for the Missouri River Basin. Missouri River Basin Commission, 10050 Regency Circle, Omaha, Nebraska.

[2] Geraghty, J.J., D.W. Miller, F. VanDerLeeden, and F.L. Troise. Water Atlas of the United States, Water Information Center, Inc., Port Washington, New York, 1973.

[3] Murray, C.R. Estimated Use of Water in the United States, Geological Survey Circular 556, 1965.

the most rainfall. Precipitation exceeds 1 inch only 3 or 4 days per year on the average.[4] Most rainfall events merely settle the dust.

Obviously water conservation and intensive water resource development are acute water resource needs in the region. This paper explores potential opportunities to conserve water in the Missouri River Basin.

WATER USE IN THE MISSOURI RIVER BASIN

Knowledge of how water is used in the basin is basic to any attempt to conserve or recycle water. Water use in the ten Missouri River Basin states is presented in Tables 1 and 2. Those data provide a basis for analyzing the potential success of various water conservation practices in the area. Portions of some of the states lie outside the basin boundaries.

Murray et al.[5] provided withdrawal and runoff data that were used to estimate water budgets for the upper and lower Missouri River Basins (Tables 3 and 4). Based on those estimates, rain supplies an average of 519 million acre feet of water annually. Irrigation - largest withdrawal use in the basin - requires 79 percent of all water withdrawn. Industrial use - next largest withdrawal use - requires 14 percent. An additional 5 percent is used for public, and 2 percent for rural, supplies. Runoff averages 9 percent of the total rainfall in the upper and 22 percent in the lower basin.

Clearly, evapotranspiration is the largest single source of water loss in the region - losses average 86 percent in the upper and 76 percent in the lower basin. Losses of water evaporating from soil, plant, and water surfaces are difficult to reduce or recycle. However, evaporative losses are so great that even small percentage gains would be significant, particularly in the semi-arid upper basin, which contains 89 percent of the basin's land area.

OPPORTUNITIES FOR CONSERVATION AND RECYCLING

Necessary goals in the Missouri River Basin are to save water through management, recycling, and judicious use. Obtaining new water sources through weather modification, water harvesting, interbasin transfer, or further development of ground and surface water resources is also important. Data in Figure 1 suggest that 1965 withdrawals utilize 63 percent of the 1980 dependable supply - a supply projected at 37 million acre feet.[6]

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[4] Future Irrigation Water Demands - Impact of Technology and Management, Kansas Water Resources Board, Bulletin 11, 1960.

[5] Murray, C.R., Estimated Use of Water in the United States, Geological Survey Circular 556, 1965.

[6] Ibid.

TABLE 1

WITHDRAWAL USES OF WATER IN THE
MISSOURI RIVER BASIN STATES, 1970.*

	Total Withdrawal, 1000 Ac-ft/Yr	Irrigation, 1000 Ac-ft/Yr	Public Supply, 1000 Ac-ft/Yr	Industrial Supply, 1000 Ac-ft/Ur	Rural Supply, 1000 Ac-ft/Yr
Colorado	15,455	14,560	445	360	50
Iowa	2,350	29	280	1,905	200
Kansas	4,255	3,360	280	470	145
Missouri	3,920	86	570	3,135	170
Minnesota	3,810	22	380	3,250	190
Montana	8,960	8,510	125	235	48
N. Dakota	730	215	56	415	36
Nebraska	6,720	5,265	215	1,110	135
S. Dakota	670	260	67	215	135
Wyoming	6,495	6,050	55	345	28
TOTALS	53,365	38,357	2,473	11,440	1,137

* Adapted from Geraghty et al.[7] Partial figures may not add to total because of independent rounding.

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[7]Geraghty, J.J., D.W. Miller, F. VanDerLeeden, and F.L. Troise, Water Atlas of the United States, Water Information Center, Inc., Port Washington, New York, 1973.

TABLE 2

IRRIGATED ACREAGE AND WATER USE,
MISSOURI RIVER BASIN STATES, 1970.*

	Irrigated Acreage* 1,000's of Acres	Irrigation Water Withdrawn* 1000 Ac-ft/Yr	Conveyance Loss** 1000 Ac-ft/Yr	Consumptive Use** 1000 Ac-ft/Yr
Colorado	4,600	14,580	1,680	7,055
Iowa	54	29	0	29
Kansas	1,800	3,360	455	2,955
Missouri	180	86	0	69
Minnesota	50	22	0	22
Montana	2,200	8,510	2,013	5,990
N. Dakota	74	215	67	150
Nebraska	4,100	5,265	985	3,815
S. Dakota	150	260	99	125
Wyoming	1,700	6,050	1,780	2,610
TOTALS	14,908	38,357	7,079	22,820

* Adapted from Geraghty et al.[8]

**Data obtained from Murray[9] but adjusted to correspond to irrigation water withdrawals given by Geraghty et al.[10]

[8]Geraghty, J.J., D.W. Miller, F. VanDerLeeden, and F.L. Troise, Water Atlas of the United States, Water Information Center, Inc., Port Washington, New York. 1973.

[9] Murray, C.R., Estimated Use of Water in the United States, Geological Survey Circular 556, 1965.

[10]Geraghty, J.J., op. cit.

TABLE 3

ANNUAL WATER BUDGET: UPPER MISSOURI RIVER BASIN

		Million Acre-Feet	Percent
Rain		416.	100%
WITHDRAWAL		21.	5%
Irrigation	18.0		
Public Supply	1.0		
Industrial Supply	1.6		
Rural Supply	.4		
Consumptive Use	(12.4)		
RUNOFF		39.	9%
RECHARGE		?	?
EVAPOTRANSPIRATION		356.	86%
TOTAL		416.	100%

TABLE 4

ANNUAL WATER BUDGET: LOWER MISSOURI RIVER BASIN

		Million Acre-Feet	Percent
Rain		103.	100%
WITHDRAWAL		2.	2%
Irrigation	.1		
Public Supply	.2		
Industrial Supply	1.6		
Rural Supply	.1		
RUNOFF		23.	22%
RECHARGE		?	?
EVAPOTRANSPIRATION		78.	76%
TOTAL		103.	100%

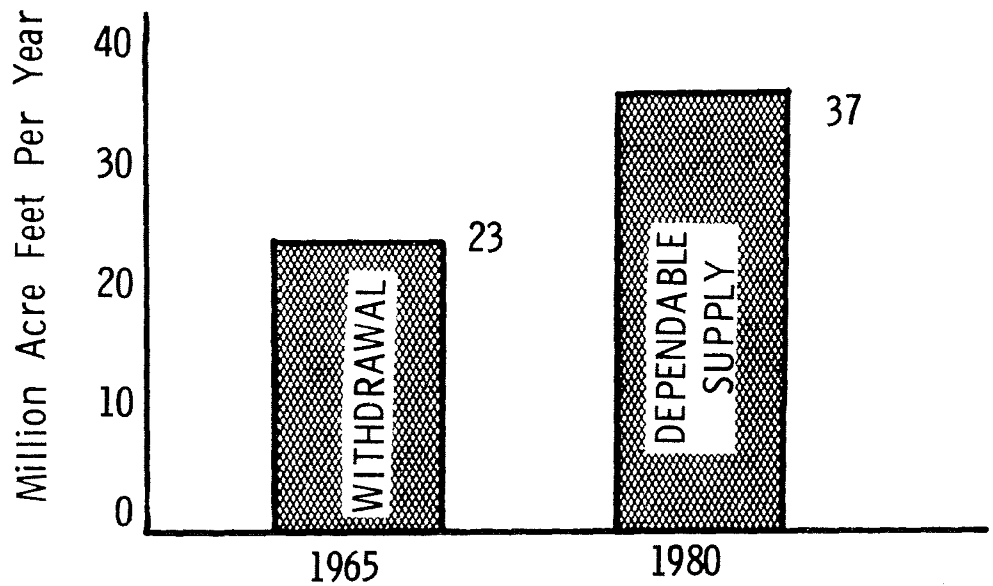

FIGURE 1. Water Withdrawal and Dependable Supply, Missouri River Basin

Current use plus projected increases in irrigation alone will exceed the dependable supply. Murray[11] suggests withdrawal and consumptive uses are approaching the dependable supply in the arid West. Under the projected conditions, total fresh water withdrawals may exceed estimated dependable supply due to groundwater extraction and repeated withdrawal of surface water.

Because projected demand for water will soon exceed the dependable supply, it is important to know where the most water can be saved for the least cost.

Urban and Rural Water Supplies

Charles W. Howe et al.[12] concluded that use of available technologies could save up to 32 percent of current in-house use (9 percent for showers, 18 percent for toilets, and 5 percent on automatic washing machines). However, those savings would come at the cost of expensive equipment and would be instituted only after water prices rose dramatically. Howe concluded that water prices are not likely to rise high enough to trigger a major shift.

Withdrawals for public supplies (one million acre-feet per year) and for rural supply (one half million acre-feet per year) are small. Consequently, total water saved by conserving or recycling those supplies would be small. For example, a 91 percent saving in public water supply would be required to provide a million acre-feet of water for use elsewhere in the basin. Consequently, major efforts to conserve water in the region should be focused on uses other than public or rural supplies. Continued attention to the quality of public and rural supplies will be required, however.

Industrial Supply

Next to irrigation, industry withdraws the most water in the basin. Four states - Missouri, Iowa, Nebraska, and Minnesota - use 82 percent of all water used for industrial purposes by the 10 basin states. In the United States and the Missouri River Basin, about 82 percent of all self-supplied industrial water is used to generate electricity. Nearly 97 percent of the water used for thermo-electric power generation and 70 percent of water used by other industries are for cooling. Combining all industries, about 90 percent of the water used is for cooling, leaving 10 percent for other purposes.[13] In the upper and lower basins, Murray et al.[14] estimate that less than 3 percent of the water withdrawn for self-supplied industrial water is consumed. Stated differently, 3.2 million acre-feet are withdrawn but 3.1 million acre-feet are returned.

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[11] Murray, C.R., Estimated Use of Water in the United States, Geological Survey Circular 556, 1965.

[12] Howe, C.W., C.S. Russell, R.A. Young, and W.J. Vaughn, Future Water Demands - The Impacts of Technological Change, Public Policies and Changing Market Conditions on the Water Use Patterns of Selected Sections of the United States: 1970-1990, Report NWCEES-71-001 prepared for National Water Commission, Resources for the Future, Inc., Washington, D.C., 1971.

[13] Murray, C.R., op. cit.

[14] Ibid.

The quality of return-flow industrial water may have been altered by additions of heat and organic and inorganic substances, so, in some cases, water treatment may be necessary before further use. Clearly though, the bulk of water withdrawn is returned to basin sources and is available for further withdrawal. Neglecting water quality considerations, it appears that major efforts to conserve or make additional water supplies available in the basin should be focused on nonindustrial uses.

The energy crisis has instituted new water requirements for coal mining, transportation, and gasification processes that will greatly increase demand for industrial water in some states. Conservation and reallocation of water supplies will play major roles in meeting demands for the additional water required.

Irrigation

The Missouri River Basin contains about 28 percent of the nation's irrigated acreage; in 1965 fully 79 percent of all water withdrawn was used for irrigation. More than 96 percent of the irrigated acreage in the ten basin states is concentrated in five states: Montana, Wyoming, Colorado, Kansas, and Nebraska. In those five states, 90 percent of all water withdrawn is for irrigation.

Projected growth of irrigation in the Missouri River Basin, Figure 2, is of interest because irrigation requires, by far, more water than any other withdrawal use. In 1965 irrigated acreage in the basin proper was estimated at 7.4 million acres. The framework plan[15] suggests an additional 10.8 million acres could be irrigated by 2020 A.D., a 146 percent increase. Groundwater is the expected water source for 55 percent of the increase in irrigated areas. At today's usage rate, an additional 28 million acre-feet of water would be required. Such uses would have far-reaching economic and competitive consequences in the region.

Increased use of irrigation water is expected to far exceed increased use of industrial and municipal water, especially in the five states where irrigation is important. In Kansas for example,[16] use of irrigation water is expected to increase by 6.4 million acre-feet per year or 36 percent by the year 2000. Water use by municipalities and industries is expected to increase only 0.8 million acre-feet per year or 167 percent during that same period.

Irrigation requires lots of water -- about 31 acre-inches for each of the 14,908,000 irrigated acres in the ten basin states. Of that amount, 5.4 inches is lost in conveyance and 18.3 inches is lost to evapotranspiration. Excluding Minnesota, water saved by eliminating conveyance losses would supply 86 percent

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[15] A Framework Plan for the Missouri River Basin. Missouri River Basin Commission, 10050 Regency Circle, Omaha, Nebraska.

[16] Future Irrigation Water Demands - Impact of Technology and Management. Kansas Water Resources Board, Bulletin 11, 1960.

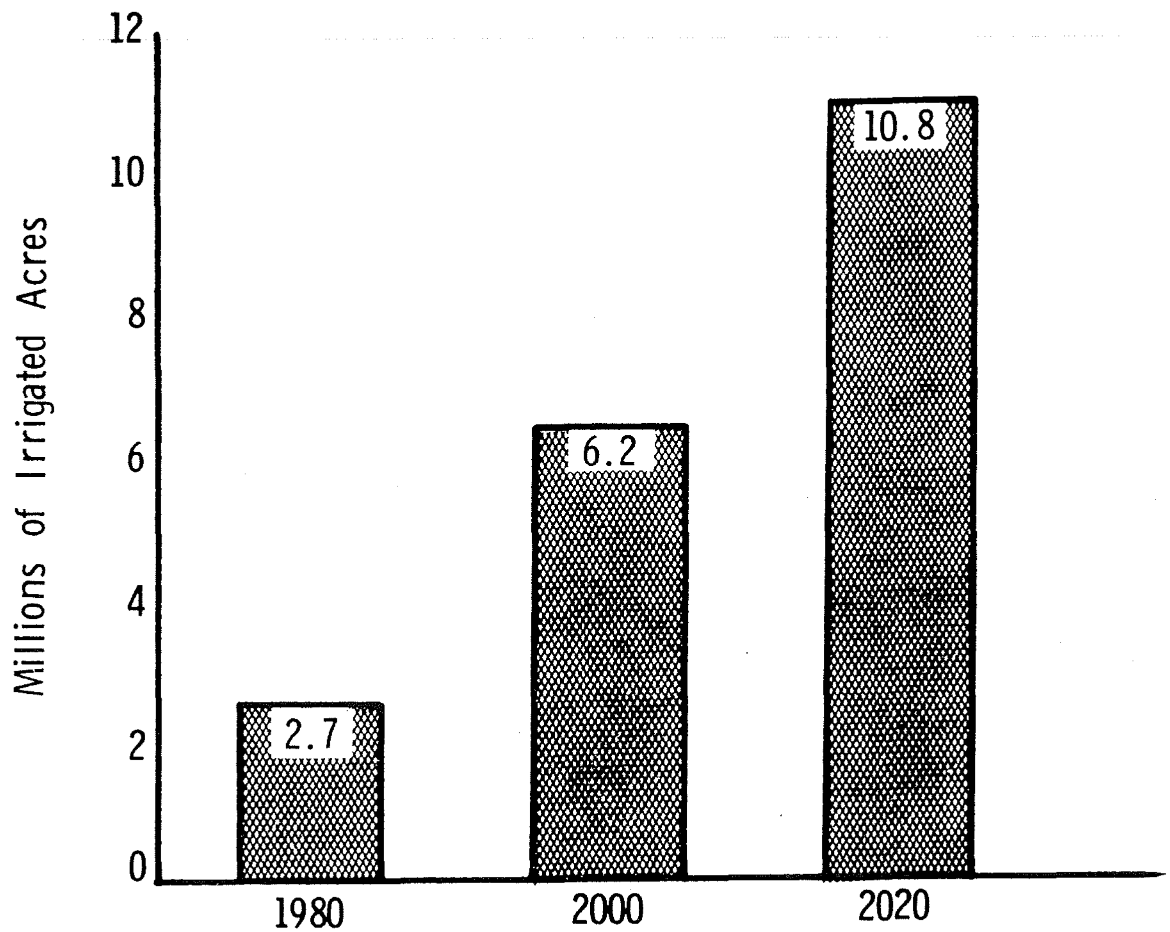

FIGURE 2. Projected Increase of Irrigated Acres, Missouri River Basin

of all industrial water used in the remaining basin states. Reducing water lost by evaporation also would result in significant benefits. Saving water through more efficient irrigation practices merits careful attention because of (1) the great quantity of water used for irrigation; and (2) potential progress to be achieved through efficient irrigation practice.

By comparison, to conserve or recycle a million acre-feet of water each year requires, respectively, 0.2 percent, 6 percent, 91 percent and 31 percent savings in rainfall, irrigation, public, or industrial water supplies. Irrigation and agriculture represent the big water users in the basin and present the greatest opportunity and challenge to conserve and efficiently use our precious water resources.

Rainfall

Rainfall -- the ultimate supplier of water for soil, crops, forest, groundwater, and stream -- should be given careful consideration in any effort to conserve or increase water supply. Soil, crop, and watershed management; minimum tillage, terracing, and summer fallowing; water harvesting; weed control; and reducing evapotranspiration and increasing water use efficiency all play significant roles in converting and efficiently using rainfall. Weather modification promises to become increasingly important as a way to augment rainfall.

Rainfall supplies an average of 519 million acre-feet of water to the basin each year. Small savings in rainfall will yield big dividends in increased water supply and in crop production. For example, a 1 percent increase in use efficiency or saving in rainfall would mean an additional 52 million acre-feet of water. Not all the rainfall conserved would enter streams or reservoirs but would greatly benefit crop production. Such increases in efficiency would materially benefit the economy of the basin.

CONSERVATION AND RECYCLING PROCESSES

Three major avenues to conserve water seem apparent. One is taking legal or regulatory action to conserve and allocate water. The second is water conservation by individual water users. The third is research designed to discover new ways to use water more efficiently. Each of the three is considered briefly below.

Legal Action

The commitment of ground and surface water to irrigation, industry, municipalities, and various other uses has been guided by law: the riparian and appropriation doctrine; the Reclamation Act; and flood control, drainage, and numerous other laws. Past policy, now under question, has provided for federal development of structures for impounding, storing, and regulating surface waters. With that impetus, many dams and reservoirs have been developed in the basin.

In addition, individuals have substantial groundwater interests. In Kansas more than 85 percent of the water to irrigate 1.8 million acres is supplied by privately developed groundwater. In some areas of the state groundwater reserves may be depleted in 45 to 50 years.[17] The Kansas legislature has authorized groundwater management districts so local users may, within the law, regulate their use of groundwater.

Questions facing members of groundwater or water conservancy districts include regulations, development of new wells, water rights, reasonable and proper use, and enforcement. Laws and public policy, adopted by state and national legislative bodies, will continue to be powerful forces guiding efforts to develop, conserve and use our water resources.

Conservation by Individuals

The heart of any move to conserve water resources is the individual water user and opinions of his fellow citizens. An alert and aroused citizenry is saying to every water user: Use our water resources efficiently. Avoid wasting or polluting our water. If you pollute, clean it up. Farmers and ranchers are the first proprietors of water resources in the basin so they should head the list of those who wisely use and conserve water. Of course, urban and industrial users also must do their share. Since irrigation is the big water user, a few suggestions follow for individual irrigators to consider:

(1) Develop an efficient system -- efficient for water application and use of labor. Avoid over-irrigation and wasting tailwater.

(2) Insure easy water measurement -- know how much water is used. Use of water meters would increase efficiency of groundwater use more than any other single practice.

(3) Use good production practices -- select good seed and adapted/high yielding crops. Fertilize judiciously, effect proper weed control and plant population. Well managed, high yielding crops use little more water than poorly managed, poor yielding crops.

Conservation Through Research

Continually changing water demands, economic pressures, production and management techniques, markets, raw materials, and resources demand a continued flow of new knowledge to provide new solutions to changing problems. Conserving large quantities of water is not likely to result from a single discovery but rather from a series of developments built into improved management systems. In many areas, research is needed before further advances can be made.

Because great quantities of water are used by agriculture and for irrigation in the Missouri River Basin, and because of significant opportunities to increase water use efficiency, a substantial research effort should be maintained in support of those areas.

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[17] Darling, D.W., Economic Implications of Irrigation - A Pilot Study, Kansas Water Resources Board, Bul. 9, 1968.

The energy crisis and the need to mine, transport, and gasify coal and reclaim land will require imaginative research to insure wise allocation, avoid or remedy pollution, and properly recycle needed water supplies. Energy is essential to maintain a strong economy.

Research needs for industry and municipalities should not be overlooked, although much of that effort could involve water quality rather than water supply. Quantities of water used in support of industry and municipalities are relatively small but many people enjoy the benefits.

Improvement in water use efficiency in wheat production is cited as an example of the complex nature of advances that have been made - and others that still are needed to meet expanding needs for water resources by all segments of society.

By the year 2000 popultation is expected to increase in Kansas by 150 percent; wheat production is predicted to increase 212 percent; sorghum production, 190 percent; corn production, 204 percent; soybeans, 359 percent; and cattle, 230 percent.[18] Similar increases are expected in the remainder of the Missouri River Basin and the nation. To undergird such growth will require increased use of water resources or improved water-use efficiency in virtually every segment of our society. Certainly an increased efficiency in agriculture will be required.

The changes in water-use efficiency effected in Kansas wheat production, using 5-year averages, between 1935 and 1970 are given in Figure 3. For the 1940 period, annual statewide rainfall averaged 28 inches, wheat yields averaged 14 bushels per acre, or ½ bushel per inch. For the 1970 period annual rainfall still averaged 28 inches, but average yield had increased to 31 bushels per acre, so water use efficiency rose sharply to 1.1 bushels per inch. Per-acre wheat yields and water use efficiency both more than doubled during the 30 years.

At Tribune, Kansas, 35 percent of the increase in wheat yield since 1919 has been attributed to the release of 21 new varieties -- varieties better adapted to extract soil moisture and to produce in the Kansas environment; 65 percent of the increased yield has been attributed to summer fallow, timely and proper tillage, and improved weed control.[19] At locations farther east in Kansas the effect of summer fallow declines and the effect of fertilizers on wheat yields dominates.

The challenge to produce 2 bushels of wheat instead of one for each inch of rainfall is a complex challenge requiring the best ideas of scientists in many disciplines. Similarly, the challenge to conserve or increase water use efficiency in industry or wherever water is used will be an exciting, rewarding work requiring dedicated research efforts.

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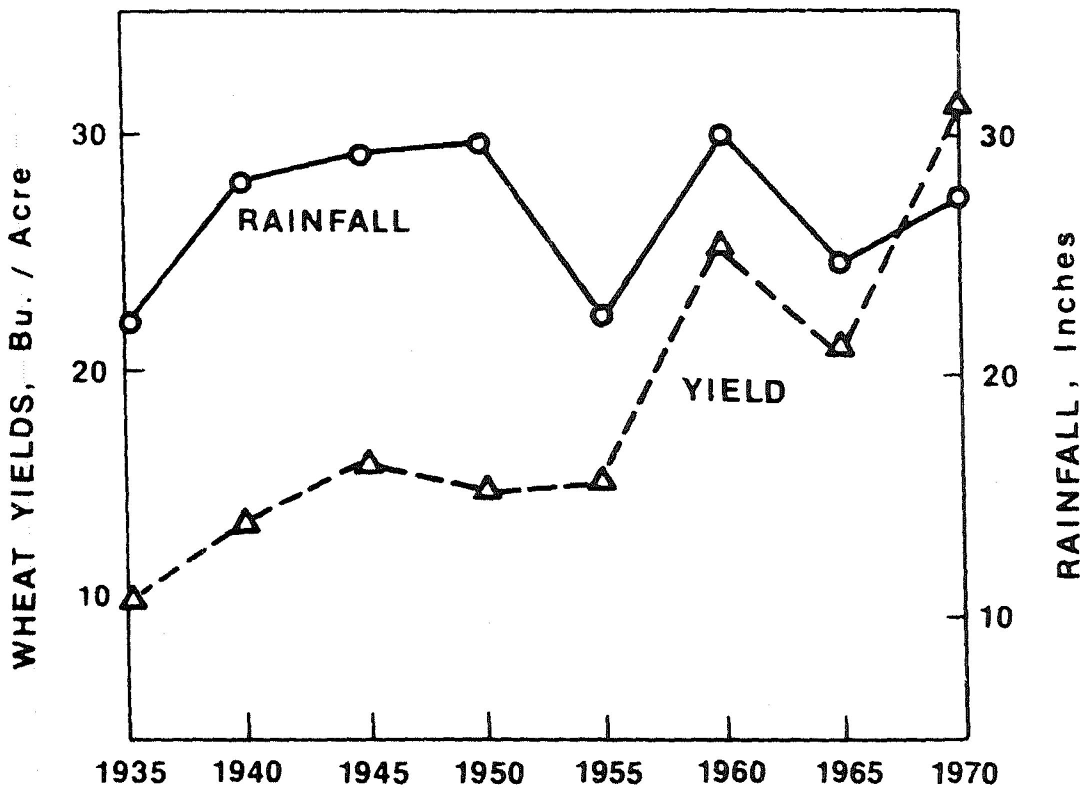
[18]Emerson, M.J. Inter-industry Projections of the Kansas Economy. Department of Economics, Kansas State University.

[19]Gwin, R.E., Jr., O.W. Bidwell, R.C. Angell, and G. Muilenburg. Making the Most of Soil, Water, Climate in West-central Kansas. Kansas Agricultural Experiment Station, Bul. 557, 1974.



WHEAT YIELD AND RAINFALL

(5 year averages)

Figure 3. The Relationship Between Statewide Wheat Yield in Kansas and Rainfall, 5-year Averages.

CRITICAL ENERGY-WATER ISSUES RELATIVE TO POLLUTION-ENVIRONMENT IN THE MISSOURI RIVER BASIN

by

Theodore T. Williams
Montana State University

The energy crisis which rocked the nation last fall, and which may or may not be temporarily resolved this summer, has affected the Missouir River Basin in a rather special way. This basin seems destined to be an energy-export area for the next several decades, supplying the rest of the nation with a significant fraction of its energy.

Oil fields in the basin have produced a significant part of the nation's petroleum needs for 50 years. Exploration for new sources continues at a rapid pace. Oil shale offers some exciting possibilities, although of less significance in the Missouri Basin than in others, especially the Colorado.

Harnessing of geothermal energy is another activity that is gaining momentum in the basin. One exploratory well being drilled in Montana expects to tap a 13-cubic mile mass of heated rock. The rock mass is expected to yield (using the most conservative estimates) at least a billion dollars worth of energy per cubic mile.

But the area of most concern, especially from a pollution-environmental standpoint, is coal.

THE FORT UNION FORMATION

The Fort Union coal formation, underlying a wide area of Montana, Wyoming, and North and South Dakota, is estimated to contain 1-1/3 trillion tons of coal -- 40 percent of the known U.S. reserves. The BTU in the economically strippable reserves alone are estimated to be sufficient to supply all the nation's energy needs for many decades. Additional coal formations underlie parts of Iowa and Missouri.

Needless to say, there has been a tremendous flurry of development activitiy in the Fort Union area in recent months, with new strip mines being strated, daily unit trains running to Midwest cities, applications for permits for gasification, electric generating plants, filings for water appropriation, etc.

The residents of the coal-producing Northern Great Plains states view all this sudden interest in coal development with mixed emotions. On the one side they see an economic boom for their area (which by the way may not be all good in their eyes, because it will attract more people to an as yet relatively unspoiled, sparsely populated area). On the other hand they see vast areas of devastation from unreclaimed strip mines, smoke stacks belching forth black smoke and poisonous fumes, and ruined streams and underground water resources.

LOCAL VS. FEDERAL CONTROL

What seems to concern the people of this vast area the most is that they aren't sure they can really control their own destinies; that decisions on energy development are being made for the area by bureaucrats in Washington, and coal and power tycoons in 80-story office buildings thousands of miles away.

The states most concerned have taken a vareity of steps in an effort to regain control of the situation -- aimed at delaying, slowing down, or halting entirely further development of the coal resource in their states. High severance taxes, siting laws, stiff land reclamation acts, water diversion moratoriums, have all been enacted in recent months by states in the Fort Union area. The Montana Energy Advisory Council has recommended the policy (not yet adopted by the legislature) that there shall be no more construction of mine-mouth plants for power generation, gasification or liquefaction in the state. The Montana position would permit coal to be exported, but would say that metropolitan areas using the energy should bear the burden of air and water pollution from burning of coal, instead of Montana.

POLLUTION-ENVIRONMENTAL PROBLEMS ASSOCIATED WITH COAL DEVELOPMENT

Pollution-environmental problems assocaited with coal development depend on the type of development.

(1) Extraction -- whether stripped or deep (underground) mined and shipped out by unit train or slurry pipeline.

(2) In situ burnes (hydrogenated) in place without mining and then transmitted by pipeline to load centers.

(3) If coal is burned in the area, whether converted to electric power and the electric power transmitted out of the area on wires; or gasified or liquefied and transmitted by pipeline to load centers.

Of critical importance also is the magnitude of development. One strip mine or one electric generating plant may be tolerated. Thirty strip mines or fifty power generating plants represent a problem of an entirely different order of magnitude. Estimates of development in the area range all the way from almost nothing to Northern Plains Resource Council scenarios suggesting that all available water in the region will be needed for gasificaiton and liquefaction.

THE DAVIDSON STUDY

During the past year the Water Resources Research Centers of Montana, North Dakota and Wyoming undertook a joint study (funded by an OWRR matching grant) to assess the research needs associated with coal-energy development in the Northern Great Plains. Dr. Jack Davidson, a former professor of economics at Montana State University and the University of Wyoming, and now director of the Sea Grant program at the University of Hawaii, coordinated the study. It culimanted in a definitive assessment which has been cited numerous times in the past several months by federal and state agencies. Davidson considered research needs under eight major headings and identified 100 separate areas needing research.

The Davidson study involved input from a great many people in the three-state area, including respresentatives of state and federal agencies, universities, developers, planners and environmentalists, to elicit opinions as to what the real problems of the region are, or may be. Several workshops were held as part of the study, and these got people from each state acquainted (often for the first time) with their counterparts in the other states.

High on the list of research needs cited by Davidson are the following:

(1) Trace Element research. Some of the chemical and mineral substances contained in coal and its overburden, if sufficiently concentrated, are harmful to plants, animals and people. Concern with trace elements encompasses the problem of environmental release of trace pollutants into the atmosphere and hydrosphere as a result of combustion, conversion and waste disposal processes; the atmospheric transports, and the subsequent uptake and recycling and effects of pollutants in the environmental biota and the surface and subsurface hydrospheres.

(2) Atmospheric Effects. As a result of the concern over trace elements, there are a host of problems associated with atmospheric mobilization of coal conversion emissions.

(3) Waste Disposal Problems. The problem varies by location and type of conversion process, and depends on the type of waste produced, alternatives for disposal, and the values associated with resources, such as groundwater, which may come in contact with these wastes.

(4) Land Reclamation. Reclamation emerges as an issue of major importance for persons and groups concerned with the environment and with the postmining future of the areas under consideration. Most states now have legislation requiring varying levels of reclamation as a condition for engaging in strip mining operations. Few concerned environmentalists, however, would agree that present reclamation legislation will assure adequate reclamation. They consider the issue far from settled either with respect to what is an acceptable level of reclamation or how reclamation is to be affected.

(5) Water Quantity and Quality Problems. The National Academy of Sciences report on strip mining reclamation concludes that:

While there is probably sufficient water available in most areas to meet the requirements of mining and reclamation activities, there is insufficient ground and surface water in the major coal rich areas to meet the requirements of large scale conventional electric generation or coal gasificaition and liquefaction facilities.

Of importance also is the effect of mining on both surface and underground flows. Since many coal seams are aquiferous, strip mining for coal will inevitably disrupt groundwater patterns in those areas. This will affect the quality and quantity and even availability of water to current users. Mining may also disrupt natural drainage networks and thereby disrupt downstream water rights. The potential effects of disposal of wastes of coal conversion plants in the ground and surface hydrosphere are unknown.

It is significant that over half of all the needs cited by Davidson are in the fields of pollution and environment protection.

FURTHER DEFINITION OF RESEARCH NEEDS

There has been a continuing effort, even since publication of the Davidson report, to further define research needs in the energy-water area, and pollution-environment problems continue to be high on the list.

The most recent assessment of research needs in this area was a regional workshop at Montana State University last month which involved university researchers from three Missouri River Basin states, and state agency representatives from Montana. This workshop considered the impacts of use of coal for electric power generation and for gasificaiton -- assuming both a low and a high ultimate level of development. It considered separately the impacts of coal extraction by itself. One hundred fifty research categories in six major areas were considered and ranked as to how critical each is in terms of need for each of the development hypotheses. The concensus of the workshop was that chemistry and geohydrology of river and lakes are high areas for research, as well as quantification and measurement of environmental impacts from an economic standpoint. Design of water quality monitoring systems was also suggested for research.

CURRENT RESEARCH AND PROPOSALS

A considerable amount of research is now underway in each of the Fort Union Formation states, addressing some of the critical needs. Many more proposals have been written and are pending before the review panels of various federal funding agencies. Reclamation studies and groundwater quality and quantity assessments are being conducted in Montana by university researchers. The Montana state government has recently been awarded half a million dollars to evaluate impacts of water withdrawals from the Yellowstone River in eastern Montana. I might comment here parenthetically that Montana University researchers are finding, as are researchers in other states, that the state governments are getting into the research business on a wholesale basis. This has obvious implications for all of us.

The Montana University system has prapared a massive propoasl to the National Science Foundation (RANN) which would involve 50 or more researchers on three university campuses and would address a great many impacts of energy development on pollution and environment. At least two regional proposals by the Water Resources Centers in Montana, North Dakota and Wyoming are pending. Each of these would have components addressing environmental impacts.

CONCLUSION

It is evident from the foregoing that there are many potential pollution and environmental impacts associated with energy development in the Missouri River Basin, and especially in the upper basin states comprising the Fort Union Coal Formation. The people of the area are becoming more and more alarmed as development progresses, and are demanding that steps be taken to lessen the impacts which seem certain to occur. The research under way represents only a small start toward answering the host of problems that are on the horizon.

ENERGY-WATER RELATIONSHIPS

by

J. Ernest Flack
University of Colorado

Whenever our nation has been faced with a crisis -- war, drought, depression, etc. -- a certain pattern of response has come into play. Much of this response is based on what we have done before under similar, or somewhat similar, circumstances -- raised an army through conscription, soil conservation programs and loans, public works programs, etc. The institutional and policy arrangements now being made with regard to energy-water issues are likewise based on historical precedence.

Given this mode of response, two major thrusts of recent years are important in determining to what extent and how well the energy-water problem is handled. These two forces are:

(1) Public participation in planning; and

(2) The environmental impact of development.

With the heightened awareness of the pervasive nature of technological decisions to affect many aspects of life outside the immediate decision area, the call for more public participation in decision making has made itself heard to the extent that it is required in many types of decision activities. The second force is well known and need not be documented further, except to say that the sharp contrast between the increasing demand for energy and the concern with pollution of the environment has led to the desire among many to control and slow development.

If we now consider the typical response of the past to some new problem of national concern such as energy-water, wherein we adapted and modified existing laws and institutions to respond and meet the new situation, one could well ask whether that procedure serves our best interests today? Or do we need a basic change to incorporate a new ethic into our daily lives?

In other words, can the processes and procedures of accommodation (based on the historic growth ethic) give us the requisite policy and instituions to handle the no-growth of the future? Perhaps not. Maybe the change is too great -- the change from the cowboy economy of the frontier to one of a closed-system spaceship earth -- to be handled by simply modifying our existing laws and institutions. To handle this new "game" we may need a new set of rules and regulations (policies and institutions) derived specifically for the new game.

For instance, instead of water being a servile resource to accommodate whatever level of energy production is forecast, water enters the game as a major player by limiting the amount of energy production which can be accommodated in the energy-water equation. In palce of the water requirements being a function of energy production, the situation is one in which energy is a function of water availability. Specifically, instead of talking about major water import schemes to support the energy extraction industry of the coal fields of the Upper Missouri Basin, one would consider the limitations of coal development and utilization in the basin as restricted by the availability of water for that purpose.

Instead of policy and institutions following after technological development, envision broad-based national, regional and state policies with their supporting institutions that direct and manage the technological development of alternative energy producing and energy consuming programs.

That the need is for a broad-based energy policy can be illustrated by a couple of examples.

In Montana, after years of delay, the State Legislation in 1973 adopted certain water rights policies as a direct result of potential coal development and the water rights being acquired by the coal developers. Montana is one of the last western states to adopt legislation providing a procedure for the determination and confirmation of existing water rights, establishment of a system of centralized records of all water, and a permit system.[1] A part of this act provides that a public agency may reserve water for future beneficial use or to maintain a minimum flow or quality of water.

This year Montana enacted a bill placing a 3-year moratorium on new permits to appropriate surface water or to change the use of water in the Yellowstone River Basin, one of the prime coal surface stripping areas in the basin. Some of the language of the act is of interest.[2]

> 89-8-103....The legislature, noting that appropriations have been claimed, that applications have been filed for, and that there is further widespread interest in making substantial appropriations of water in the Yellowstone River Basin, finds that these appropriations threaten the depletion of Montana's water resources to the significant detriment of existing and projected agricultural, municipal, recreational and other uses, and of wildlife and aquatic habitat. The legislature further finds that these appropriations foreclose the options to the people of this state to utilize water for other future beneficial purposes, including municipal water supplies, irrigation systems, and minimum flows for the protection of existing rights and aquatic life. The legislature....declares that it is the policy of this state that before proposed appropriations are acted upon existing rights to water in the Yellowstone Basin must be accurately determined for their protection, and that reservations of water within the basin must be established as rapidly as possible for the preservation and protection of existing and future beneficial uses.

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[1]Chapter No. 452, Montana Session Laws 1973, Senate Bill No. 444.

[2]Chapter No. 116, Montana Session Laws 1974, Senate Bill No. 728.

89-8-105....(1) The department may not grant or otherwise take any action on an application until....three (3) years have elapsed....or ....a final determination of existing rights has been made.... (2) A reservation estabished before such applications for permit is granted is a preferred use over the right....and the permit....shall be issued subject to that preferred use.

89-8-107....The department may apply for reservations and shall, as rapidly as possible, assist other appropriate state appropriate state agencies and political subdivision in applying for reservations within the basin....The United States or any agency thereof may not apply for a reservation in the basin....until the requirements of section 3....of this act are met. Particular emphasis shall be given to applications to reserve water for agricultural, municipal and minimum flow purposes for the protection of existing rights and aquatic life.

It is thus the stated policy of Montana to protect, through its water rights administration, the existing and future uses of water for agriculture, recreation and domestic purposes against industrial usage. This is not to say that Montana is anti-development, but rather that development along traditional lines is given priority over the coal-related developments.

As another example, in carrying the development issue further, I would like to quote from a recent Engelbert paper:[3]

"Participation by a greater number of diverse groups is healthy for the democratic process. However, when interest group alignments and coalitions narrowly polarize around pro-development and anti-development positions, obscuring thereby other significant factors, then the political process is not well served."

Unfortunately, where we lack general policy with regard to land use, development and growth, the issues tend to degenerate to the simple position of growth or no-growth. It is probable that no-growth under our present economic posture is neither desirable nor attainable. What we are really talking about is controlled growth -- controlled by public policy as related to the availability and the scarcity of natural resources including water, and to the wishes of the public served by and living in the region. I believe that it would be our position what with a given public attitude and desire regarding growth, the degree of control exercised by the state and the region should be directly related to the availability or scarcity of the requisite natural resources, including water, to support and sustain that growth. For instance, if we find that in a given part of the Missouri region it is proposed to develop a coal gasification project and that a certain population is projected for that same area, and that while there

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[3]Engelbert, Ernest A., "The Political-Social Aspects of Energy-Water Relationships", in The Role of Water in the Energy Crisis, Nebraska Water Resources Research Institute, 1973, p. 28.

is sufficient land and agriculture will not be adversely affected, there is not enough water to both maintain the population, the gasification industry and the agriculture, then it becomes a matter of policy to closely specify the alternatives and present the issues to the public living in that area or state to make the decision on the mix to be permitted under state controlled growth policy. Such a mix should not be determined by the industry which is developing as much as it can while meeting various zoning regulations, land use requirements, pollution standards for air and water, and acquiring the needed water and coal through purchase.

Do our existing state and federal policies come anywhere near delineating the desired type of growth policy? It does not appear so and, in fact, the various regulatory agencies do not even circumscribe the standards of growth very well. The recently issued National Academy of Sciences report to the Energy Policy Project of the Ford Foundation on rehabilitation of western coal lands, states:[4]

> "Most state laws governing surface mining and rehabilitation in the West do not provide for adequate planning, monitoring, enforcement and financing of rehabilitation. State agencies...are under staffed which impairs implementation of...the law."

> "Unfortunately, the variability of institutional arrangements particularly the uneven provisions and enforcement of existing state laws may inhibit rehabilitation efforts."

If this conclusion is generally true for all energy-water related resource developments in the region, then state laws not only do not provide adequate control and management but they may actually inhibit such efforts.

The NAS Report goes on to suggest a remedy:[5]

> "We recommend that minimum regulations governing the surface mining of coal be promptly established by federal statute to provide for the planning, monitoring, enforcement, and financing of rehabilitation and taht the costs..be financed by mining operations."

The report also recommends federal-state sharing of regulation responsibility and that public participation in planning and decision-making be fostered. Extrapolating the findings of the NAS Report to the general water-energy field, one could easily conclude that the states in the Missouri region have a long way to go before a systematic approach to the problems of growth, environmental pollution, energy demands and scarcity of water and other natural resources can be made.

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[4] Rehabilitation Potential of Western Coal Lands, Ballinger Publishing Company, Cambridge, Massachusetts, 1974, p. 4.

[5] Ibid, p. 5.

The first prerequisite to any policy formulation is an accurate knowledge of the resources available. It is necessary to assemble and catalogue all available data on land use, population, water supply (both surface and groundwater), water and air quality, and energy resources of all types. The purpose of such a compilation is not only to bring the data together and have it readily available in usable form but also to point out additional data needs.

The state and federal agencies such as the U.S. Geological Survey, Bureau of Mines, State Engineers and Departments of Natural Resources and the Missouri River Basin Commission could then enter into agreements to gather, assemble and analyze this data. That the opinions based on present knowledge regarding the impact of resource-energy development on water resources are highly divergent can be demonstrated from the following excerpts from the previously cited NAS Report.

In discussing the problem of strip mining coal beds near the surface which are important groundwater aquifers, the report states:[6]

> "Water requirements for surface mining and rehabilitation are not large and should not seriously deplete aquifers or compete with existing uses. However, disruption of natural drainage networks at mine sites may interfere with downstream water rights, and underground aquifers that are intercepted by mining operations may be drained or subject to change in flow patterns, causing problems for established users."
>
> And on p. 45 of the same report; "In most of the western coal fields the coal beds that lie close to the surface are also aquifers...Flow patterns in these aquifers would be changed, and some parts undoubtedly would be dewatered."

The question arises, just how important is the problem of disruption of aquifers by the mining of the coal beds? Kathy Fletcher, Energy Specialist for the Rocky Mountain Center on the Environment, in her discussion of the Report states:[7]

> "The problem of mining aquifers is recognized...In that this is a rather <u>common</u> (emphasis added) situation, this is an important recommendation...In addition, it would have been useful...to discuss ...whether an artifical aquifer can be created...or whether it is inevitable that reclamation will cause damming or disruption of the groundwater system."

But John L. Thamses, University of Arizona hydrologist, in his discussion states:[8]

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[6]<u>Rehabilitation</u>, op. cit., p. 4.

[7]Ibid, p. 177.

[8]Ibid, p. 192.

"...it is true that some coal deposits are also important local aquifers...but certainly not all, not do I believe even most."

and his point is supported by Carl E. Bagge of the National Coal Association in his discussion:[9]

"Disruption of groundwater aquifers by surface mining is an uncommon (emphasis added) occurrence; documentation exists for mined land where downstream flow patterns have been beneficial for established users."

The answer to the questions of the extent and seriousness of the water supply problem and other natural resources' availability can only be answered through data acquisition and analysis by the concerned agencies themselves -- in this case the states of the Missouri Basin. Once such data is in the process of being acquired on a regular basis and being translated into meaningful formats that are useful in decision making for both experts and laymen, then more general and broadly based policy objectives can be formulated for the growth-energy-water relationships of the Basin.

In place of regulatory functions, most of the state agencies and the regional organizations will have to focus on the institutional aspects of formally adopted planning policies for the region. It would appear that more emphasis will have to be placed on the authority-type of government to handle these regional problems. While it may not be desirable to establish another Tennessee Valley Authority, it would appear that the states and federal agencies must cooperate to a much greater extent than they have in the past through the river basin commissions or the interstate compact commissions. Some combination of planning, implementation and enforcement is necessary if truly effective policy-institution arrangements for energy-water are to be established in this region.

If such a course is not pursued, and it must be done with vigor, the conflicts, between conservation and growth advocates, between local and state and regional governments, will multiply to the detriment of the citizenry of the region -- who will in the final analysis, through their action or inaction, largely determine their own destiny.

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[9] Rehabilitation, op. cit., p. 161.

DISCUSSION REPORT

John L. Wiersma
Chairman
South Dakota State University

George S. Clausen
Reporter
University of Kansas

The Missouri River Basin, with 15 percent U.S. land area but only 4½ percent of population, has historically had an agriculturally based economy and earned its living exporting agricultural products. Now it finds itself endowed with a new exportable product, coal, and is in the process of learning how to become a wise energy exporter.

The first few requests for water from companies desiring to gasify coal are far in excess of what the states feel they can allocate by the normal water right procedure and still have water enough for traditional uses which will also grow.

In order to give themselves time to plan for orderly development, the states directly involved have initiated delaying actions (such as a 3-year moratorium on issuing new water rights in Yellowstone River Basin, severance taxes and land use restrictions). This isn't because they don't want the development (states are losing population and employment looking for new opportunities), but because they desire to control their own destinies. This desire for independence on the part of the residents seems to be as strong as their concern about the influx of short-term residents and the accompanying air and water pollution. In other words, the states desire time to figure out how best to reap the benefits from coal production in terms of employment and growth, and how to avoid being used by energy tycoons and the federal government.

Specifically some of the greatest conflicts expected and questions to be resolved are:

(1) Should coal be extracted and used to generate power at the mine mouth? The advantages of this are the obvious employment and growth opportunities for the region, but the disadvantages include air and water pollution, water supply problems, land restoration problems and the fact that power cooridors use up much already valuable agricultural land.

(2) Should coal be extracted and shipped to points of use before being converted to energy? If unit trains are used for this, there is little water supply problem, but the use of coal slurry in pipelines presents water supply problems as well as water pollution problems at the use points.

(3) Should coal be burned in place? This could eliminate a majority of the restoration problem, but the technology is not presently available to assure this course of action.

It is interesting to note that although the land reclamation process seems great ($500-$5000 per acre), when passed on to the consumer only a small cost per consumer is necessary. The limiting factor, therefore, is not money, but probably water and materials.

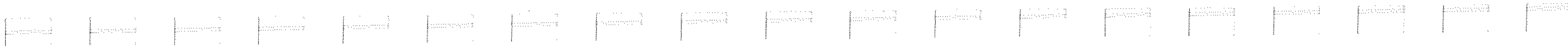
(4) How can adequate water be assured for traditional uses while adding on the energy water requirement? The crop yield per inch of rainfall on the Great Plains has more than doubled since the 1940's, but crop demand is expected to go up by 20 percent to 30 percent by the year 2000. This will either require more water or much more efficient irrigation operations.

(5) How can the public truly become involved in the planning process? Local citizens are very desireous of determining their region's type and rate of growth and are actively seeking ways of assuring this. In this regard it was noted that there were numerous examples of opposite conclusions being reached by experts on problems whose solutions were necessary to the establishment of public policy. For instance, the effect of strip mining on groundwater flow is currently being debated.

The central problem was concerned with assuring natural resource development and the maintenance of a quality environment at the same time. There was a general concensus that the optimum amount of energy and agriculture to be produced should be based on the amount of water available, not vice versa as is the policy currently being pursued by the federal government. Private industry should not be allowed to exploit the coal resource as fast as possible while we are in the process of changing our very value system. Economic growth and dollar profits are not the only criteria now being considered.

REGIONAL WORKSHOP

V - ARKANSAS-WHITE-RED, RIO GRANDE, TEXAS-GULF



ENERGY PRODUCTION AND WATER SUPPLY

by

Dan M. Wells

G. A. Whetstone

and

Robert M. Sweazy
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Water is a prerequisite to the production of energy; in the Southwest, energy is a prerequisite to the production of water. Agricultural, industrial, and municipal supplies are pumped from aquifers and/or pumped from reservoirs in river valleys, frequently at an elevation lower than the point of use. If the food and fiber production of the High Plains is to be maintained, it will be necessary to pump much more water through much greater lifts in the future.

The functional relationship between water requirements and potential energy sources is always complicated in the Southwest by the necessity of utilizing much of the energy produced to transport and, perhaps, treat the water needed for the production of energy. The situation can best be clarified by considering a number of potential energy sources and their corresponding water requirements.

HYDROELECTRIC POWER

With the headwaters of many of the streams being in semi-arid plains, southwestern riverbeds often produce more dust than water. For example, the North Concho River near Carlsbad, Texas,[1] with a drainage area of 1,249 square miles, has an average discharge for 48 years of record of 38.4 cfs. During the water year 1972 (October, 1971 - September, 1972) there were only 17 days (5 in October, 4 in May, 2 in June and 6 in September) during which the flow averaged more than one percent of this long-time mean. The flow was zero from November 19 to May 6 inclusive, from May 15 through June 28, and from July 3 through September 20. Of the total flow for the year, 69.5 percent occured on September 21 (798 cfs average).

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[1]1972 Water Resources Data for Texas, Part I, Surface Water Records, U.S.Geological Survey, p. 423.

Despite such hydrologic bases, Texas had 19 "major" hydroelectric plants in operation at the end of 1967 and two more under construction.[2] Additional hydroelectric plants may well be added in the future, particularly if they incorporate pumped storage operations.[3] While the energy contribution of such plants may well be negative, their effect in improving the peaking ability of systems of thermal power plants frequently provides economic justification for adding pump-turbines, motor-generators, and a second reservoir to a project viable for other purposes.

The only water properly "chargeable" to the hydropower generation would be the excess in evaporation incurred in providing the additional reservoir surface.

THERMOELECTRIC POWER

Water used for electric utility generation of thermoelectric power as reported by the U.S. Geological Survey for 1970,[4] was as shown in Table 1.

Nationally, the figure for this class of water use had increased 23 percent over the 1965 estimate, corresponding to a 49 percent increase in power production. Thus, a substantial increase above the tabulated values would be called for in appraising current use. Future use, at least of fresh water in the southwest, will probably increase at a lower rate, or it may well decline as water of lower quality and/or air-cooling are substituted.

A strong indication of this means of adaptation by the utilities to the stringencies in fresh water supply may be seen in the Texas Gulf figures which show that 45 percent of the surface water withdrawn and 20 percent of the water consumed was saline. The difference in the two percentages would doubtless be a reflection of the greater number of cycles exacted from the fresh water before releasing it. In the drier inland areas without saline surface water, much of the cooling water employed is sewage effluent.

Some complex problems lie ahead for the utilities in the field of quality of return flow. If each cycle were to add nothing to the water, which seems likely, the quality would still deteriorate because the concentration of all inclusions rise when water is evaporated. In fact, warm water is itself suspect in that it might disturb the present ecological balance. No conjecture is required in concluding that warm water is less efficient than cold as a coolant.

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[2]Godfrey, F.A., and Dowell, C.L., "Major Hydroelectric Power Plants in Texas," Texas Water Development Board, Report 81, August 1968.

[3]Whetstone, G.A., "Hydro Potential of the Texas Water Plan," Water Power (London), 22:52-53, 1970.

[4]Murray, C. Richard and Reeves, E. Bodette, "Estimated Use of Water in the United States in 1970," U.S. Geological Survey 676, p. 34.

TABLE 1

THERMOELECTRIC POWER (ELECTRIC UTILITY USE) OF WATER IN THE THREE SUBREGIONS OF THE SOUTHWEST EAST OF THE CONTINENTAL DIVIDE[5]

Water Resources Council Region	Thermoelectric Power (electric utility use) in MGD					
	Water Withdrawn				Water Consumed	
	Fresh Ground-water	Surface Water Fresh	Surface Water Saline	Total Fresh	Fresh	Saline
Ark-White-Red	46	1900	0	1946	82	0
Texas-Gulf	51	4700	3800	4751	100	24
Rio Grand	15	6	0	21	17	0

[5]Murray, C. Richard, op. cit., p. 34.

Conventional thermoelectric plants using once-through water as a coolant approach 40 percent efficiency in converting potential energy of fossil fuels into electric energy. Such plants using natural gas at 1,000 BTU per cubic foot as a fuel, could be expected, for each cubic foot of gas burned, to exhaust about 100 BTU up the stack, to reject about 500 BUT to a heat sink (water), and to produce about 400 BTU in electric energy for distribution to the system. This relatively high efficiency of conversion depends to a large extent on the availability of a relatively cool sink for the waste heat produced. The use of wet cooling towers decreases the efficiency of the system because of the higher temperature of the heat sink and because of the energy required to operate fans and pumps in the cooling towers. The use of dry towers reduces the efficiency still further.

Electric utilities in Texas estimate that, in generating about 100 billion kilowatt hours of electricity in 1970, they consumed about 135 thousand acre-feet of water. Most of the power was generated using once-through cooling systems or cooling lakes at the heat sinks.[6] Approximately 113,000 acre-feet of the water consumed was fresh water, with the remaining 22,000 acre-feet being saline, brackish, or municipal wastewater. The utilities have estimated electric power requirements for the year 2000 to be about 750 billion kilowatt hours, and have estimated that, if once-through cooling systems were used, approximately 882,000 acre-feet of fresh and saline water would be consumed in power generation. They have also estimated that the proposed EPA requirement that all power plants be equipped with cooling towers would result in a net increase of about 441,000 acre-feet of consumption of water for power generation, an increase of 50 percent. Apparently, the EPA has decreed that all plants be equipped with cooling towers by 1983. It is not apparent that Texans would be willing to trade almost half a million acre-feet of water for the privilege of having the temperatures of all streams in the state maintained at a "natural" temperature, if given a choice.

Because of the extraordinary safety precautions designed into nuclear power plants, such plants are inherently less efficient than conventional fossil fueled plants. In nuclear fueled plants, only about 330 BTU of electric power is produced from each 1000 BTU of heat released in the reactor. Also, nuclear power plants do not have smoke stacks in which part of the waste heat is exhausted to the atmosphere. Hence, about 670 BTU of each 1000 BTU of potential energy contained in nuclear fuels must be rejected to water in order to make the systems operational. As a result, a nuclear power plant must reject about 2 megawatts of energy to water for each megawatt of electric energy produced, as opposed to a fossil fueled plant of the same output which, if it uses once-through cooling water, must reject only about 1.25 megawatts to a water sink.

The enormous coal reserves of the country provide the best hope for meeting energy needs for the next several decades. Since electrical energy

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[6]Drew, Howard R., Vice President for Research, Texas Electric Service Company, Private Communication, June 1974.

can be transported over long distances much more cheaply than can the coal from which energy is generated, it is apparent that it would be desirable to locate a great deal of power generation capacity near the major coal reserves of the country. Unfortunately, most of these major reserves of strippable coal are located in arid or semi-arid regions of the country where not enough water can be made available to convert them into electric energy at the mine mouth.

WATER NEEDS FOR FOSSIL FUEL RECOVERY

Significant quantities of water are required for recovery of fossil fuels. Most secondary recovery systems for oil use water as the driving fluid to repressurize a field, and coal mining operations may use water for washing the coal, controlling dust around the mining operation, and, more especially, for reclamation of the area after the coal is stripped. Water may be the limiting factor in the production of oil from the gargantuan reserves of oil shale in the Colorado-Utah-Wyoming area.

Oil and Gas Recovery

Historically, Texas has produced somewhat more than a third of the oil and gas produced in the lower forty-eight states, (38.6 percent in 1973). Also, the state of Texas has about a third of the proven oil reserves of the country, and somewhat more than a third of the proven gas reserves. In Texas, oil and gas production come under the jurisdiction of the Railroad Commission, which establishes an allowable daily production from each well. The allowable is designed to provide for prolonged production from all fields. Also, the Railroad Commission determines each month the number of days in the following month that all wells are allowed to produce, thereby establishing the monthly production of oil in the state.

In the late 1950's the allowable production was as low as seven days per month. Since April, 1972, however, the allowable days per month have been the number of days in the month. That is, for about two years, the oil wells in Texas have been producing all the oil they could produce at the price for which oil was selling. Production in the state declined about 120,000 barrels per day in 1973 as compared to 1972 production.

Much of the current production in the state is derived from waterflood operations in which water is injected into the oil-bearing formation at some distance from producing wells. As the water moves through the formation, it forces out some of the oil remaining in the formation after primary recovery methods have become uneconomical. Large quantities of water are used for secondary recovery in the state, but more than 90 percent of such water is either saline or brackish. In fact, the use of fresh water for secondary recovery is estimated to have declined by about 10 percent from 1969 to 1973, while the use of salt and brackish water increased by about 23 percent in the same period. Total fresh water used for secondary recovery of oil in 1973 was estimated to be about 30,000 acre-feet, while approximately 340,000 acre-feet of salt and brackish water were used for secondary recovery. This use of approximately 1,000 acre-feet of water per day produces about 120 acre-feet (1,000,000 bbl) of oil per day.[7] The Railroad Commission anticipates that fresh water usage for secondary recovery will continue to decline in the future, while salt and brackish water usage will continue to increase.[8] Presumably, these same conditions will prevail in other states in the region, because most of the saline and brackish water used is that derived from oil production. Utilizing the water produced with oil for secondary recovery solves two problems. First, the brine must be disposed of in some way, and second, water derived from the producing formation can be expected to be compatible with the water and rocks in the formation.

Production of Oil from Shale

> "The rich oil shale deposits on the western slope of the Rocky Mountains constitute a potential source of fuel several times as great at the identified reserves of U.S. oil, and processes for extracting synthetic crude oil from the thick seams of brown black rock have been ready to go for fifteen years. Technologically, the production of synthetic crude oil from shale is a simple process. When the shale is crushed and heated to 480°C., raw shale oil is released. Because it does not require special mineral preparation, high pressures, or different catalytic procedures, the process of oil shale recovery is easier than either coal gasification or coal liquefaction."[9]

In the article from which the above quotation was taken, Metz states that studies by the Department of the Interior and the Atomic Energy Commission indicate that the limit of production of oil from shale will probably be about one million barrels per day, a fairly insignificant fraction of the current U.S. daily oil consumption of 18 million barrels. Current technology requires about three barrels of water for each barrel of oil produced. Although it is not entirely clear from the article whether or not this includes the water required to reclaim the land after the oil has been produced, it would appear that it does not.

Most of the oil shale that exists in seams thirty or more feet thick and yielding more than 25 gallons of oil per ton of shale lies in the Piceance Creek basin in northwestern Colorado. It is doubtful that even one million barrels of oil could be produced if it required three million barrels or 126 million gallons of water per day from the Colorado River Basin. It therefore appears that with present technology, water is now and will continue to be the limiting factor in large-scale production of oil from the nation's largest reserve, the oil shales.

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[7]Anon., "Water in the Public Interest," Pamphlet published by Texas-Mid-Continent Oil and Gas Association, 1973.

[8]Texas Railroad Commission, Private Communication, June 1974.

[9]Metz, William D., "Oil Shale: A Huge Resource of Low-Grade Fuel," Science, 184:4143, June 21, 1974.

Apparently, no significant reserves of oil shale exist in the states of Arkansas, New Mexico, Oklahoma or Texas.

Coal Production

The production of coal by strip mining operations requires relatively small quantities of water. However, this is not the case for relcamation of land damaged by strip mining.

Large quantities of strippable low-grade coal underlie areas of East and Central Texas. Large deposits of high-grade coal underlie Northwestern New Mexico near the Four Corners areas.

Reclamation of the East Texas lands will not place high demands on the water resources of the region because the annual rainfall is probably enough to supply all the water needed for reclamation. The problem is entirely different in Central and West Texas and in New Mexico, where supplies are generally already fully committed to other uses. Reclamation of these areas would be a very slow process requiring decades or centuries if only water from natural precipitation were to be used. Other possible solutions would be the diversion of water previously committeed for other beneficial use or the importation of water from areas of surplus. The first two alternatives are not very palatable under today's conditions, and the third is very likely impossible of fulfillment for years. It therefore appears that, as with oil shale, water may be the limiting factor in the production of much of our available coal reserves, unless it is decided that energy production is more important than maintaining the land surface in its present state.

INDUSTRIAL WATER REUSE AND SEWAGE SLUDGE RECLAMATION

by

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When Warren Viessman contacted me last spring to see if I would serve as a speaker for this workshop, I told him that "Management and Conservation" was not in my field of expertise. However, Warren talked me into it by saying that all the speakers had to do some background study and since we had plenty of time I agreed to do it. Early this summer then I began to make a study of "water reuse" and "water conservation". I have thoroughly enjoyed my study and I have learned some things that surprised me and perhaps may surprise you and thus bring about some discussion that will benefit us all.

The first thing I noticed about the subject was that there was a wealth of recent publications saying approximately the same thing, that water reuse was the answer to the pollution problem. The second thing I noticed was that water reuse can be conveniently broken down into two types: industrial process reuse and municipal and/or agriculture sewage sludge reclamation. I would like to discuss industrial reuse first.

INDUSTRIAL REUSE

The first thing that I noticed in studying industrial reuse was its relationship to energy. I, of course, am not the first to recognize this. Many people are trying to convince policy makers of this. We have the excellent paper presented by Mr. Jack Kinney, Sanitary Engineering Consultant, at our OWRR 9th Annual Conference meeting last spring and more recently, Mr. Ed Altouney, in Update (the UCOWR Newsletter) made the statement:

> "One does not have to look very hard to see that the nation is headed for a water crisis which will have far more serious consequences than the current energy crisis."

Let me use the paper of Rey, et. al. of E.P.A. which appeared in the September 1971 issue of Environmental Science & Technology. The authors have broken industrial water use into three categories: process use, cooling water and steam. The essence of the paper is that if industrial wastewater must be treated before it is discharged to a stream or river, why not recycle it back through the plant instead of discharging it back to the stream. This thinking eliminates the need for water intake treatment (except for make-up water), and the effluent treatment plant is no longer controlled by discharge water quality standards but is controlled by the water quality requirements of the process use which may be less stringent. Extrapolation of this concept to its ultimate gives us the zero discharge goal of P.L. 92-500.

On the average for all U.S. industries, 80 percent of the water used is in the category of cooling water, about 13 percent is for process use, and 7 percent for steam production. For some industries such as the petrochemical industry the ratios are even more lopsided. As an example, let us take a process unit that has a water requirement of 15 units. Suppose 10 of these units are for cooling water and 4 for process use, and then 1 unit for steam production. In a multiple-use scheme perhaps only 10 units of water are taken up with 5 units of water being recycled through the process use and steam production function. This gives a recycle ratio of 15/10 or 1.5. In a scheme that approaches no discharge, perhaps only 1 unit is taken up and 14 units continuously recycled. This would give a recycle ratio of 15/1.

I have not studied the details of this type of operation, but I know enough thermodynamics to know that it takes available energy to separate solutions into pure components and that if you continuously mix substances and then purify them, then mix them, then purify them, etc., you are going to use energy, considerable energy. Is the key question: "what are the comparative energy requirements between discharge treatment and reuse treatment?" Again, let me give you an example. At the South Tahoe water treatment plant (an interesting water reuse project I will mention again later) an activated granular carbon process is used for the removal of refractory organic pollutants including herbicides and pesticides (DDT). For the process to be continuous of course requires that the carbon be regenerated. This is done in gas-fired multiple hearth furnaces in which the bottom hearth is at 500-600^{o}F. and the top hearth as high as 1600-1700^{o}F. The energy consumption for the activated carbon regeneration, which is only a part of the overall waste treatment, amounts to about 0.25 Btu/gallon of water processed. This amounts to about the same amount of potential energy that is available from a gallon of water falling 25 ft. over a dam. To put it another way, as one of our principal investigators did at a conference we had in Fayetteville recently,

> "At the rate we are going we will soon be measuring the economic feasibility of projects in Btu's instead of dollars."

One of the references cited in this paper is called "Water Demands for Expanding Energy Developments". Is not the converse equally important - "Energy Demands for Expanding Water Developments?" I think the key question is not a comparison of energy consumption for zero discharge treatment vs. that for stringent water quality discharge standards, but rather a comparison of zero discharge treatment consumption of energy vs. natural treatment of discharge through nature's own processess. Then the question becomes time oriented, and we don't have time to go slow enough to let nature (solar energy) regenerate our pollutants (or at least we don't think we have time). Many people envision the world as a balanced, closed cycle, but this is not ture. It is not a closed system and we have it terribly out of balance. The second law of thermodynamics states that in any closed system available energy is continuously being consumed. I feel the direction to look is toward solar energy because that is the only way we can obtain energy from outside our worldly system. The key question is whether we can harness solar energy in the proper time frame.

SEWAGE RECLAMATION

If we look to sewage reclamation, there is a wealth of knowledge that has been generated. The primary use of sewage reclamation water has been for terrestrial disposal for non-eatable uses such as irrigation of parks and golf courses. However, Larsen, et. al. has commented that:

> "20 years of research have produced enough knowledge so that soils can be used as wastewater treatment systems. Soils are able to remove solids, ions, and bacteria from wastewater quite efficiently."

Kasperson, et. al. has presented a summary of six sewage reclamation projects which I would like to discuss briefly.

Lubbock - Lakes primarily ornamental with no body contact sports planned.

San Angelo - Not adopted, because drought abated.

Santee, Calif. - Primarily recreational lakes, golf course irrigation, body contact sports. The conflict-cooperation pattern existed in Santee in part because the major parties respected each other and a number of communication channels were always open. In a more rancorous dispute, or in cases of low level respect, a different pattern could emerge.

Antelope Valley - Sea water intrusion, coastal aquifer, irrigation of of landscape and citrus groves, groundwater recharge.

Lake Tahoe, Calif. - Recreation (body contact) and irrigation, very high quality.

Colorado Springs, Colo. - Non-potable uses such as irrigation, industrial water.

Kasperson, et. al. stated that the key lesson to be learned from all six of these projects was that each situation is unique and that the possibility of reclaimed water being feasible for a given situation should never be overlooked. Right now it is usually feasible for the lower-order functions of the water supply hierarchy, but potable water systems will probably be approved within 10-15 years. The major concern over potable systems is viruses, and much more research is needed in this area. The problem, with the exception of viruses, is managerial rather than technical although the engineering and economics of each individual situation must be met. Part of the managerial problem is due to our schizophrenic attitude toward water management. We have "clean" and "dirty" water divisions, or to put it another way we have "supply" and "disposal" divisions, and in any reclamation project the supply division approves a "non-potable" system but the treatment or disposal division manages it. And of course public acceptance must be satisfied. Here, I personally find no problem with body contact sports, edible fishing, crop irrigation, etc. because I favor a well-treated, controlled and tested water over that of a well in which the water quality is unknown. The Commission on Rural Water has recently published the results of their National Demonstration Water Project in which they estimate that 50 percent of water wells in the country are shallow and show a high degree of contamination. In one rural area in Georgia, 40 percent were unsafe and 15 percent grossly contaminated. I personally can attest that the same is true in Northwest Arkansas. Much information dissemination work needs to be done on well testing and construction.

In summary, I would suggest we might want to discuss further the following items:

I. Industrial Water Reuse

   A. Zero Discharge

      1. Relationships Between Process Use, Cooling Water, and Steam Production

      2. Reuse of Ash for Waste Treatment

   B. Economic Considerations

      1. Discharge Quality Standards vs. Process Water Quality Requirements

      2. Energy Requirements

      3. Thermodynamics of Solution & Separation Processes

II. Municipal Wastewater Reclamation

   A. Terrestrial Disposal and Irrigation

      1. Soil Microbiology

      2. Soil Plant Relationships

      3. Crop and Food Chain Effects of Toxic Elements

      4. Public Acceptance & Institutional Approval

   B. Recreastional and Ornamental Lakes

      1. Body Contact vs. Non-Body Contact Sports

      2. Virus Analysis

      3. Take-home and Eat Aspect of Fishing

      4. Potable Water

   C. Comparative Quality of Original Source Water

      1. Rural Well Water Quality

      2. Well Construction and Treatment

In summing up my philosophy on this subject, I feel compelled to state that I am here to do my part as a citizen, whatever it is, to help solve this world's problem. But I also must take note that Soloman, the wisest man that ever lived outside of Jesus Christ, has noted that "what is crooked cannot be straightened out, and that which is lacking cannot be numbered". He summed it all up by saying that one should "Trust God and keep his commandmants for that is the whole duty of man". In the final analysis that is all I can do and that is what I am going to raise my boys to do.

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POLLUTION - ENVIRONMENT OF THE ARKANSAS-WHITE-RED AND RIO-GRANDE RIVERS AND THE TEXAS GULF COAST AREA

by

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THE ENVIRONMENT

Arkansas River

The Arkansas River rises high in the Rocky Mountains in central Colorado, flows 1,450 miles southeasterly through Colorado, Kansas, Oklahoma, and Arkansas, and empties into the Mississippi River 575 miles above the Head of Passes, Louisiana.

The watershed covers 160,650 square miles, is about 870 miles long, and averages 185 miles in width. The Arkansas River has a total fall of about 11,400 feet, with its slope ranging from 110 feet per mile near the source to 0.4 foot per mile near the mouth. For 170 miles above Pueblo, Colorado, the river flows through a region of rugged mountains and foothills. At Pueblo, it enters the Great Plains section of the basin and flows through rolling prairies to the hilly lands in eastern Oklahoma and in Arkansas above Little Rock. Below Little Rock the valley merges into the typically flat terrain of the Mississippi River Valley.

Considering the environmental setting of the basin, one finds the flora as varied as the terrain, changing from the alpine and plateau forests of Colorado through prairie grasslands to semitropical growth in the lower courses. The fauna follows the variation of the terrain and the Central and Mississippi fly-ways bring many migratory birds to the waters of the basin.

Man has occupied the Arkansas basin since the early big game hunters entered the area around 10,000 B.C. The Spiro Mound complex in LeFlore County is listed in the National Register of Historic Places and is one of the most important archeological complexes in the United States. It was an influential ceremonial center from 700 to 1400 A.D. and the yield of artifacts from the mounds has attracted international attention.

French trade was established with the Wichitas in the early 18th Century. In conjunction with the forced migration of eastern tribes to Oklahoma territory, several trading posts were established in the early 19th Century.

Climate in the basin is semiarid to arid in the western part (except for limited areas in the high mountains), subhumid in the central part, and humid in the eastern portion. In some areas there are frequent dry periods and occasional long droughts. Basin population in 1970 was about 3.3 million above Fort Smith, Arkansas.

Water resources development in the Arkansas River Basin includes projects in Oklahoma and adjacent states, particularly in Arkansas and Kansas. The McCellan-Kerr Arkansas River Navigation System, a major feature of the basin plan, is essentially complete and is now in operation. It extends from the Mississippi River to near Tulsa, Oklahoma. Keystone, Oologah, and Eufaula Lakes in Oklahoma are key projects in the navigation plan. Lakes located in the upper Verdigris and Grand (Neosho) River Basin in Kansas also support the navigation project because of the water control they afford. Studies to determine the feasibility of extending navigation into central Oklahoma and southeastern Kansas are underway.

White River

The White River rises in the Boston Mountains in northwestern Arkansas. It flows northeast into the Missouri where the waters are dammed at Table-Rock and Lake Taneycomo dams. The river then re-enters Arkansas. It joins the Mississippi River near Rosedale, Mississippi. Near its mouth, a navigation channel joins it to the Arkansas River. The river is about 690 miles long and is navigable below Batesville, Arkansas. It is also dammed by Beaver and Bull Shoals dams in Arkansas.

The environmental setting of the basin consists primarily of alluvial plain, low level land covered with rich deposits of soils carried to the region by the Mississippi River and its tributaries. Most of Arkansas' major crops are grown in this area. An excellent system of levees and drainage ditches protects the area from flooding. Arkansas is one of the leading states producing broiler chickens. It also produces cotton, rice, and soybeans. This region also accounts for about 98 percent of the nation's Bauxite ore.

This region has belonged to France, then to Spain and then to France again, and was part of the Louisiana Purchase. Arkansas became a state in 1836.

Climate in the basin is warm and rainy. It has warm to hot summers and cool winters. The average annual rainfall is approximately 50 inches.

Water resources development includes the beginning of the McClellan-Kerr Arkansas River Navigation system. Also several lakes for flood control navigation and recreation purposes have been built.

Red River

The 1,222 mile-long Red River rises in the high plains of eastern New Mexico, flows eastward across the Texas Panhandle, and forms the boundary between Texas and Oklahoma. It skirts the southern edge of the Kiamichi (Ouachita) Mountains of Oklahoma, then meanders across southwestern Arkansas and through the Coastal Plain of Louisiana to its confluence with the Mississippi River.

The total drainage area of the Red River, exclusive of the Ouachita-Black River system, is 69,200 square miles. Drainage from the upper 39,700 square miles, where valleys are wide and flat and uplands are rolling to hilly, is controlled by Denison Dam near Denison, Texas. The area of the basin below Denison Dam, exclusive of the Ouachita-Black River Basin, includes 29,500 square miles of mostly gently rolling terrain with nearly flat flood plains.

Climate in the upper portion of the basin varies from semiarid in the west to moist and subhumid in the east. Both annual and seasonal precipitation are erratic. The long summers are hot and dry, and the winters are relatively mild except during occasional sever "northers." Below Denison Dam the climate is humid with average annual precipitation varying from 37 inches in the west to 60 inches in the lower east portion. The average annual temperature varies from 60 degrees F in the west to 66 degrees F in the east.

Agriculture, processing of agricultural products, oil and gas production and processing, and a limited industrial development are the predominant economic activities in the basin. The 1970 population of the basin above Fulton, Arkansas was about 1,030,000.

The Red River mainstem flows cannot be used for most purposes without extensive treatment due to the chloride contamination from natural sources. Generally, the tributary flows are suitable for domestic and industrial use without treatment.

Considering the environmental setting of the basin, one finds that the flora and fauna are the direct result of the varied climate and terrain. From the semiarid climate in the headwaters, one travels through the pine forests of its middle reaches to the semi-tropical cypress bayous of the Louisiana terminus. One finds antelope near the headwaters and alligators where the Red joins the Mississippi River.

Archeological records of the Red River Basin reveal the presence of man along the river for the past 12,000 years. In prehistoric times, these people were early hunters, archaic people, Pueblos, Apaches, Comanches, Kiowas, Wichitas and Caddos. Later the tribes moved into Oklahoma from the north and east. Early white explorers knew of the Red River and the French had established trade by the late 17th century. The Red River has played a consistent and important role in man's history in the Southwest.

Rio Grande River

The Rio Grande, the sixth longest river in North America, flows for 1,885 miles through the southwestern part of the United States. It forms the international boundary between the United States and Mexico for about 1,290 miles.

The upper reach of the river is fed by mountain streams of New Mexico. Above Albuquerque the river flows out upon a dry plateau. From El Paso to the Gulf of Mexico the Rio Grande forms the international boundary. The river flows through extremely dry country and is often dry because of water being diverted for irrigation. The lower reach of the river is dotted with dams and reservoirs, built jointly with the Mexican government. These dams provide irrigation water and flood protection for the lower valley. The lower valley is noted for its citrus fruits, vegetables and cotton. Most of the river is too shallow for boats.

This basin has been under many countries' flags and has many nationalities among its population. Climate varies from extreme hot in the lower basin to extreme cold in the mountains at the source.

Water resource development utilizes about all of the available water for irrigation and municipal supplies.

The Texas Gulf Coast

The Texas Coastal Zone is marked by diversity in geography, resources, climate and industry. It is richly endowed with extensive petroleum reserves, sulfur and salt, deep water ports, intracoastal waterways, mild climate, good water supplies, abundant wildlife, commercial fishing resources, unusual recreational potential and large tracts of uncrowded land. The Coastal Zone is a vast area of about 20,000 square miles, including approximately 2,100 square miles of bays and estuaries, 375 miles of Gulf coastline and 1,425 miles of bay, estuary and lagoon shoreline. About one-quarter of the state's population and one-third of its economic resources are concentrated in the Coastal Zone, an area including but 6 percent of the total area of the state.

The Texas shoreline is characterized by interconnecting natural waterways, restricted bays, lagoons and estuaries, low to moderate fresh water inflow, long and narrow barrier islands and extremely low astronomical tidal range. Combined with these natural coastal environments are bay-side and intrabay oil fields, bay-side refineries and petrochemical plants, dredged intracoastal canals and channels, and satellite industries. The attributes that make the Texas Coastal Zone attractive for industrialization and development also make it particularly susceptible to a variety of environmental problems. The Texas Coastal Zone is thus balanced between maintenance by natural physical, chemical and biological processes, and effects of industry, urban concentration and coastal land development.

Parts of the Coastal Zone are among the fastest developing industrial, urban and recreational regions in Texas; the Zone is at best a precariously balanced natural complex of dynamic environments with a history of almost yearly hurricane impact. Adequate plans to meet the potential problems of pollution, land and water use, and conservation are critically needed to insure proper development of this vital Texas region.

During the past 100 years, man has significantly modified the Texas Coastal Zone. The principal effect on coastal geology has been the extensive dredging of channels and passes with resulting discharge of sediment into bays which modifies the natural bay circulation patterns. Sediment supplied by human activities during the past few decades has far surpassed the volume of sediment supplied by natural erosion. Almost 25 square miles of bay-bottom spoil is presently being redistributed, while 15 square miles of spoil is now piled above sea level and is undergoing erosion and introduction into the bay system. More than 15 square miles of made-land have been constructed, predominantly in the Galveston and Texas City areas, although most of this made-land has been adequately stabilized.

Headward-eroding streams are accelerating the transport of sediment into bays, principally because of increased cultivation, construction of irrigation and drainage canals, and urban paving on the broad uplands. Straightening and lining of stream courses are becoming important factors in flash flooding. The impact on the natural drainage system by urbanization in the Houston metropolitan area is becoming a serious problem.

Withdrawal of vast quantities of groundwater in the Houston-Bay City-Texas City triangle has resulted in significant land subsidence. Subsidence will continue, even if groundwater use is curtailed, so that the impact of hurricane flooding and rainfall during severe thunderstorms may become increasingly severe in these subsiding bay-side areas.

The average annual rainfall ranges from 42 to 52 inches per year in the zone. This represents an excess of moisture of about 8 inches per year. The temperature ranges from a winter average of 43° F to a summer average of 70° F.

Like the Rio Grande Basin, the Texas Gulf Coast area has been under the rule of many nations, and it too has a mixed population.

The water resources of the area are planned for ultimate development under the Texas Water Plan if and when it is implemented. Municipal and industrial water demands are increasing, and increased groundwater use has caused many problems.

POLLUTION

The pollution problems of all the areas are basically the same. Municipal and industrial waste discharges have reduced water quality to, in many instances, an unusable level. Natural salt pollution in the Arkansas and Red Rivers make these unfit even for irrigation purposes.

Leachate from poorly sited sanitary land fills are beginning to create major problems in the groundwater system. Septic tank waste and industrial deep disposal water wells are problems that must be researched and resolved.

Pollution from oil field operations has all but ruined the shallow groundwater resources in the Arkansas and Red River Basins. With last year's energy crisis, rules were again relaxed for the oil operations, further compounding the problem.

Many of the lakes formed by dams built by the Corps of Engineers and Bureau of Reclamation are also experiencing pollution problems primarily because of thermal and density stratification. As an example, Keystone

Reservoir on the Arkansas above Tulsa, Oklahoma, has not been able to supply any municipal and industrial water because the inlet is at an elevation in a density stratification leaving the water too salty for use.

Because of a poor distribution of water in the high plains areas, water is being mined from the groundwater aquifers for irrigation uses. The return water is high in dissolved solids, and this results in unsatisfactory water for municipal and industrial use. However, there are plans to move large amounts of water from the eastern regions of the basins to recharge the depleted areas. This transfer is not without problems, pollution and otherwise.

Air pollution is also becoming a critical problem in these areas, because of increased industrialization. Of course, the ever-present dust is a major source of pollution in the West Texas and Oklahoma areas. Air pollution controls are now in effect in all states in the region, and hopefully reduction in this problem will result.

All states within the region have water quality standards, and with the help of EPA grants, water pollution should decline. Also, state standards for air quality and solid waste disposal have been issued.

One major problem of the upper reaches of the Arkansas and Red River Basins is that of feedlot waste. It was once said that in an area of 50 miles radius from Guymon, Oklahoma, there were 5×10^6 cattle in feedlots. The waste from these is tremendous. Currently, most of the waste is returned to the soil. But this too presents problems.

The most promising solution to many of the water pollution problems is land treatment. In Arkansas, Oklahoma and Texas, there is at least adequate land available for this type of treatment. In fact, several successful systems are now in operation. One system that treats a cannery waste has proven very successful. Land treatment of wastes has a good future here.

If land treatment of wastes becomes common, then there will begin to be problems with low flows in the rivers. Now many of the streams in the area depend on sewage discharges to maintain minimum flows. In fact, many streams would have no flow in non-flood times, without sewage discharges. Land treatment processes might create more problems than it solves.

In summary, the environment-pollution of the Arkansas, White, Red and Rio Grande Rivers and the Texas Gulf Coast are similar to every other area of the nation. However, we as engineers and water scientists must take to the challenge to improve the environment and control the pollution. These I am confident we can do.

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INSTITUTION AND POLICY ISSUES IN ENERGY-WATER RELATIONSHIPS

by

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In this context, what we are addressing is the spill-over or interaction of water with the energy problem. Clearly, in this instance it is the energy problem which is driving our concern, and thus, the dimensions of that problem are of prime concern.

With respect to the Southwest, we principally depend for electrical energy on the burning of fossil fuel although hydroelectric energy has an important role to play in the overall supply of electric energy. As yet, no nuclear plants have been built in the Southwest; however, a number are under consideration at this time and can be expected to be a part of the energy production scene in the next decade.

The immediate cause of heightened public concern with this and related questions can be summed up in the term "energy crisis." It is important to recognize that the energy crisis has two different time dimensions. First, there is the short-term aspect which was so visible at the gas pump recently but whose visibility is now fading. Of much greater importance than the short-term dislocations we experienced is the long-term energy crisis. It is this to which we should be giving our best attention. The nature of this crisis is best exhibited in the article by M. King Hubbert, in the National Academy of Science's publication "Resources and Man" issued in 1963. Hubbert makes the point that fossil fuels are finite in extent. While there may be some dispute and uncertainty as to the total supply of these materials, they are being used up at increasing rates so that in the not so very distant future, measured in one or two hundred years, the world will be faced with their virtual exhaustion. Other energy sources include hydroelectric power which is a small but important fraction of our present energy picture. However, for North America, approximately 1/3 of the total available hydropower has already been developed and further development will be at an increasing cost. Geothermal and tidal energy, while it may be locally important, can never be of more than minor importance in meeting the demand which is expected in the future. The only available source of energy which has potential of supplying the coming demands is nuclear energy. Just how soon U.S. and the rest of the world will turn to nuclear energy will be determined by our overall strategy of energy development. While fossil fuels in the form of oil, gas and coal are capable of being used for a least the next century, the day of nuclear energy must inevitably arrive.

What is the meaning of this inevitable development for our policy in institutions in the Southwest? Energy delivered from fixed sources, in other words electric power, is today provided to us through a mixture of public and regulated private enterprise. For energy sources where competition is more feasible, the free market has been used to develop our resources of oil, coal and the like. The free enterprise system and its public analogs have served the community reasonably well in promoting the economical and low priced supply of energy in its various forms. If we plan to rely on the free market in the future, then perhaps we should adopt a hands-off policy, while making sure that the free enterprise system is not hampered in moving to meet the growing demand for energy. I submit that basically this is the strategy that we should adopt both for the Southwest and for the nation.

It is not unfair to say that water resources engineering is essentially a public enterprise activity and so might naturally turn to public enterprise to deal with the energy problem including its water related aspects. In recent times it has become fashionable to downgrade the virtues of business. I believe this is unfortunate because free enterprise business has served this nation well. Perhaps the reason for this attitude can be traced to some of the excesses of business enterprises and their exploitation of the public or some sections of it; however, if we reject the free enterprise approach to solving this problem, I believe we would be committing the error of throwing out the baby with the bathwater.

What then should be our policies for the free enterprise approaches to be used? I believe that the role of government is to set the rules of the game that business plays and, at the same time, to be the referee to see that the game is played fairly. The role of business is to play the game while making as much money as possible for the stockholders. If the forces of supply and demand are allowed to work, they will control the business so that it is motivated to maximum efficiency. The community at large is the beneficiary of this maximum efficiency operation.

There is not much dispute in our community today that we are prepared to pay for most products and services in both money and in activities to protect the environment. Our propensity to act in this manner is increasingly characteristic of our way of making public decisions. This change is not a sharp break with the past but simply a shift of emphasis with regard to a consideration that has always been present. Now our willingness to pay environmental costs is more explicit, but unfortunately, what the environmental cost is and how much we are prepared to pay can be in dispute. By comparison, dollar costs are comparatively easy to determine although there is always the question of who is going to pay them.

The problems for our institution then are to decide what environmental costs we are prepared to pay for energy production. It is naive to think these can be nil or that energy demand can be reduced to lower values. While we might argue about when power consumption will be double present value, what is certain is that that day will arrive in the very near future. Whether it is six or ten years away does little to alter the dimensions of the problem it brings in its train.

In moving to the ultimate nuclear strategy which I believe is absolutely inevitable, there are a number of intermediate steps that our energy picture will probably pass through, and the problem for our institutions is to settle the optimum conditions under which these interim solutions can be utilized. For instance, setting very restrictive limits on strip mining is a way of imposing a high environmental charge on that form of energy development. If that charge is high, it must either be paid or we move to the least costly alternative to that, if one is available. As the consumer is the ultimate payer, as I pay more for energy, I have less money for the other things in my budget. Setting high charges for energy development may deny the community cheap alternatives to the detriment of us all.

From the water resources point of view, the effect of energy development on the water environment, the constraints placed upon potential energy developments by its water demands, are of professional concern to us. The technical alternatives in energy production, if they are water consuming or water demanding, must compete with existing uses for that water. If low-value water users stand in the way of water being used for high-value energy development, then the community once again pays to protect the low-value user. At the coming on the scene of a new high-value use for water, such as for energy, the problems involved in transfering water from a traditional but low-value use to a new use poses important social problems. One response might be to deny that any change might be made. This may be the most costly of all alternatives. A more fruitful process would be to allow the economical solution to prevail, but at the same time, to recognize the hardships and dislocations caused to the low-value users and the individual cost they are put to in making an adjustment which is good for the community as a whole. This clearly is a realm for governmental intervention unless the market mechanisms function so that the low-value users are fully compensated when they sell their water rights to the high-value competitor.

On the national scene, as distinct from the local scene, there is a further role for public intervention and that is to see that important potential developments in technology are undertaken. These are the ones which are beyond the range that the private investor can contemplate or are too big a risk. In an evolutionary industry like the electric power industry, the generation by burning of fossil fuels is the normal mode of operation. Further development of this technology does not appear to be a problem beyond the capability of the industry. However, developing the revolutionary techniques involved in the breeder reactor, which now seems feasible for electric power production, would appear to be a legitimate realm for public investment.

In summary, I believe that our policy and institutions in the Southwest, as well as throughout the nation, should be of a character that they can respond to energy and energy water problems by seeing that to the extent possible, we use the free market. And under these conditions, we the public will receive the most economical solution to the problem. By most economical is meant the solution which is the least total cost where this total cost will be made up of dollar costs, social costs and environmental costs. Our institutions must make clear what are the social and environmental costs we will accept by suitable rule making and standard setting. For large technological developments which represent a step which is of a magnitude larger than private enterprise can contemplate then there is a clear public responsibility. At the same time, I believe that our institutions should concentrate on educating the public on the facts of the matter which are that nuclear power must come, although when it does come should be decided by economics. How we pass through the intermediate stages using other fuels, will depend on the relative economy of these in various places, and our institutions should facilitate these decisions being made openly in the market place.

DISCUSSION REPORT

Marvin T. Edmison
Chairman
Oklahoma State University

Thomas G. Gebhard
Reporter
New Mexico State University

When Texas and the surrounding states get together, they like to tell each other how different they are from the rest of the country. As our friends from Arizona and Southern California know, the southern part of the United States does have different energy problems. For instance, the slogan -- "save energy - set the thermostate at 68°F"-- can cause consumers to use more energy. In most public and commercial buildings in the southwest the heating and the air conditioning run simultaneously in the winter. On a 75°F day in mid-January a 68°F setting will cause the air conditioner to run more, thereby using more energy. Many of the slogans have nothing in common with the Southwest.

Our speakers all recognized the different nature of the water-energy relationships in the Southwest. Conditions in the Southwest vary, but a few generalizations can be made. Most are problems which extend from the fact that the demand for water exceeds the supply. The importance of water rights laws cannot be understated. The economic value of water is very high, and the existing federal subsidies reflect the importance of irrigated agriculture to the local economics. The water quality problems are increased by the lack of water to dilute the chemical and biological constituents within the water. On top of the other problems, our water resources are now to be used to assist in the energy conversion process of our unused energy resources.

Dan Wells presented a good analysis of the amount of water needed to produce energy inthe Southwest and in particular, Texas. Most of the participants have talked about the amount of water necessary to produce energy; Dan notes that in this area energy is needed to produce water. He also noted that 1/3 of the oil produced in Texas is by flooding the formation and repressurizing. In west Texas, there is a high economic value to this water. The High Plains reports that only .2 percent of water consumed is used for oil recovery, and that the oil taxes produce 60 percent of the financing for local schools and governments. In addition, the group felt that any tradeoff of irrigation water for energy production would be an undersirable trade and that if energy is to be produced, more water should be brought in the region.

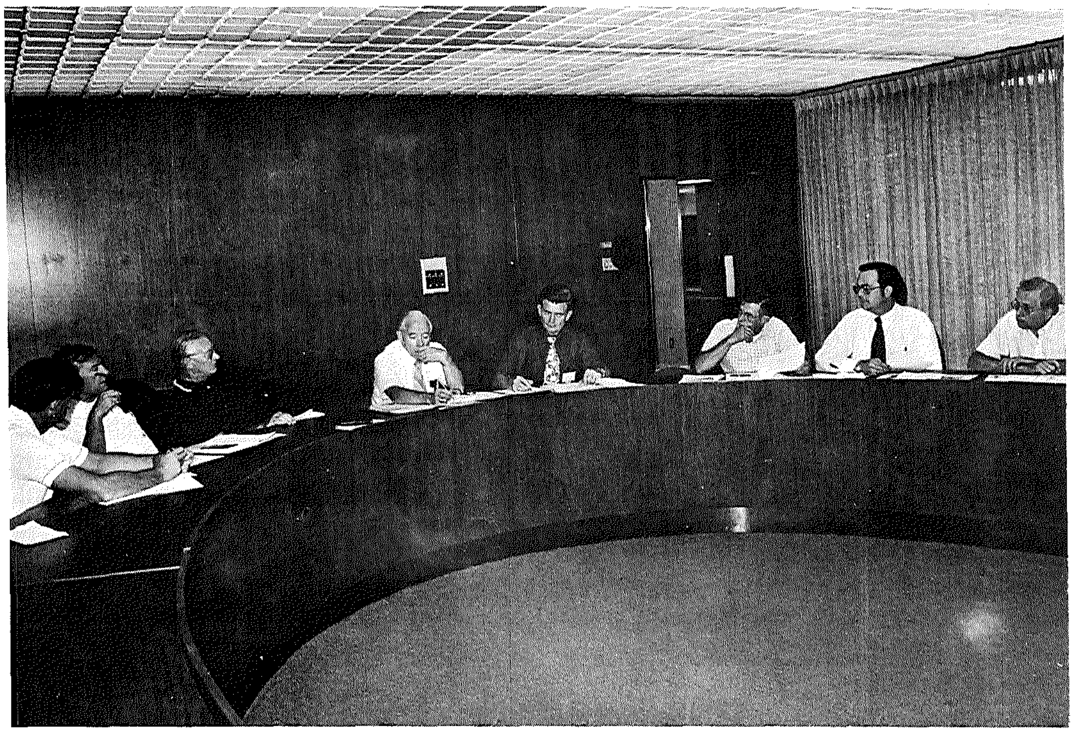
Buddy Babcock defined the tradeoffs to be made on water reuse and recycling. Basically, industry can conserve water by recycling but the cost tradeoffs on energy use are undefined.

Rich DeVries again emphasized the varied nature of the hydrology and the pollution of the region. He mentioned that one stream served an environment dominated by antelope at one end and alligators at the other end.

Bill Butcher made a presentation which evoked a good deal of conversation. He stated that fossil fuel exists only in a finite quantity and that eventually a switch must be made to nuclear energy. Man can only control the timing of the change. He was a strong advocate for using a free market economy to aid in controlling the time. Of course, he constrained the free market by the total efficiency constrant of the lowest dollar, social and environmental costs.

Although the Southwest region has been a major energy supplier, we appear to be reluctant to use our meager water resources for large projects of energy conversion.

In conclusion, I would like to point out that the regional structure of water basins does not reflect the regional structure of the energy markets. Thus, if UCOWR or the Water Institutes continue to discuss the water demands for energy conversion, a restructuring of the regions should occur.



Education and Research in Water Quality Committee

REGIONAL WORKSHOP

VI - COLUMBIA-NORTH PACIFIC

CRITICAL ENERGY - WATER ISSUES RELATIVE TO MANAGEMENT AND CONSERVATION OF WATER RESOURCES

by

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INTRODUCTION

In considering the topic of critical energy-water issues relative to management and conservation of water, I consider it important to question what the title and its principal words mean. The first word "critical" can be considered in three different ways and still have relevance to the topic of energy and water resources. First, it is easy in this day and age to take the meaning of critical in the context of finding fault; second, it is logical to take a look at our topic from the meaning concerned with making a careful analysis and judgment of the situation; and third, it can be considered in the meaning of the world related to a crisis or at a turning point. Certainly as we read and hear about the subject of energy, we are at a critical point in our nation and our region's history with regard to energy. When water politics of transferring water from one region to another is mentioned, it conjures up a crisis situation and soon becomes a critical issue in my part of the country.

With all these definitions there are elements we can be concerned with and be in the realm that our conference is intended to address itself to, but I presume we would be considered more constructive if we address ourselves to considering the element of crisis at hand and consider the definition concerned with making a careful analysis of the situation at hand.

Since the workshops are organized into geographical regions, I will direct most of my comments to the Pacific Northwest as the region with which to be concerned.

PROPOSALS FOR IMPROVED MANAGEMENT AND CONSERVATION OF WATER AS A RESOURCE

In both the energy field and the water field, it is very popular and easy to say we can conserve and not use so much as we are or have been using. Yes, that is true because we have lived in a period when national, regional and local policies of pricing and of use tended to encourage using more and more per capita. In fact, in some ways we tend to measure our well-being, and certainly our standard of living, in the amount of energy used per capita and the amount of water used per capita. As we start searching for ways to better manage and to conserve in the interlinked areas of energy and water, we then must ask the question -- what are some ways we can improve and manage our water use so as to conserve the resources and to also be less demanding of energy? I would like to survey the more conventional areas of: (1) domestic use, (2) waste disposal, (3) industrial use, (4) energy production, (5) agricultural use, (6) transportation use, and (7) recreational use.

Domestic Use

Most proposals claim that other countries do not use so much for domestic use, so we could even drink less, certainly use less for bathing and for washing our clothes. But the usual comment is that this is such a minor amount of the total water diverted for use, that really it is not that important. However, it is an alternative for conserving water, and it may even conserve some energy also -- but can it be done? Sure, it could be done if it were declared a policy and an educational campaign undertaken to change a custom that is deeply entrenched in the American way of life. True, it may only make a minor contribution in the entire water picture. Perhaps the greatest incentive might be a completely revamped pricing system of charging for water that would put a premium on using less water per capita and looking for decreased use in future designs of water facilities. A question might be asked -- is the Pacific Northwest region willing to consider such a conservation alternative?

Wastewater Disposal Systems

Wastewater reuse is being strongly advocated as a means of conserving water, and it certainly has merit in saving water. This is especially true in domestic use wherein there is a minimum of actual human consumption of the water. In my own community, we are considering using effluent from the wastewater treatment plant to water a golf course and lawn areas on the campus that are close to the treatment plant. Very likely, this may take more energy than the energy used in the past, but as we look to increased demands for water, the alternative of getting a supplemental water supply will be even more demanding of energy than utilizing the wastewater. It all sounds very encouragaing, but as is often the case, it is more than even the need for energy to pump and redistribute the water. The problems involved in water rights and institutional acceptance appear to be almost beyond solution. The use of treated wastewater for recharge of groundwater aquifers has gained much recognition in the last decade and offers a real management and conservation alternative. Its practice in the Pacific Northwest is rather limited to date. Assurance that the water quality of existing groundwater will not be degraded is needed. A drain well permit system is being instigated in Idaho to try to protect the existing water quality of the groundwater. Lacking is a cheap method of measuring the effect of this injection or recharge on the groundwater of the local aquifer.

Industrial Use

The big emphasis here is the recylcing of water in many of the common uses made by industry. In the past decade, excellent progress had been made in finding ways of recycling water. In the beet sugar industry in the Northwest, excellent progress has been made now that water quality standards are being utilized. There is more incentive, and if recycling is cheaper than alternative supplementary methods of getting new water, certainly industry will adopt recycling as a management and conservation measure.

I note two excellent reports on this topic of reuse or reclamation of wastewaters. One is a report by Leeds, Hill and Jewett, Inc.[1] and the second is a report by Kasperson, Baumann, Dworkin, McCauley, Reynolds and Sims.[2] The first report gives some excellent methodology for analysis in the realm of economic analysis but really gives very little real-world economic data to verify that the practice is really working. Another excellent survey of water reclamation and reuse is an article published by Irwin J. Kugalman[3] of the Advanced Waste Treatment Research Laboratory of the National Environmental Research Center, USEPA at Cincinnati, Ohio. This surveys the recent progress of water reuse in areas of water planning, industrial reuse, irrigation and groundwater recharge, indirect reuse and direct potable reuse. None of these studies contain anything that would cover the situation in the Pacific Northwest. Certainly the study by Kasperson[4] is getting at an important problem of understanding some of the factors that influence public acceptance of use of renovated wastewater.

Energy Production

Supplying water for energy production normally is concerned with furnishing water for cooling thermal power plants and for processing the fuel to an acceptable condition. In the Northwest until recently, this has been no problem because such a dominant amount of the energy was produced by hydropower plants, but now as that source ceases to a viable alternative, thermal power plants are becoming a demand for water use. A relatively abundant water supply would normally encourage use of once-through cooling, but water quality standards for temperature increase in the streams of the Pacific Northwest has dictated using cooling towers, which is more economical in use of water -- but does it really net us a more efficient energy? Thus, management and conservation of water for power production means increased use over the past, but it has put urgency in trying to find acceptable sites for energy plants and critical demand for water sources to cool the plants. Here, the idea of using less energy per capita, or at least stabilizing the tendency for increase, is a management and policy alternative that faces a society that is reluctant to give up a growth ethic as a sign of progress. One of the great conveniences of the Pacific Northwest is the convenience of electrical heat. Often mentioned is the possibility of using waste heat from power plants for space heating.

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[1]Leeds, Hill and Jewett, Inc., "Economic and Institutional Analysis of Wastewater Reclamation and Reuse Projects," Report 14-31-001-3177 for the Office of Water Resources Research, Consulting Engineers, 120 Montgomery St., San Francisco, California, 1971.

[2]Kasperson, R.E., Baumann, O., Dworkin, D., McCauley, D., Reynolds, J., and Sims, J., "Community Adoption of Water Reuse Systems in the United States," A report to the Office of Water Resources Research, Worcester, Massachusetts, 1974.

[3]Kugalman, I.J., "Water Reclamation and Reuse," Journal of Water Pollution Control Federation, Vol. 46, No. 6, p. 1195-1200, 1974.

[4]Kasperson, R.E., op. cit..

In energy production, the hope of using geothermal resources has received much publicity. It directly involves both energy and water in the process of harnessing the resources. Unfortunately, in the Pacific Northwest we have no real experience with geothermal power production. It is an alternative on which to seek more information in an attempt to meet our needs. I mentioned that hydropower is ceasing to be a viable alternative, but the remaining sites in many cases have become the subject of great environmental controversy. The period for development of pump storage projects in the Pacific Northwest for furnishing peaking power is just beginning to become an economic reality, so energy production and water use promises to become even more urgent in the demand for critical appraisal of what alternatives should be pursued.

Agircultural Use

This important use of water demands attention in an appraisal of possibilities for improving management and conservation of water if for no other reason than that a very large quantity of water withdrawn for use is for agricultural use. In the Pacific Northwest, the Pacific Northwest River Basins Commission,[5] through the Water Resources Council, and the 1965 National Reports of Water Assessment indicate that irrigation water withdrawn amounted to 29,574,000 acre-feet while industry and public water supply made a withdrawal 3,373,000 acre-feet. If we report this estimate of water use on a water consumed basis, it is even more impressive. Agricultural or irrigation consumptive use was estimated to be 11,252,000 acre-feet, while industry and public water supply was estimated to have a consumptive use of 315,000 acre-feet -- nearly 36 times as great a consumption use of water for irrigation. From this, one can see why some would say, why worry about conservation of water for domestic and industrial use? More and more pressure is exerted to find ways of improving the efficiency of use in irrigation. It would appear that the recent philosophy in an organization like the U.S. Bureau of Reclamation is to direct its energies to obtaining increased efficiency of use. Some new ideas involve subsurface and trickle irrigation to provide water to plants so that a minimum of loss occurs. In my state of Idaho, the advent of sprinkler irrigation has certainly brought about increased farm water efficiency but not without increased use of energy. One of the great questions in many irrigation projects is the question of what happens to that so-called over-use of water. It appears as return flow downstream of the first use and is a very natural part of an old reuse practice. In many cases, this return flow is delayed flow that is beneficial to other water uses and is the means of another use at a lower point. We have several methods of improving irrigation system efficiency such as lining of canals, better scheduling of applications, application by sprinkler or trickle irrigation and better operation of storage reservoirs. But at what cost is the efficiency improvement made,

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[5]"Water Resources", Appendix V, Volume 1, Pacific Northwest River Basins Commission, Columbia-North Pacific Comprehensive Framework Study of Water and Related Lands, Vancouver, Washington, 1970.

both in dollars and energy use, and what are the institutional restraints and water politics of states and regions that influence the patterns that can and will be possible in the future? This represents a very fruitful field for research and for diplomacy in future conservation and management policies.

Transportation Use

Our country's earliest concern as a national policy for water seems to have begun with navigation of inland waters and fostering of commerce through shipping goods by water transportation. As the pinch on fuel for providing motive power for trucks and trains more critical, the obvious saving in energy of moving goods by water transporation takes on a means of conserving energy but maybe not conserving water. In the Pacific Northwest, the development of navigation on the Columbia River and the Snake River is really much in its infancy. The recent National Water Commission[6] that questioned the present subsidy to navigation and recommended that the cost be distributed more to the immediate beneficiaries has some interesting ramifications. The question might be asked -- will such a new policy foster increased efficiency in use of energy? Certainly, after witnessing in the Netherlands the part use of water for navigation plays for that country in competition for wolrd commerce, it is easy to recognize that management and conservation of a water resource for commerce is no small item and promises to play a more important role even in the Pacific Northwest.

Recreational Water Use

Since most of the time recreational use of water does not involve a consumptive use nor an extractive use, one would tend to say that conservation and management in the context of either water or energy can have little impact, but increasing demands for recreational use do demand a price. Often, we operate reservoirs to accommodate this important use of water and desire to the detriment of obtaining maximum power, and certainly the energy used in travel of pleasure boats and of vehicles to participate in recreation is a growing comsumption of energy. The question might be asked, should water development and water planning encourage such a use, or should we restrict such to curb man's activity? In the Pacific Northwest, this concern for recreational use of water in its broadest context involving fishing demands real attention and a policy that seems evident is one that will meet people's desires for leisure-time activity.

POSSIBLE ACTION ALTERNATIVES

As we consider the critical nature of these many possibilites for improvement in management and conservation alternatives for meeting the period ahead, it appears urgent to provide more information to decision makers to cope with the problem, and I would submit the following are needed:

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[6]National Water Commission, 1973, "Water Policies for the Future", Final Report to the President and to the Congress of the United States, Washington, D.C., pp. 5797.

(1) An educational program showing how conservation of both water and energy can be achieved in even minute amounts and certainly an effort to bring people to an awareness that wasting a resource is not best for our future.

(2) An overhauling of some of our pricing policy to encourage more efficiency in use of both energy and water.

(3) A more concentrated study of economics of conservation in real-world situations that hopefully will show that measures of better management and conservation of water will be profitable to a region.

(4) A critical appraisal of institutions and customs that frequently dictate policy toward management and conservation of water.

(5) A search for better methods of physically controlling water in its many uses and particularly in controlling water as it becomes a resource of use in conveyance, storage and acceptance as a waste carrier.

In this, it might seem wise to develop some priorities for which educational institutions can best lend their attention and make a contribution in helping solve the issues involved in the water-energy field. This might be a fruitful area for us to discuss in our workshops at this conference.

POTENTIAL ENVIRONMENTAL IMPACTS OF ENERGY SELF SUFFICIENCY IN THE PACIFIC NORTHWEST

by

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The potential impacts of the new energy self sufficiency policy called "Operation Independence" on water resources and the general environment may be as great in the Pacific Northwest as in many other regions of the United States. The Pacific Northwest is currently dependent upon hydroelectric power as its primary source of electrical power for domestic and industrial energy. Most of the best hydroelectric power sites have already been developed. There are, however, several significant hydroelectric power projects which may become economically more desirable if the energy shortage intensifies and as costs increase. The sites I refer to are: (1) High Mountain Sheep, (2) Nez Perce, (3) China Gardens on Snake River; and (1) Lower Canyon, (2) Freedom and Crevice on Salmon River. Other sites in other parts of the region also would be affected by increasing energy costs.

If these dams were to be built, the impact on the environment of the Pacific Northwest would be drastically changed. Several hundred miles of free-flowing river would be lost. Several migratory fisheries would be destroyed (salmon and steelhead). In addition, the impoundments would also detrimentally affect the archeological, big game and aesthetic resources of the river areas involved.

The benefits gained by such development would consist of a relatively small incremental gain in electrical power (small in terms of projected needs), some added reservoir recreation, improved access for fishermen, hunters, loggers, miners and recreationists.

At present there is relatively little substitutability among alternative electrical power sources in the area. In the future as available hydroelectrical sites are either built upon or determined infeasible for various reasons, thermal power from both nuclear and fossil fuel sources will be used to meet electrical loads. There will undoubtedly be some tradeoffs between hydropower and thermal power sources as a result of increasing energy costs. This is already being manifested in the pressures being brought about by increasing fuel costs which will be eventually translated into the alternate costs calculations used by FPC (Federal Power Commission) in its cost calculations. As a consequence, this will bring considerable pressure for development of the lower cost sources of electrical power.

The development of hydroelectric power in the Pacific Northwest deserves an additional comment. That comment is that the number of sites available will be dependent to some extent upon the cost of energy, but ultimately the number is finite. At the present time, the area is in the process of shifting from a hydroelectric base to a thermal base for its electrical energy needs. By the year 2000 it is estimated that thermal power sources will make up 60 percent of the base load and hydro 40 percent.[1]

The obvious research which emerges from this narrative is that for the development of evaluation processes which identify problems, determine weighting processes, and estimate tradeoffs among the several developmental and environmental effects involved. Gains in kilowatts must be evaluated between hydro and thermal plants on the following basis. The tradeoffs are: (1) losses in fish and wild rivers compared to (2) increased levels of nuclear and air pollution hazards. In either case, society must face the fact that environmental damages will occur. Optimally, it would be desirable to minimize the effects of such damages. Actually, we don't know how to minimize these adverse impacts. These kinds of questions raise the fundamental conflict that exists between the standard of living and quality of life. Considerably more research is needed in this area if rational choices are going to be made among the alternatives presented above.

WATER RESOURCES COUNCIL'S QUESTIONNAIRE[2]

Turning to a point which may have great impact and influence on water use and environment in the Pacific Northwest, I refer to the recent questionnaire sent to all states by the Water Resources Council's "Task Force for Energy Self Sufficiency." The six questions asked were:

(1) What major energy developments are being considered in your state?

(2) What do you anticipate as the major problems to be in regard to: (a) water quality deficiencies, (b) water rights, (c) increased efficiency of water use, (d) environmental restraints.

(3) Give suggestions for meeting the problems of water supply for energy in your state.

(4) In order to meet "energy-water requirements," certain alternative solutions may be proposed at the federal level, including: (a) interbasin transfer, (b) federal jurisdiction over water rights, (c) reallocation of existing storage.

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[1]Mann, P., "Hydroelectric Subproject," Water Resources Research Institute, University of Idaho, Scenic Rivers Study Report.

[2]Water Resources Council's Questionnaire, May 23, 1974, "Idaho Statesman," Boise, Idaho.

(5) Cite laws of your state which would be impediments to energy development.

(6) What are the priorities for programs and projects to make water available for energy developments in your state and regional groups of states?

Each of the above questions represents a federal intrusion on state water rights and water utilization. It appears that the framers of the questions presume a new or higher allocation of water for the states than that which already exists. Secondly, it also appears that these questions raise the spector of interbasin water transfers, and it may not be in error to presume that the federal construction agencies would take a lively interest in such a scheme because they would benefit greatly from the construction possibilities. Finally, there is the question which no one has answered: Why the interest in the "states" water for energy self sufficiency?

The most obvious answer to this latter question is the expressed national need to achieve "Energy Self Sufficiency by 1985."[3] If the nation is to achieve this goal of "energy self sufficiency," it will be necessary to develop the extensive coal, oil shale and tar sands resources of the Intermountain West. These energy resources are located either in arid areas of the Intermountain West or in areas where the water supplies are already appropriated for alternative uses which have a higher priority in terms of water rights (agriculture, municipal and industrial, etc.). The present water allocations in these areas have reduced the quantities of water available for energy development to the point that the scale of energy development will be significantly curtailed unless some alternate sources are found. The quantities of water required would be very large, and the source area nearest is the Pacific Northwest. In fact, the Snake and Columbia Rivers are the only rivers within a reasonable distance which can supply the quantities of water required.

A further question is: What are the quantities of water required? The answer to this question is somewhat unknown because it depends upon the level of development envisioned and the type of energy sources being developed. Coal-fired electric generating plants use 15 acre-feet per megawatt per year, or a plant with the capacity to produce a gigawatt would use 15,000 acre-feet per year. Coal gasification plants require between 15,000 and 19,000 acre-feet of water annually for each 250 MM cubic feet of gas produced per day. And oil shale processing plants require 17,400 acre-feet of water annually for each 100,000 barrels per day per plant. It can easily be inferred that water will be a very necessary ingredient if we are going to utilize these sources of energy, let alone achieve energy self sufficiency by 1985.

A further example is the specific water needs for the state of Utah. The present status of water availability and utilization in Utah, based on the "Upper Colorado Basin Compact," is shown in Table 1.

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[3]"Operation Independence," U.S. Department of Interior, 1974.

TABLE 1

WATER AVAILABILITY AND UTILIZATION IN UTAH*

	Acre-Feet
Total Allowable Depletion	1,322,000
Present Depletions	684,000
Future Depletion (Central Utah Project)	531,000
Uncommitted Water	107,000

*Robert S. Halliday, "Water Critical in Future for Utah's Energy Extraction," Salt Lake City Tribune, July 7, 1974.

The projected water needs for energy development in Utah are unknown, but what is known is that the present filings for water rights add up to 1,550,000 acre-feet, which can be compared to 107,000 acre-feet available for diversion. The estimated water shortage adds up to 1,443,000 acre-feet.

The need to supply this water cannot be met from Utah's "Upper Colorado Basin Compact" water. The only realistic alternatives are: (1) groundwater, (2) water from the Great Salt Lake, and (3) water provided by interbasin diversion. Groundwater in Utah as elsewhere in the West is already heavily appropriated for irrigation, and this is not likely to provide much of the water needed for energy development. The water in the Great Salt Lake or brackish water from other sources requires expensive treatment to make it useful for energy extraction.

The water needs of the state of Utah are only part of the whole water picture because both Colorado and Wyoming also have considerable quantities of coal, tar sands and oil shale which exceed those known in Utah. The water situation in these states is not any better than that for Utah. They are also participants in the "Upper Colorado Basin Compact" and have their shares of Colorado River water allocated under the "Compact." A further point under the Colorado River Basin Compacts is that Mexico has a claim on the water in the Lower Colorado River which indicates that an average of 75,000,000 acre-feet of water will be released from Hoover Dam over a specified 10-year period (an average of 7.5 million acre-feet per year over the 10-year period). This condition was specified in the "Lower Colorado River Basin Compact." If the Upper Colorado River Basin states are to have water in excess of their current Colorado River allotments, one way would be to supply water to the Lower Colorado River. One plan for doing this is the "Dunn Plan" formulated in 1965.[4] This plan would deliver from 5 million to 15 million acre-feet of water in three stages of development of 5 million acre-feet each to Lake Mead on the Nevada-Arizona border. This plan would free 7.5 million acre-feet of upstream water which could be used for energy development in the Upper Colorado Basin states. If the need existed, the quantity of water could be increased to 10 or 15 million acre-feet according to this plan by pumping water back upstream from the lower Snake River.

At the time Dunn formulated his plan, he estimated that water could be delivered to Lake Mead at a cost of $37.60 per acre-foot. This low cost was achieved by maximizing the hydroelectric power potential after the lift as the water drops down to the level of Lake Mead. These costs have increased by a factor of 3 or 4 times since then. This means that the cost of moving an acre-foot of water from the Pacific Northwest to the Pacific Southwest would range between $112.80 to $150.40 per acre-foot. These costs would prove too high for agricultural uses, but not prohibitive for energy development. These costs are lower than those estimated to move water by aqueduct from Lake Big Horn behind Yellowtail Dam to

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[4]Dunn Plan, data obtained from the Senate Hearings on S.1004, S.1013, S.861, S.1247, S.1409 Bills to Authorize the Construction, Operation and Maintenance of the Central Arizona Project (Arizona-New Mexico), and Colorado River Project and For Other Purposes, May 2-8, 1967.

Gillette, Wyoming. The costs of this diversion were estimated to be $220 per acre-foot by the Northern Great Plains Program, Water Work Group.[5] One reason the costs of the "Dunn Plan Diversion" would be lower is because of the considerable power recovery potential once the water has been lifted to 5,000 feet and is being dropped to Lake Mead.

ENVIRONMENTAL IMPACTS

The impacts of large-scale water diversions out of the Pacific Northwest would be many. The most immediate impact would be the loss of the last 100 miles of free-flowing water on the Snake River below Brownlee Dam. This is the famous "Hells Canyon," the deepest river canyon in the United States--5,000 feet deep. In addition, much would be lost in terms of fisheries resources, river recreation, hunting, aesthetic resources, archeology and other irreplaceable resources.

A second important set of impacts would likely occur because there is a need for large amounts of electrical energy to pump water. The total energy requirements for the pumping system used in the "Dunn Plan" are shown in Table 2. The required energy would have to be supplied from other than existing energy sources. This would imply the development of additional hydroelectric capacity on other rivers in the Northwest in order to make up the deficit. The deficit varies from 9.4 to 69.7 billion kilowatt hours. The other major hydroelectric power sites in the Pacific Northwest would have to be developed in order to supply the energy deficit. The other major sites include most of the wild and scenic rivers in the area. A good example is the Salmon River which, it is estimated, if developed to its full hydroelectric potential, could generate 13.6 billion kilowatt hours. This would provide sufficient energy to make up the energy deficit for the 5 million acre-feet diversion. Obviously this would result in considerable environmental damage, such as the impoundment of 200 miles of free-flowing river, loss of important migratory fisheries (salmon and steelhead runs), and other losses similar to those discussed for the Snake River.

A third important impact would be the loss of water for future irrigation (and possibly for existing irrigation) in Idaho. The "Dunn Plan" was designed to take the first 5 MAF of water out of Brownlee Reservoir. It was assumed that this could be done without affecting upstream water supplies in Idaho (1965). The present situation tends to be considerably different than that in 1965. The projected water needs in Idaho for future irrigation needs are shown in Table 3.

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[5]Water Work Group, Northern Great Plains Program, Briefing Session Draft, June 3, 1974.

TABLE 2

ENERGY REQUIREMENTS BY STAGES OF DIVERSION
"DUNN PLAN," 1965[6]

Stage	Lift Ft.	Pumping Energy	Hydro Energy Loss	Total	Hydro Energy	Deficit
				Billions of KWH		
5 MAF	3,170	20.3	7.5	17.8	18.4	9.4
10 MAF	3,340	42.9	13.6	56.5	18.4	38.1
15 MAF	3,700	71.4	16.7	88.1	18.4	69.7

[6]Op. cit., Senate Hearings

TABLE 3*

ESTIMATED WATER NEEDS FOR FUTURE IRRIGATION IN IDAHO

Item	Years	
	2020	2070
Acres	3,849,000	6,005,000
Water Requirements AF	1,739,000	9,610,000
Water Available AF	1,730,000	8,000,000
Water Deficit	-9,000	-1,610,000

*C.C. Warnick, "Report of Irrigation Subproject," Water Resources Research Institute, University of Idaho, Moscow, Idaho, June 1971.

These data indicate that there is no surplus water in Idaho if future uses are considered. In fact, new sources of water will have to be found by 2020 and this need will increase dramatically by 2070. By 2070, Idaho will have a demand for 30 percent of the water in the first stage of the "Dunn Plan" diversion.

ECONOMIC IMPACTS

It is obvious that diversions of the magnitude discussed would put energy in competition with agriculture for the use of water. This competition would occur in the middle and upper Snake River areas where the agricultural economy of the state of Idaho is almost totally dependent upon irrigation. If energy water needs were permitted to deplete water diversions for agriculture so as to displace irrigation, the effect on the state economy would be felt immediately. The areas involved would be returned to desert and rangeland, and communities would lose their economic and tax bases. The area would suffer outmigration and only dry land agriculture would survive. This would be a very bleak future, for many parts of Idaho and other areas in the Pacific Northwest could also be affected in the same way depending on the magnitude of diversions.

Some of the problems involved revolve around legal issues such as who really owns the water in Idaho. Stated another way which is more encompassing: What is the validity of state water rights? If water rights are not valid, how can agriculture as a marginal water user compete with energy for water supply? What basis exists for a state to protect its current level of economic development? This is particularly relevant in states which do not have the option of developing energy resources. What are the tradeoffs between energy development and irrigation, between energy development and regional economic development based on other resources? These questions are pregnant with implications for water resources development. It brings into focus issues of regional economic development as contrasted to national economic efficiency. How important is the need to maintain viable agricultural economies in the Pacific Northwest compared to developing the energy resources of the Intermountain States, which we are told will provide the nation with energy self sufficiency by 1985? What is the opportunity cost of limiting the development of energy resources to the amount of water available in the areas where these resources exist? What incentives are available to encourage the water-short states to economize on their water use and promote efficient water technology for the development of energy resources?

A RESPONSE TO THE WATER RESOURCES COUNCIL'S QUESTIONS

In light of the above comments and "straw man" type of methodology presented, how are the non-energy states to answer the questions of the Water Resources Council's Task Force for Energy Self Sufficiency? My comments will pertain strictly to Idaho's interest in water uses, but I feel that some of what I will say should be acceptable to the other states (Oregon and Washington) in the Pacific Northwest.

The answer to the first question which concerned interest in major energy developments would be that there _is_ interest in major energy developments. This interest, however, is tied to the development of thermal, largely nuclear power as the Pacific Northwest shifts from primary reliance upon hydroelectric power to thermal power as its electrical energy source. There are some hydroelectrical sites which still exist and which could be developed if the need existed. However, competing uses of these water resources must be considered.

To answer the second question concerning water deficiencies, rights, increased efficiency of water use and environmental restraints is very difficult. The problem is that the whole range or spectrum of water uses must be considered along with an assessment of economic and environmental impacts. There is no simple answer available that can be given at the present time.

The answer to question three, which asks how will the state provide water for energy development, is that it will be provided as it has been in the past. In-stream use for hydroelectricity will be permitted while consumptive use of water by thermal power plants will compete with other uses on a basis of priority of water rights. None of the Pacific Northwest states have extensive deposits of energy resources such as are found in the Intermountain States, so no need exists to use water for energy development related to coal, oil shale or tar sands.

Question number four arouses the most interest in Idaho. This question raises the spector of interbasin transfer and adds to it the possibility of federal jurisdiction over water rights along with the reallocation of existing storage. One of the points made earlier in this paper is that there is no excess water in Idaho which can be diverted out of state if a realistic view of water needs is taken. The nature of the present uses of water, the need to determine in-stream minimum flows, and increased demands for irrigation water as the world demand for food increases will all put added strain on the Snake and Columbia Rivers' water supplies.

If large water diversions out of Snake and Columbia Rivers are contemplated, it should be recognized that the most immediate impact will be to stop the future irrigation development in the Snake River Basin. And, it would not take very much to divert enough water to reduce the acreage of irrigation which presently exists.

The possibility of drying up Idaho for energy development becomes more of a reality when the imposition of federal jurisdiction over state water rights is suggested. If this were the case, the larger federal interest in energy self sufficiency would undoubtedly take precedence over irrigation rights because of the political influence which could be brought to bear by the remainder of the nation. The impact of this would be to destroy the local economies, and possibly, depending upon the condemnation procedures, result in many farmers losing part or all of their capital investments in their farms. This could also occur if federal jurisdiction over water rights was not implemented and the water rights were brought up by energy interests for interbasin transfer. The result in either case would be nearly the same for Idaho. Without water the agricultural economy of the southern part of the state would decline, the tax base disappear, and the people also. The only difference would be that the farmers might be able to recover their capital if the water rights had to be purchased from them.

The last point on the reallocation of storage would have the same effect as either of the other two alternatives in that water would be taken away from the farmers and used to develop out-of-state energy resources.

Question number five, which asks that laws be cited which would be impediments to energy development, can be answered relatively straight forwardly for Idaho. There are no specific laws which would be impediments to energy development or prevent the provision of water for energy development. The Constitution of the state of Idaho guarantees the right to appropriate water for beneficial use. Beneficial uses consist of: (1) domestic, (2) irrigation, (3) municipal and industrial, and (4) mining. This would be the most important restriction on obtaining water for energy development. Water for energy development would come under municipal and industrial use which ranks third in priority.

The sixth question, concerning the priorities for programs and projects for energy development, involves the development of state planning in water resources. The states of the Pacific Northwest are all involved in such planning. In Idaho the planning process is fairly well along, but priorities for water use programs and projects have not been determined.

CONCLUSIONS AND RECOMMENDATIONS

If the Water Resources Council wants to know what the Pacific Northwest states think about supplying water to develop the energy resources in the Intermountain States, they have asked the right set of questions. These six questions involve economic, environmental, legal and political matters which have important consequences, both for the states involved in the development of energy sources, and those involved in supplying water for energy development. The issues raised need to be fully evaluated prior to making any decisions which would have either long-term or irreversible consequences.

A catalog of researchable problems would include the following topics:

(1) Environmental impacts of energy development both in the states which have energy resources and those states which supply water.

(2) Economic impacts and evaluation of the opportunity costs of potential changes in water uses both in the states of water origin and those involved in energy development.

(3) Legal questions which determine who has jurisdictional rights over water, the state or federal government.

(4) Regional research studies on economic, environmental and physical structural impacts and the incentives and subsidies which would be required to change water uses from agriculture to energy development.

(5) The evaluation of externalities related to diversions of the magnitude which would be required.

(6) An assessment of social changes and effects which would result in the areas where streamflows would be depleted and in the areas being supplied with new water.

The above is not meant to be a complete list of researchable topics. It does represent some of the major issues involved in the potential water for energy concept. The nature of these topics also would assume that the concepts of multiple objective planning would be considered in any such massive water scheme that would divert the quantities of water required to fully develop the energy resources of the Intermountain States.

The current world energy situation may require that the U.S. have a stated policy of "energy self sufficiency." However, whether this need exists to the point that regional economies can and should be sacrificed to attain this goal is at this point in time questionable. Many questions need to be answered, much research needs to be done before any diversion plans are drawn up, or any discussion of implementing such diversions considered. The consequences of not considering the environmental and economic impacts of massive energy development would cause large disruptions of the Pacific Northwest economies, environment, and would turn much of the area into a wasteland.

Finally, there are other factors which need careful consideration when the possibility of diverting water from agricultural use to energy is contemplated. The world food supply is currently falling behind world population growth. The need for food, which for the past several years has been growing rapidly, has also been reflected in an increase in the demand for food as reflected by the higher prices farm commodities are bringing in the marketplace. Food now represents an important part of the United States foreign exchange. This foreign exchange may be a more important national need than the need for energy self sufficiency. The point is that before we rush headlong into a massive water diversion program to develop our energy resources in the Intermountain West, we, as a nation and as states, need to consider all the relevant alternatives and their benefits and costs.

INSTITUTION-POLICY REGARDING ENERGY-WATER RELATIONSHIPS IN THE PACIFIC NORTHWEST

by

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There are many aspects of the political-institutional policy areas in the Pacific Northwest which are similar to those of other regions. While acknowledging this is true, I will direct my attention to the Pacific Northwest and will emphasize those aspects and issues which are unique to the Pacific Northwest.

The purposes of my presentation will be to: (1) discuss some general aspects of institution-policy which I feel must be considered; (2) make some observations about institutional policy related to water-energy relationships to which attention should be drawn; and (3) provide a general context for discussion by this group. I will bring some issues to the floor from my own perspective and experience and allow these to serve as the basis for discussion and elaboration.

At the outset, two things must be emphasized, both because they are pervasive and because they often are ignored. First, a large number of water-related decisions are made on the basis of political, rather than technical, legal or administrative bases. Much of our orientation has been from the standpoint of technical and economic orientations. It is not uncommon to hear pleas for more "rational" or "efficient" decisions based upon adequate technical or economic data. I have no argument with this approach in principal except that it often ignores the deep realities of water-related decision making. Water is a scarce commodity. It is the object of substantial demands by numerous economic and non-economic interests. Decisions must be made to accommodate these demands. Technical data can be an extremely important input into the decision-making process. Nevertheless, the decision in the final analysis is often based upon political considerations which take place in the relative absence of technical data, or which overlook data for reasons of political expediency.

Contrary to what administrative scientists have believed in the past, political decision making is not limited to elected office holders. Administrative agencies do make political choices, exercise options and establish priorities--in short, they make decisions which determine who benefits from water allocation decisions. In fact, some observers suggest that we have paid too much attention to elected officials, high-ranking agency executives and legislatures in evaluating the impact of political decisions. Indeed, there is strong evidence to suggest that the multitude of political decisions are made by lower-level and middle-level bureaucrats.

The second important point that I wish to emphasize is this: Change in the governmental areas is not policy neutral. Every change in administrative organization has a differential impact in that it benefits some groups or individuals more than others, and typically is detrimental to certain individuals or groups. For example, some observers have argued that the multitude of irrigation districts constitute an unnecessary proliferation of governmental entities. They may argue for a coordinative mechanism by which the activities of the irrigation districts may become standardized and their activities controlled. Such a change would not be well received by the powers-that-be in the local irrigation districts. Rather, one might expect a very intensive campaign by those persons in the local districts whose prerogatives would be threatened. Indeed, such organizational change would shift the balance of power from local communities to a more central authority and may for a period of years result in less efficiency rather than more because of local resistance.

To the extent that energy production becomes a major national objective, we can anticipate some strong reactions. The existing balance between agencies and groups will be altered. Some will perceive a benefit to themselves and others will perceive a detrimental outcome.

Before I am accused of being a typical ultra-conservative political scientist, guardian of the status quo and frightened of all organizational change which modifies the "American System," let me elaborate just a bit further. I did say that organizational change does hurt some and help some. Various changes will differentially impact the benefited and the harmed. It is important not to reject all change as bad, but rather to evaluate organizational change in light of who is benefited and who is not--in terms of a net benefit-cost ratio, if you will. Change will thus be evaluated as "good" or "bad," not in terms of some ultimate "one best way," but in terms of the outcomes that each observer prefers.

Now with that rather lengthy statement of context, let me turn to some more specific institution-policy issues in the Pacific Northwest. First, let us consider the broad heading of "federal development slowdown." In the recent past, the major development agencies, namely the Corps of Engineers and the Bureau of Reclamation, have enjoyed neither the public favor nor the massive construction budgets of only a few years back. In part, this relates to the "pro-private development" mood of the present administration. The National Water Commission Report also has not been universally accepted, particularly by such powerful groups as the State Reclamation Associations and the Pacific Northwest Waterways Association, both of which represent groups which have enjoyed the benefits from federal development at subsidy prices.

I think the slowdown also reflects some other political-institutional changes in the Pacific Northwest. One of these relates to what Helen Ingram calls the "changing decision rules" in water resources development. The preferential access to the decision-making arena which certain groups have enjoyed is being eroded and contested.

Ingram cites as typical dominant groups the local chamber of commerce types with a highly localized view of water resources development. This has also been true of the Pacific Northwest. The regional variations in this region have related primarily to energy development. The relative unanimity of purpose displayed by the chamber of commerce types which favored the private power preference policies of the Corps and the Bureau has, for more than half a century, been matched by equal unanimity by groups favoring public power in the form of PUD's and BPA. The controversy has centered in Oregon and Washington and has been most intense in Washington.

On the one hand, the controversy is nearly over, although both sides still are a bit guarded in their approach to the other. On the other hand, both private power and public power advocates are facing stronger opposition than before from non-economic interest groups which have an anti-development bias. Both of these changes result in a development slowdown. The former merely enables the federal slowdown, the latter encourages a total slowdown. In the context of the situation in which development agencies have had to severely curtail their development programs, these agencies are prepared to grasp at any opportunity to expand their operations once again. The Corps of Engineers and the Bureau of Reclamation have maintained some co-operative arrangements relative to energy production in which they divided the west between them, so to speak. It was through mutual arrangement, for example, that the Corps constructed Bonneville Dam and the Bureau constructed Grand Coulee Dam. If the responsibility for energy development continues to fall upon these agencies, mutual accommodation may continue.

However, a change in federal policy could materially affect the way in which these agencies deal with each other. Several alternatives exist. It may become national policy to strengthen energy development and continue to play down irrigation development. It may become national policy to emphasize a duality between irrigation and energy, as in the use for irrigation of warm water from reactor cooling. It may become national policy to place all energy development in a single agency--neither the Corps nor the Bureau. It may become national policy--as often happens-- to "wait and see." The latter could leave both agencies groping for a piece of the action in the energy field.

To the extent that the overall program of either agency is served by a given policy, that agency will support the policy. To the extent that both agencies will benefit from mutual accommodation, the two will cooperate. To the extent that there is uncertainty, both agencies will attempt, to the point of conflict, to insure that they have a piece of the action.

I believe that this rather limited discussion applies equally to other agencies who have a stake in the energy field and to pressure groups that may benefit from energy development. I would certainly apply this kind of thinking to the public power-private power arena. The two forces are not yet so cooperative that a public policy favoring one to the substantial exclusion of the other would not result in considerable conflict. I think we are in a period of uncertainty in this regard, and the future should be interesting.

There is another force which currently is intruding into the decision arena, namely the appeal for greatly increased levels of public participation.

Many agencies are attempting to encourage more public involvement with several methods, none of which have been effectively evaluated. Public participation has been touted as a kind of gospel, a return to democracy, if you will. There are several aspects of this subject which we might deal with in the discussion period. For now, let me say that it is doubtful that any of the public involvement programs have directly and materially influenced public policy. It is, however, very likely that most agencies are much more cautious in their program planning efforts and are at least well aware of the existence of a potential force in public opinion. Thus, public involvement could be a deterent upon an active program of energy development. This deterent will be softened to the extent that the public can be made to perceive an energy crisis.

Let me state one last institutional-policy issue. No matter what form of energy development we embark upon, the demands upon water supply will increase, in my opinion. The effect of this will be to intensify the water allocation problem. In the Pacific Northwest, there is currently no negotiated division of water as between states. There was one such attempt during the 1950's and 1960's in the proposed Columbia Interstate Compact.

Since then, demands upon water have increased tremendously. The impact of the situation will be to make interstate negotiation much more difficult than was the case when Columbia River waters appeared almost limitless, except when California wanted some.

We should not forget the pressures placed upon state water allocation agencies, even if they knew how much water there is available for appropriation. The energy question places one additional uncertainty into the picture.

I have identified but a few of the institutional-policy questions which are related to energy-water relationships. There are many more, and I hope we can deal with some of them during the discussion period.

SUMMARY

(1) Many decisions are political.

(2) Changes are not politically neutral.

(3) Issues:

(a) Erosion of power of the traditional interest groups by environmental groups.

(b) Less severe public-private power controversy.

(c) Need for construction agencies to group for new programs.

(d) Public opinion as a force to be reckoned with.

(e) Intensify the water allocation problem with interstate implications as well as intrastate difficulties for water allocation agencies.

DISCUSSION REPORT

John S. Gladwell
Chairman and Reporter
University of Idaho

Three speakers presented papers at this session: Dr. E.L. Michalson, University of Idaho; Dr. H. Doerksen, Washington State University; and Professor C. C. Warnick, University of Idaho.

Dr. Michalson's paper was entitled, "Energy, Environment and Pollution in the Pacific Northwest." Among the many points raised was one dealing with research needs. As he pointed out:

> "One obvious research need which emerges from this narrative is that for developing evaluation processes which identify, determine weighting processes, and estimate the tradeoffs among the several developmental and environmental effects involved. The gains in kilowatts must be balanced against losses in fish, wild and scenic rivers, and other resources which exist in nature. These kinds of questions raise the fundamental conflict which seems to exist between standard of living and quality of life."

A number of possible impacts of potential diversion of water for energy development were pointed out: (1) under some "plans" there would be a loss of many miles of free-flowing water, affecting fisheries resources, river recreation, hunting, aesthetic resources, archeology, and other irreplaceable resources; (2) the loss of energy because of the vast amounts required to pump the water to be diverted; (3) the loss of future irrigable lands because of the reduced supply available; and (4) the impossible situation which would develop if water depletion were effectively to displace any existing irrigation.

One major question raised was: "Who really owns the water in Idaho?" Although no answer was provided, the specter of consequences should control be taken from the state was ominous.

Dr. Doerksen's paper dealt with institutional aspects:

> Two generalizations should be recognized in dealing with energy-water relationships. First, many decisions are based upon political, rather than technical, legal or administrative bases. This is true, not only at the level of elective officials, but also at the level of lower-level "bureaucrats." Second, changes in the governmental arena are not policy neutral. Almost any change has a differential impact upon various groups, benefiting some more than others. Therefore, it is important to evaluate institution-policy in terms of who is benefited and who is not.

In the Pacific Northwest, there are several current situations which will affect how institutions respond to energy development requirements. First, there has been an erosion of the political power which has been enjoyed by the previously dominant water development construction agencies and their traditional support groups. Some of this erosion relates to the growing ability of non-economic groups to influence policy. Second the traditional intensive conflict between public and private power advocates is now lukewarm. Third, the national administration is relatively unsupportive of water development by federal agencies in preference to private development. In this climate of uncertainty, agencies can be expected to grope for new responsibilities under the politically popular energy function. Depending upon how things go, we can expect either conflict or cooperation between agencies and their allied groups.

We can also anticipate that agencies will pay attention to the potential deterrent of public opinion, because public involvement has been touted as a goal of "motherhood" magnitude. In the recent past, public involvement has been attempted by agencies in various forms. We can expect that public opinion will become more supportive of energy development to the extent that energy is perceived to be a crisis.

Finally, energy will require substantial amounts of water. This will intensify water allocation problems of our intrastate and interstate nature. We can expect both forms of allocation to be particularly conflict producing.

Professor Warnick presented a paper entitled "Critical Energy-Water Issues Relative to Management and Conservation of Water Resources." In the delivery of this paper he discussed: (1) domestic use; (2) waste disposal; (3) industrial use; (4) energy production; (5) agricultural use; (6) transportation use; and (7) recreational use. He noted that pricing could be used as an incentive for water conservation. He also proposed the idea that using less energy per capita, or at least stabilizing the tendency for increase, is a management and policy alternative that faces a society that is reluctant to give up a growth ethic as a sign of progress.

In conclusion, Professor Warnick pointed to at least five needs:

(1) Educational programs to show how water and energy can be conserved;

(2) Overhauling the pricing structure to encourage efficiency;

(3) More concentrated study of economic factors in a real-world context to see what the value of conservation actions really are;

(4) A critical study of institutions and customs that seem to control actions; and

(5) Search for better methods of physically controlling water.

REGIONAL WORKSHOP

VII - CALIFORNIA, GREAT BASIN, UPPER COLORADO, LOWER COLORADO

ENERGY PRODUCTION AND WATER SUPPLY

by

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BACKGROUND INFORMATION

The area of concern for this workshop group is shown in Figure 1 and includes the Colorado River Basin, the Great Basin and California. The area is one of extreme contrasts -- in climate, in elevation, in topography, in vegetation, in resources, in population and in scenic attractions. For a workshop in "Energy-Water Relationships" it offers, perhaps, more of a challenge than other regions of the U.S. While it includes the most arid regions of the country, it also contains some of the largest energy reserves. Although the energy is here to be developed, the required water is in short supply.

Water Resources

The surface water runoff from the area is given in Figure 2 as contours of average annual inches of runoff. Vast portions of the area are seen to yield less than an inch of runoff each year. The principal rivers and drainage basins are shown in Figure 3 and the runoff is summarized in Table 1.

From the supply of water must be deducted the current withdrawals for irrigation, public water supplies, industrial and other uses. With the water resources already overcommitted in much of the area, little will be available for future additional uses such as energy developments.

Energy Resources

The principal coal deposits are shown in Figure 4, oil-shale deposits in Figure 5, petroleum fields in Figure 6, and gas fields in Figure 7.

Examination of the maps quickly shows that many of the resources occur in the same areas and that these rich hydrocarbon reserves are also located in some of the most arid lands of the region.

Hydoelectric power production and potential are shown in a different way on Figure 8.

Figure 9 shows the total energy flow pattern in the United States in 1970 (Joint Committee on Atomic Energy, 1973). This compact way of showing much important energy data along with Table 2, "Fuel Reserves of the United States" (Cheney, 1974), helps one grasp the magnitude of the energy crisis.

From Figure 9 it can be seen that natural gas and petroleum now supply about three-fourths of our energy, coal about a fifth, hydropower 4 percent

(Source: U.S. Water Resources Council, 1968)

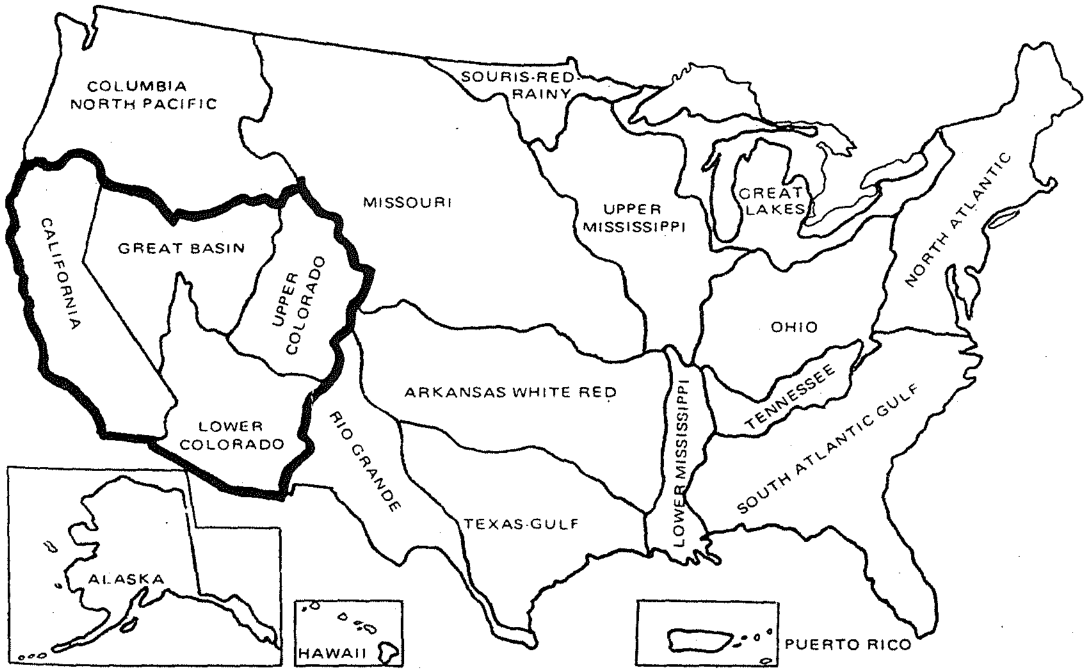

Fig. 1. Water Resource Regions of the United States (From Water Encyclopedia, 1970)

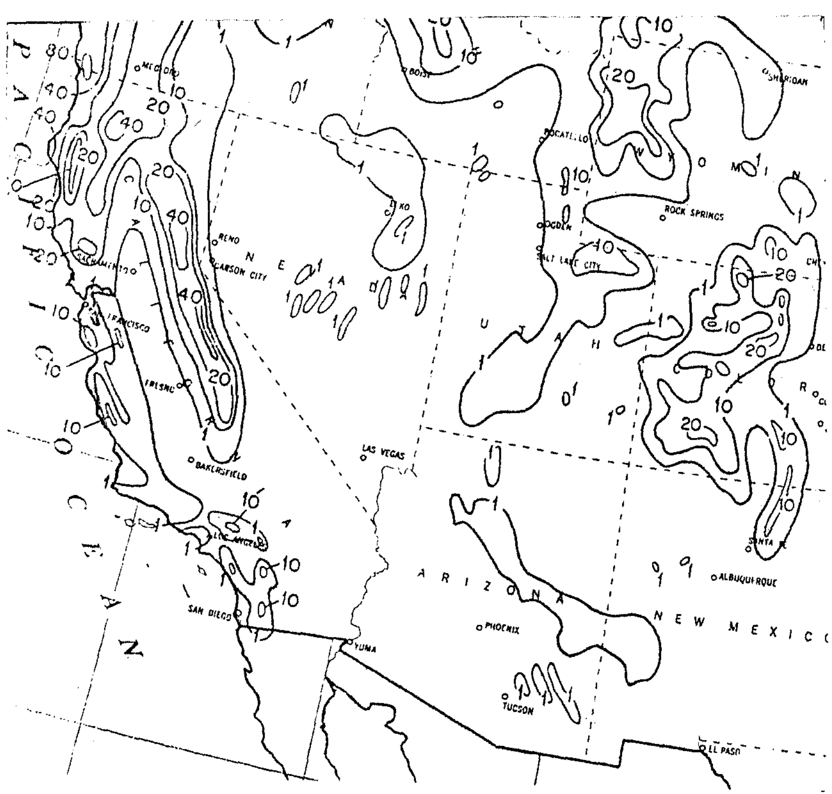

Fig. 2. Average Annual Surface Water Runoff (From Water Atlas, 1973)

TABLE 1*

AVERAGE RUNOFF

Region	Area (thousands of square miles)	Average runoff	
		Inches per year	Billions of gallons daily
Colorado River	258	1.1	13
Great Basin	200	1.1	10
California	112	12.0	64

*Water Atlas (1973)

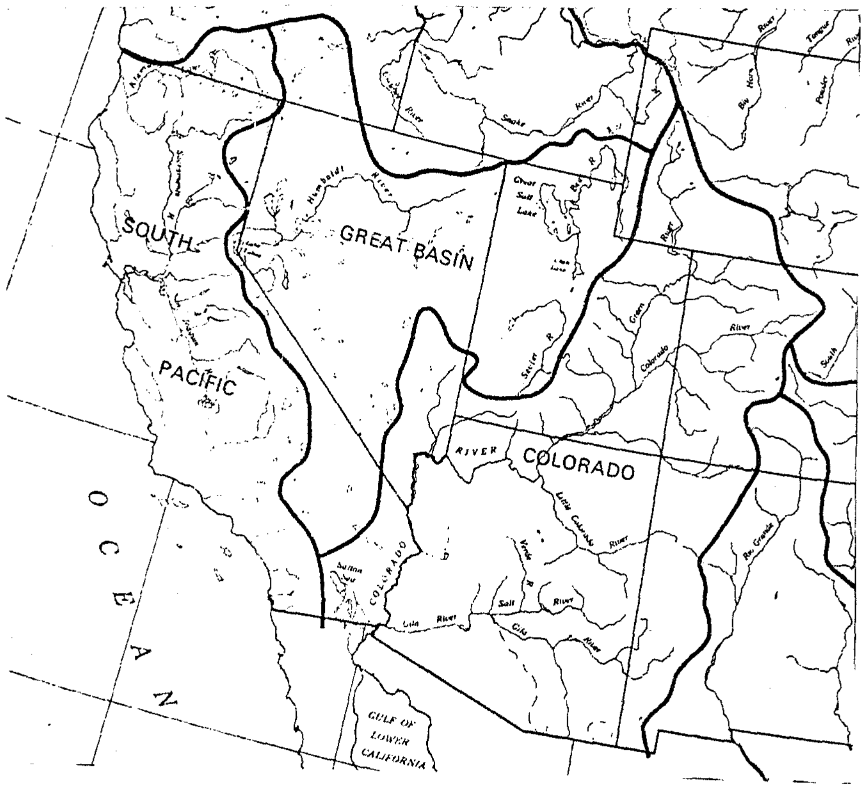

Fig. 3. Principal Rivers and Drainage Basins
(From Water Atlas, 1973)

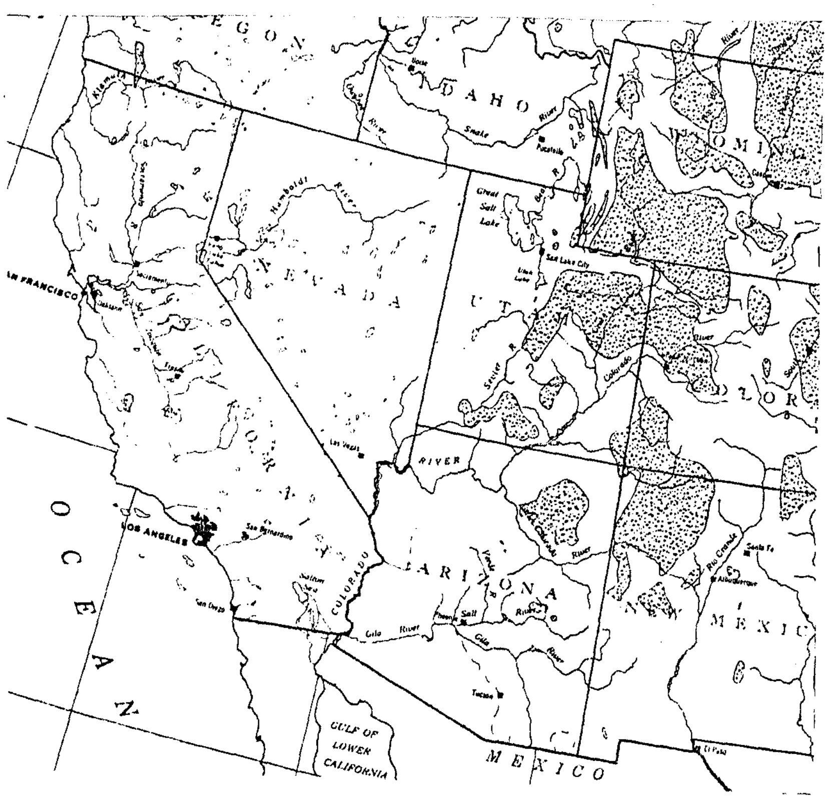

Fig. 4. Principal Coal Deposits
(From Water Atlas, 1973)

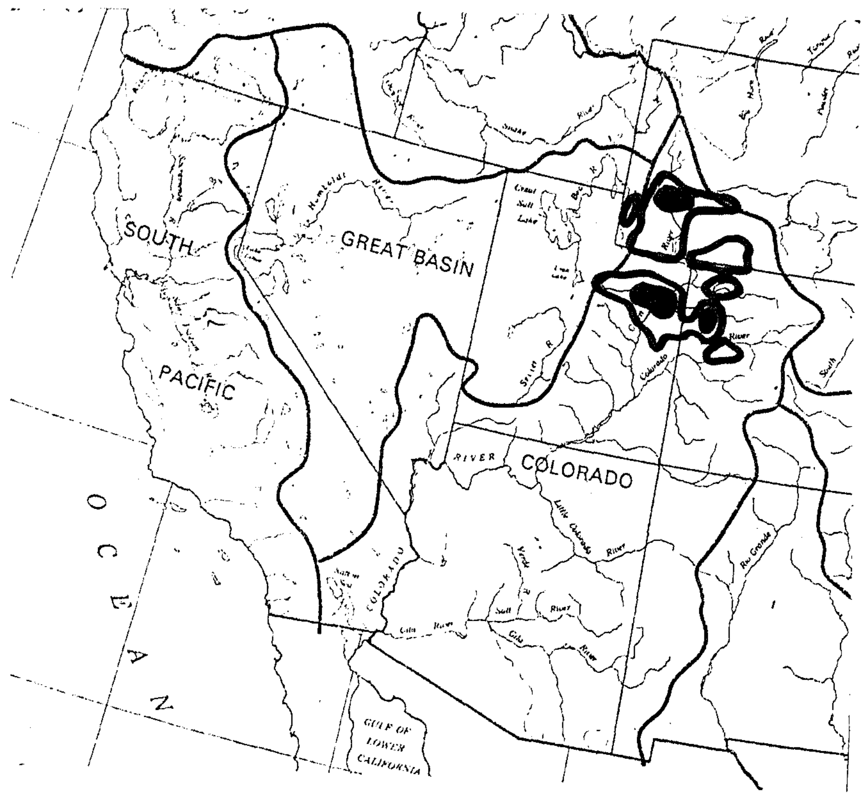

Fig. 5. Oil Shale Deposits
(Source: National Atlas, 1970)

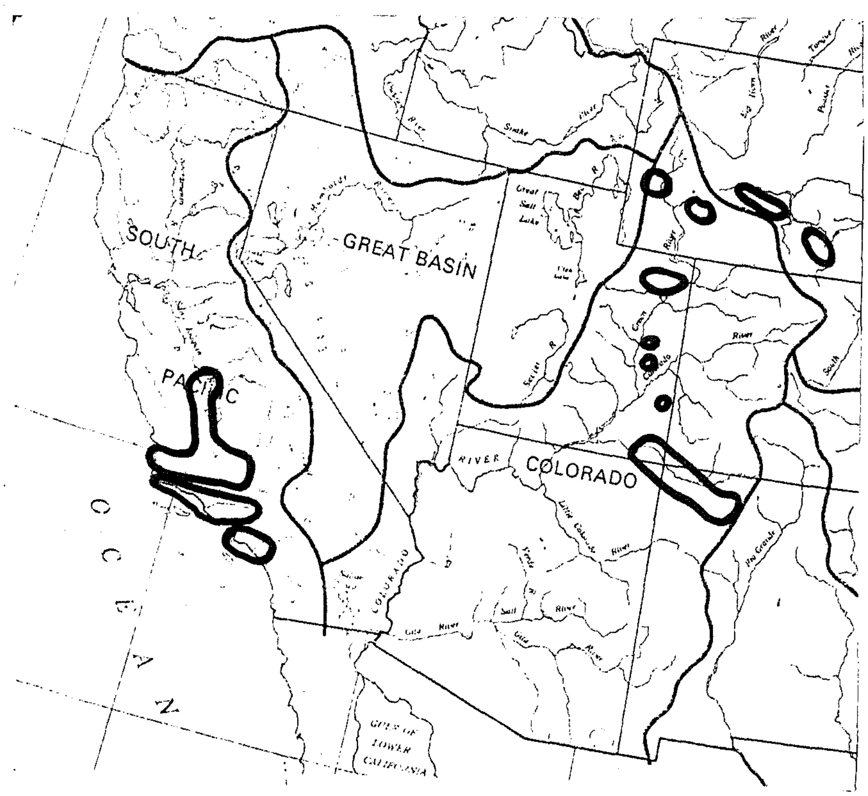

Fig. 6. Oil Fields
(Source: National Atlas, 1970)

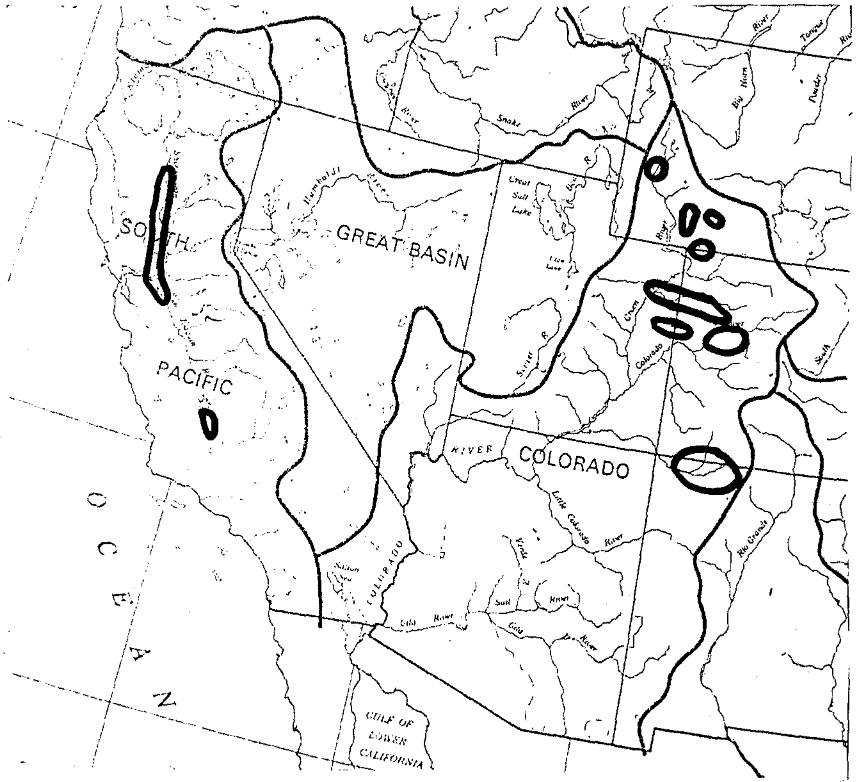

Fig. 7. Gas Fields
(Source: National Atlas, 1970)

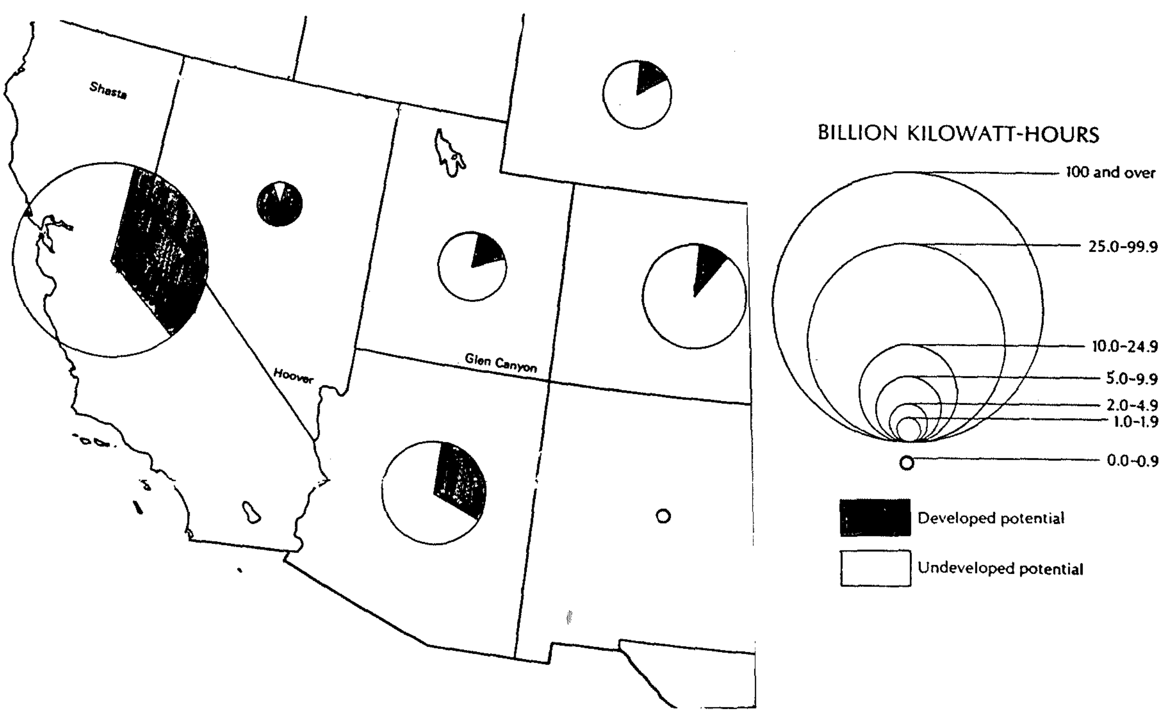

Fig. 8. Hydroelectric Potential: 1966
(From National Atlas, 1970)

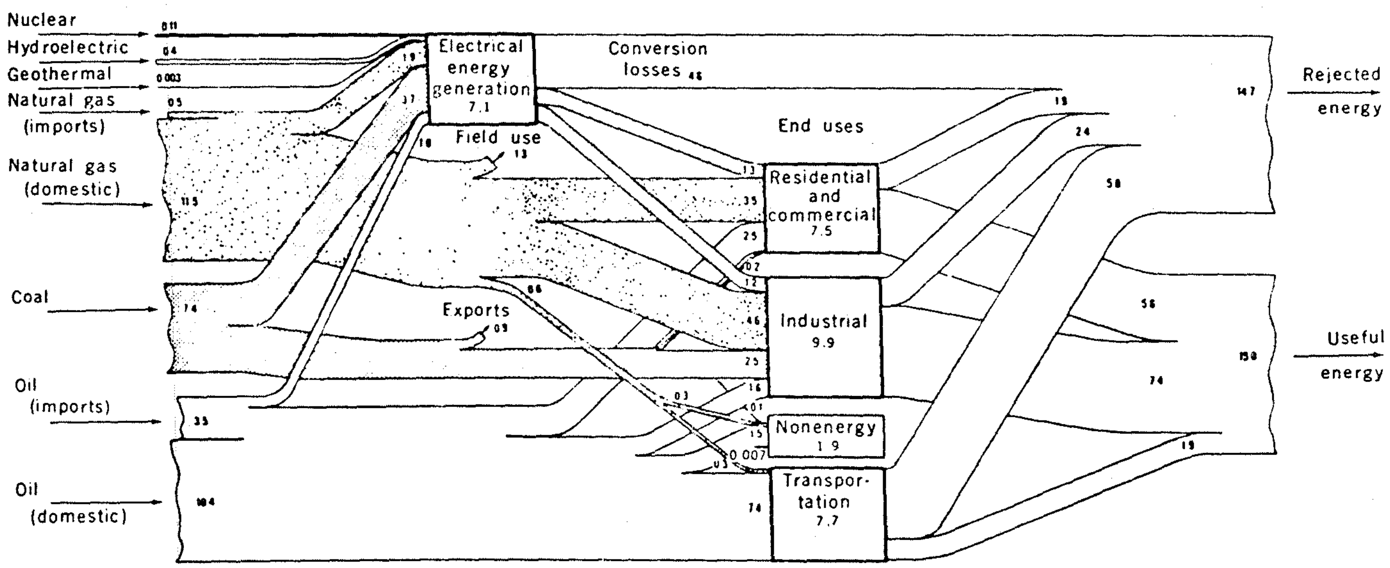

Fig. 9. Total energy flow pattern in the United States 1970. Units are in millions of barrels of oil equivalent per day. (1 ton coal equivalent per year = 0.01312 barrels of oil equivalent per day). [Source: Joint Committee on Atomic Energy, Certain Background Information for Consideration When Evaluating the "National Energy Dilemma," U.S. Government Printing Office, Washington, D.C. (1973)] (From Science, 19 April 1974)

TABLE 2

FUEL RESERVES OF THE UNITED STATES

	Percent of total energy[1]		Years: reserves/production	
	Present technology and reserves	Ultimate recovery	Present technology and reserves	Maximum ultimate recovery[2]
Coal	88	74	700[3]	6,000
Petroleum	2	5	11[4]	130
Natural gas	3	5	11[5]	340
Natural gas liquids	—	1	—	—
Oil shale	5	13	0	1,500
Uranium	2	2	20[6]	670

[1]National Coal Association 1972.

[2]Total recoverable, paramarginal, and submarginal discovered and undiscovered resources calculated by Theobald et al., 1972, divided by present production.

[3]Total recoverable production from Theobald et al., 1972.

[4]<u>World Oil</u>, August 15, 1972.

[5]Bureau of Natural Gas, 1972.

[6]Mining Engineering, May, 1973.

and all other sources including atomic energy about 1 percent. Half the energy is discarded as waste heat. When one notes in Table 2 that with present technology and recovery of known reserves, the petroleum and gas will only last 11 years, it is easy to see that some changes must soon be made in our energy flow pattern. Apparently coal, oil shale and nuclear energy must soon supply much larger portions of our energy needs, and improvements must be made rapidly in the efficiency of use.

Water Requirements in Energy Production and Conversion

Energy customers usually demand their energy in the most convenient form. Thus the residential customers, for convenience and cleanliness, want their heating energy in the form of gas or electricity rather than coal or oil. Return to steam locomotives would be inconvenient, costly and environmentally unacceptable with present technology compared to the present diesel burning locomotives. Thus, the demand is not just for energy, but for energy in preferred forms, and the energy demand will require both energy production facilities and energy conversion facilities in ever-increasing numbers. Unfortunately, the nuclear electric power plants, conventional coal fired thermal plants, coal gasification plants, coal liquefaction (hydrogenation) plants and oil shale recovery facilities are all costly both in dollars and in water.

Fairchild (1973) has summarized some consumptive water requirements as is shown in Table 3.

To appreciate the size of plants some comparisons will be helpful. The total capacity of Utah Power and Light Company (which serves most of Utah) is just under 1,400 MW. A quarter of a million cubic feet of gas per day would meet about half of the heating and air-conditioning requirements of the state of Nebraska. With the U.S. now using about 18 million barrels of oil a day, the 100,000 barrels per day may appear small, but it is a significant amount and would meet all the needs (in crude oil equivalent) of Utah for coal, oil and natural gas.

The actual production of energy is not the only water-using activity causing concern. Water will be needed to restore strip-mined lands and to rehabilitate spent oil shale. Water will be needed to supply the new towns near the coal and shale lands. Water is needed for some kinds of energy tranport (example: pumping of coal slurries). Water is needed for energy storage (examples: pump storage facilities or the electrolysis of water to produce hydrogen fuel). Other examples of peripheral water uses associated with energy production and conversion could be given.

WATER-ENERGY ISSUES AND PROBLEMS

Some of the water-energy issues and problems which the workshop should discuss are as follows:

(1) What are the energy resources of the area (coal, oil, gas, oil shale, hydroelectric power, nuclear materials and solar energy)?

TABLE 3*

CONSUMPTIVE WATER REQUIREMENTS

Energy	Coal Required (Tons Per Year)	Water Consumed (Acre-Feet Per Year)
1,000 MW Thermal Plant	5,000,000	9,500-17,000
Coal Gasification - 250,000,000 Cubic Feet Per Day	6,500,000	20,000-30,000
Coal Hydrogenation - 100,000 Barrels Per Day	15,000,000	20,000-30,000
Oil Shale - 100,000 Barrels Per Day		12,000-20,000

*Bureau of Reclamation information.

(2) What are the present and future energy needs of the area? Of the U.S.?

(3) What energy resources are available for export to other parts of the U.S.?

(4) What are the water resources of the area?

(5) What are the present and future water requirements of the area for all purposes except those related to energy?

(6) What water resources are available for use in energy production and conversion?

(7) Will these water resources be sufficient for energy production as well as for new towns and cities and for restoration of the mining sites to an acceptable state?

Because of the variability of the water conditions in the area, these questions must be answered for each subarea. While some areas may have water surpluses, other areas may require imports.

A special panel of the National Academy of Sciences (NAS) has concluded that, unless the American public is willing to pay for massive new diversions into some areas, water supplies will not be sufficient both to restore strip-mined lands and to support large-scale gasification of coal.

(8) What will be the effects of energy production on water quality?

According to Metz (1974), spent shale must be watered heavily to remove salts before most grasses will grow. Oil shale production of a million barrels a day would deplete the Colorado River flows enough to increase the salinity of Lake Mead by 1.5 percent, and leaching the spent shales might have an even greater effect on the salinity of the river. Retention al all salts at the site might be necessary to avoid considerable expenditures downstream for desalinization.

(9) Must water be dedicated in perpetuity to energy production? Or could temporary water rights be granted?

In the initial years of a thermal plant development, evaporative cooling might be used with the requirement that air cooling be developed in later years when the water will be needed more urgently for other purposes. An oil shale development using mining and surface processing might be replaced with in situ conversion of the oil when the technology is sufficiently developed. This would save much of the water required for site restoration and rehabilitation.

(10) What should be the form of energy export from the area?

If water is not available to gasify or liquefy the coal to generate electricity at the mine mouth, the export may have to be limited to raw coal. The coal could be transported to areas of water surplus for further processing.

(11) What reduction in water requirements for energy production are likely through new technology?

(12) What alternative energy sources might be used (atomic, geothermal, solar wind, tides)? Would these alternatives conserve water?

(13) What are the thermal water pollution problems of the energy industry? Should certain kinds of power plants be limited to seacoast sites where seawater could be used for cooling?

(14) What are the prospects for energy storage and how are these related to water?

Solar energy production must be tied into energy storage facilities or other supplemental sources. Pumped storage of water for hydroelectric power is one proposed method of energy storage. Another way of storing solar energy would be the production of hydrogen by electrolysis of water. This scheme would store the energy in a form adaptable to private transportation.

(15) What are the prospects of energy conservation as a means of meeting some of our needs?

At present, half our energy is wasted through inefficiency of the production and use processes. Improvements of just a few percentage points would save vast quantities of energy and substantial amounts of water.

The above questions suggest some of the energy-water issues in the Colorado River Great Basin - California region. Through thoughtful discussion the workshop can surely suggest other issues and some answers to the energy-water problems.

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ENERGY-WATER RELATIONSHIPS: MANAGEMENT AND CONSERVATION IN THE CALIFORNIA-COLORADO RIVER-GREAT BASIN REGIONS

by

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INTRODUCTION

The area addressed in this paper is composed of the California, Great Basin, Upper Colorado and Lower Colorado Basins. I will restrict my comments to the seven Colorado River Basin States which encompass almost the entirety of these basins. This area may well be one of the most critical in the nation in our goal of energy independence. For it is within these seven states that a substantial portion of the nation's coal reserves, oil shale and uranium exist, together with significant amounts of hydropower and potential geothermal energy resources. However, not all the energy resources in these states lie within these drainage basins. Not only do these basins contain major energy resources, but they also produce a significant portion of the nation's food and fibre. Further, the area is characterized by its aridity, chronic problems of water shortage and international water commitments. These factors when brought together form the basis for this discussion, namely management and conservation. In regard to this topic, I do not intend to address the impact of major interbasin water transfers or portential weather modification sucesses in the energy water relationships but will deal principally with the existing water resource systems.

WATER-ENERGY RELATIONSHIPS

In order to rationally discuss the topic of mangement and conservation in energy-water relationships, we must first define what we mean by these terms and at what level we will treat pertinent issues of which there are many. In ruminating over these two words and their meaning in this relationsip, I had the nagging feeling that there was something missing from the conference program and from the outline I had developed for this talk. To begin with, the word "management" in this context is defined as "act or manner of managing; handling, direction or control" while the most appropriate definition of "manage" would be "to succeed in accomplishing a task, purpose, etc." Conservation is the act of conserving. Conserve is defined as "to keep in a safe or sound state; preseve from loss, decay, waste, or injury; keep unimpaired."[1] The missing element in this conference comes out

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[1] The American College Dictionary, Random House, New York, 1960.

in the second definition above, namely what is our "task" or "purpose" for managing? Mangement occurs to fulfill the objectives of a plan and then only in accord with established policies.

We have a national goal to achieve energy self-sufficiency by 1980 or 1985 for which a plan is now being developed. We have a national commitment to deliver to Mexico water of a guaranteed quality from the Colorado River. And at the same time, we have a semblance of a plan for water resource use and development in the Colorado River Basin stemming basically from the Reclamation Act of 1904 and the then national commitment to reclaim the West. This water resource plan might be said to have been preeminently successful as one views the extent of irrigated agriculture and hydropower development that has resulted. Further, there are state water resource plans which are in various stages of development and implementation.

In a recent talk before the Economic Club of Chicago, EPA Administrator Russel Train told members, "We are starting to see that our energy and environmental ills stem essentially from the same source: from patterns of growth and development that waste our energy resources just as liberally as they lay waste our environment." Train went on to say, "I am...much encouraged by the emphasis that John Sawhill, the new administrator of the Federal Energy Office, has thus far given to the need to conserve energy... I would hope that this commitment to conservation will lead to early adoption of an explicit national strategy that spells out specific goals, time table and measures that will enable us to achieve sustainable levels by the mid-80's."

Recognition that water will play a vital role in energy development prompted the FEO to ask the Water Resources Council how much water was available for energy resource development. The WRC responded with the question of how much energy did FEO want to develop. As a result of this exchange and an Interior meeting in Denver of June 3, a Water Resources Council Report is due out in September on the potential water resources for energy. Similarly, the FEO's national plan for energy independence is scheduled for completion some time in November.

Colorado River Basin

The Colorado River, under the existing "plan" of development, is a bankrupt stream in terms of both its quality and the commitments for use of water. In "Project Independence" our energy planners have totaled up our nation's coal, oil shale, uranium and other energy resources and concluded that they may be sufficient to make us independent. Until very recently, as noted, there has been little apparent consideration of the large volumes of water necessary to carry out development of these energy resources.

It has been variously estimated that between 76,000 and 295,000 acre-feet of water per year (AFY) will be consumed for a one-million-barrel-per day shale-oil production capacity and that the most likely range will be between 121,000 and 189,000 AFY.[2] It has again been estimated (assumed?)

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[2]Davis, G. H. and L. A. Wood, "Water Demands for Expanding Energy Development," U.S. Geological Survey Circular 703, U.S. Department of Interior, Washington D.C., 1974.

that upwards of 340,000 AFY could be made available to shale-oil industry from the three Upper Basin States' 5,750,000 AFY allocated share of the Colorado River flow. If, inded, the average flow of the river were 15,000,000 AFY, then presumably about two million barrels per day of shale-oil could be produced. This use of water alone would consume the divertable portion of the "decreed" average annual flow and thus would leave no room for other energy resource developments which might be contempleted in this region such as coal gasification (10,000 - 45,000 AFY/250 million standard cubic feet per day), coal liquefaction (200,000 AFY/million barrel per day) and coal slurry transportation (20,000 AFY/25 million tons coal). Considering that there might be upwards of four 250 million scf coal gasification plants and 100 million tons of coal slurry transport per year in the basin, this would represent an additional 120,000-260,000 AFY water demand. With a two-million-barrel-per-day shale-oil capacity, the range in water requirements from the Colorado system for energy resource development alone would be 270,000-850,000 AFY. This would be a water demand that does not now exist.

This demand, however, does not include that for projected increases in electrical energy generation in the seven basin states. The seven states currently have planned for completion by 1982, about 14,000 MW of coal fired capacity and about 8,000 MW of coal and 2,000 MW of nuclear capacity are scheduled for the Colorado River Basin . Assuming that either pond or evaporative cooling will be utilized for these plants, the water demands from the Colorado system will range between about 150,000 and 300,000 AFY. New demands on Colorado River Basin water could thus total somewhere between 420,000 and 1,150,000 AFY. Since the average flow of the Colorado has recently been only about 13,000,000 AFY and the flow is fully committed or planned for up to the "decreed" average flow of 15,000,000 AFY, there could conceivably be a deficit of nearly 3,000,000 AFY if existing and contemplated water development plans are followed. It does not seem likely that traditional methods of management and conservation will be able to save enough water to satisfy all the demands which we wish to place on the Colorado River system.

Another aspect of the energy-water relationship that has not received sufficient attention is the energy demand that will be created by meeting our national commitment to Mexico and the 1983 water quality standards. Congress just recently approved a Colorado River Salinity Control Program which, if the President signs it into law, will pump some $280 million into the system for this purpose. Of this total, about $155 million is scheduled for desalinization of waters flowing into Mexico with the balance to be spent on Upper Basin salinity control efforts. The power requirements for this desalinization may run as high as 10 MW per 100,000 AFY processed. This, in turn, creates an additional water demand. An additional power demand will be that necessary for advanced waste treatment of municipal and industrial and possibly agricultural return flows to meet the 1983 water quality goals. These cumulative energy demands will be significant.

What is needed in this circumstance is an integrated energy production/energy resource water development plan which takes cognizance of the capabilities of this region and the national and regional needs for energy, agricultural products, minerals and manufactured goods. A systems approach is imperative. Diversion of water from existing agricultural uses within the basin to energy and mineral ptroduction will necessitate an increase in agricultural productivity in some other region and likewise for other products.

A systematic analysis of this problem is necessary to develop a plan for this region. The river basin states cannot simply turn their water resources to energy production without first analyzing the impact of this reallocation of water on other regional, national and international commitments.

The Great Basin

Energy-water relationships in this region are less complicated than are those in the Colorado Basin. The area is characterized by its closed drainage basins, few rivers and lack of significant coal, oil, or oil shale resources. And, unlike the Colorado where all water is committed but not necessarily yet fully appropriated, the surface runoff in the Great Basin is both committed and appropriated and in many instances, due to reuse, the total stream appropriations and diversions exceed the natural runoff. Groundwater, both in storage and perennial yield, is significant in this region. The mineable component, however, far exceeds the perennial yield. Most of the groundwater basins have experienced some degree of development and a few are overcommitted in terms of perennial yield representing at some future date the need to find supplemental water supplies for existing uses. Groundwater from storage in the lightly developed or undeveloped valleys could, with appropriate changes in water law, be developed for power generation purposes. However, since this water is a depletable resource, there is a finite life to such capability and there could be serious associated problems of land subsidence and water quality deterioration.

The greatest potential energy resources in the region are geothermal, solar and wind. Development of geothermal energy will place little demand on the water resources and may, in fact, somewhat augment the existing supplies. Since the area has less agriculture (and some of that supported by water transfers from the Colorado), displacement of that industry by power generation for energy needs within the region will have limited impact outside the region but possibly significant local impacts. However, if the region, because of its sparse population and widely spaced metropolitan areas, is viewed as desirable for siting major muclear or coal-fired generating stations to satisfy extra-regional energy needs, then the problems of displacement of existing water uses could be more severe and extend outside the region. Again, water-energy planning is necessary but much less critical than in the Colorado River Basin.

Of greatest concern within this region will be satisfaction of growing internal power demands and the maintenance of acceptable water quality in both surface waters and groundwater reservoirs.

California

Water-energy relationships in that portion of California not in either the Great Basin or Colorado River Basin are at once more simple yet more complex than in either of the other two regions. More simple because the waters involved are under a single state's jurisdiction and more complex because the state represents by far the greatest energy load center and biggest water user of the western states. Like the Great Basin, California has essentially none of the energy resources that will create water problems in the Colorado Basin, but does have geothermal energy resources. Possibly one of the critical problems in this region is the apparent inability to site nuclear power plants on the coast. These plants, because of concern for coastal seismic activity and ocean pollution will have to be sited inland and depend upon fresh water for cooling. To help satisfy this state's insatiable demand for electrical energy, the California utilities are planning for an additional nuclear generating capacity of approximately 5,400 MW by 1982. Of this capacity, approximately 3,000 MW will presumably be inland and required between 33,000 and 66,000 AFY for cooling. If energy resource development in the Colorado displaces agriculture based on Colorado River water and new generating capacity in California is forced to depend on surface or groundwater, will there be sufficient water to sustain California agriculture or expand that industry to offset possible losses in the Colorado? As with the other two regions, California must also face the problems of water quality maintenance and the concomitant expanding energy demands to meet 1983 standards.

MANAGEMENT AND CONSERVATION

Where then, as multi-disciplined practitioners in the field of water resources, does this situation lead us in the area of management and conservation in energy-water relationships? To begin with, there is going to have to be a definition of our regional and national management objectives. We have a national goal of becoming independent of foreign energy resources, but does that mean self-sufficient under our existing energy use practices or under some less energy-intesive life style? Is a two-million-barrel-per-day shale-oil industry necessary, or could we obtain the same degree of independence through similar investment in new mass transit systems or a shift in modern housing and city planning concepts? The auto industry and the public have already responded to increased petroleum prices and shortages by manufacture and use of smaller and more efficient cars. Are four 250 million scf per day coal gasification plants for space heating necessary or could some degree of self-sufficiency be achieved through more stringent building codes, investment in better insulation and individual solar heating desgn? Are massive investment and energy consumption for advanced wastewater treatment to meet 1983 standards necessary or could the same objectives be met, in part, through significantly reduced domestic water use and individual domestic chemical waste treatment units? Could energy demands necessary for water supply be significantly reduced through a similar reduction in domestic water use, a major portion of which is used to maintain lawns and other greenery in the arid regions? In short, there are some basic questions that need to be addressed in regard to the energy and water necessary to maintain the standard of living and life style that we are now accustomed to. We need to explore those areas of our utilization which might be altered and yet allow us to maintain an acceptable standard and style of living. From what I have seen to date, current energy planning does not appear to be addressing these basic questions or examining alternative means of achieving self-sufficiency objectives. A systems analysis approach is necessary and the water resources people have to get involved at an early stage.

There are four elements of the management and conservation problems that I would like to briefly address. These elements, none of which are truely independent, are: (1) hydropower; (2) water conservation; (3) energy conservation; and (4) water recycling/reuse.

Hydropower

At the policy level of energy-water management, we should re-examine the requirements of benefit-cost analysis in investment in water resource projects, especially those that have any hydropower potential, no matter how small. If we look back at the number of small to medium size reservoirs built in the West from which hydropower generation was deleted or not considered because the benefit-cost ratio would have been too small, we have to question the wisdom of that water management policy. If there are only 200 such structures in the West and each has only the average potential to produce 10 MW, the combined capacity would be 2,000 MW, or the equivalent of one large coal or nuclear-powered generating station. More significantly, the "fuel" would have been free, non-polluting and non-water consumptive. In light of the facts that we will forever be facing an energy shortage, increasing water and air pollution to produce energy, and our desire for high quality water, we should consider the feasibility and costs of retrofitting existing dams and reservoirs with hydropower generating facilities and abandon the B/C ratio in the decision to produce hydropower in all future water projects.

Water Conservation

In the category of water conservation, we can look to our principal consumptive use sectors of domestic, municipal, industiral, agricultural and power generation uses to see where potential use savings could be made. Domestic water use could be significantly reduced through complete metering and new water-rate schedules which increase the unit cost of water as the use increases. Domestic reduction in water use would first occur outside the home through a reduction of lawn area and other vegetation. Drastic price increases would be necessary to reduce in-house water uses. Reduction in home irrigation would represent a major shift in life style in many parts of this region where the artifically prolific greenery of the desert metropolitan areas is one of the characteristics which makes these areas attractive and desirable to live in. The National Water Commission has recommended that the price of water for domestic and other uses reflect the costs of service to each class of user and the quantity used. However, it is doubtful that such pricing would encourage much domestic conservation as current price structures for most water utilities, both public and private, are such that they are not subsidized, but often in the case of municipal systems subsidize other governmental functions. If significant reductions in this use of water could be achieved, there would be some energy savings possible. As an example, consider Las Vegas Valley, where it is estimated that by about 1990 some 300,000 AFY will be used, with most of that water being lifted approximately 800 feet from Lake Mead. The average power load to move this water would be about 38 MW with a peak load of about 60 MW. A 50 percent reduction in water use would reduce power demands approximately a like amount, but would require about a 150 percent increase in residential water rates.[3] This reduction in water use would probably result in a less attractive community which might not be aesthetically acceptable and could be detrimental to the local economy.

The greatest potential for water conservation in this region, according to the National Water Commission report,[4] lies in the area of irrigated agriculture. Extensive use of irrigation scheduling and sprinkler irrigation are offered as ways that could conceivably result in major water savings. However, such increases in "efficiency" may be greatly influenced by salt balance considerations either to promote such "efficiencies" or to maintain existing practices. It is felt by many that such increases in efficiency are false savings in that crop growth requires only a certain amount of water and that excess applications within a basin find their way back to the system as return flow with possibly some increased evaporation losses over the "efficient" system. Increased irrigation "efficiency" may thus basically alter only the spatial and time distributions of flows and possibly the salinity of these systems but not significantly affect the volume of water available for other uses. Trans-river basin diversions and diversions into the Great Basin would, however, be an exception as increased efficiency in out-of-basin irrigation would increase water availability in the basin of origin. Energy savings through increased irrigation efficiency is an unknown aspect,but when it is evaluated, and it should be, the energy requirements necessary to produce the materials, such as pipes, pumps, etc., which will allow increased efficiency, should be considered as legitimate energy expenditures.

Water conservation in the industrial sector may be negligible as there is little incentive to be frugal. The cost of water to most industry is so small compared to the value of goods produced that tremendous price increases would be required to have any effect at all. Additionally, there may be little opportunity for actual water reductions in necessary amounts of process water.

In the power generation field most of the water requirement is for cooling purposes and there may be some opportunity for water conservation. However, conservation of cooling water may involve tradeoffs with thermal efficiency and thus energy production. Dry cooling towers which require no water are feasible in cold climates, but their use does reduce thermal efficiency. Once-through cooling with water is the most efficient cooling method and next to the least water consumptive process, but the resulting thermal loading on inland waters and estuaries is generally environmentally

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[3]Fitzsimmons, D.R., "Water Price Elasticity of Household Water Consumption in Las Vegas Valley, Nevada," unpublished masters thesis, University of Nevada, Reno, 1973.

[4]"New Directions in U.S. Water Policy," National Water Commission, U.S. G.P.O., 1973.

unacceptable and is thus being scrutinized by the EPA. Currently then we are boxed into supplying between about 11,000 and 22,000 acre-feet of water per 1,000 MW of power generation for pond or evaporative cooling respectively. Cooling ponds are used to reduce the heat content of the water before return flow to the receiving water and with evaporative cooling, there is no return flow.

Energy Conservation

In the third category, energy conservation, there is really little that falls under the purview of the water resource specialists. We have all been requested by the utilities and government to use our dishwater and clothes washers only when full, to take shorter showers, to drive slower, join car pools, turn off lights, keep air conditioner settings higher, keep heating system settings lower, etc., etc. All of these conservation practices will presumably be reflected in a reduced demand for water in the energy production system, but the cumulative effects are probably not meaningful in terms of the total water demand for energy production. Two areas which bear scrutiny by the water resource specialists, however, are those of the water supply and wastewater treatment functions. There may be potentially significant savings in the operation and design of water distribution systems, the operation of groundwater basins and surface reservoirs and our standards for pressure maintenance and minimum flows. In the waste treatment area it may be possible to design more energy-efficient treatment processes and water handling methods. There is also the potential for taking greater advantage of the gas produced in the digestion of wastes, as in a great many instances the excess beyond that needed to heat digesters is simply wasted to the atmosphere. Also, we need to examine the tradeoffs involved with energy consumption and water quality objectives.

Water Recycling/Reuse

This category, water recycling/reuse, may be the most productive in terms of energy and water conservation, especially when conservation of water is taken to mean preservation of quality as well as quantity. To date, the primary considerations in water recylcing schemes have been (1) to extend the available supply and (2) to meet water quality criteria. The energy efficiency of these proposals have not, to the best of my knowledge, been thoroughly studied. Energy savings and conservation of water quality may be possible; however, recylcing, like increased irrigation efficiency, will not create any new water. Areas where recycling benefits may accrue are in power generation through use of treated municipal wastewater and agricultural return waters for cooling; in agriculture through use of treated municipal wastewater for irrigation; in recreation through use of treated wastewater for irrigation of parks, golf courses and greenbelts; and in industry through on-site treatment and reuse of process water. Recycling of water for direct domestic reuse may not be energy efficient because of the extremely high level of treatment necessary to meet drinking water standards.

SUMMARY

In conclusion, then, management and conservation in energy-water relationships must be proceeded by a thorough assessment of our energy-water goals and the development of adequate plans. Further, our goals for water quality must be re-examined in light of their meaning to energy production and consumption. Once we have some clearly defined goals and plans, then the water resource community can isolate those water management and conservation practices which will have meaningful impact on the energy situation.

THE POLLUTION ENVIRONMENT -

by

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The setting of this discussion is the Colorado River Basin, the Great Basin and California. For the purposes of simplifying the discussion, I shall emphasize the Great Basin and Colorado River Basins for these are the areas which still have substantial development potential in terms of resources in general, but particularly those relating to energy development. In addition, the Colorado River Basin and the Great Basin have a good deal in common in physiogeographic settings and climate, in socio-economic and cultural development.

It is perhaps prudent for us to look at the region in a historical sense as a definition for its natural setting, its subsequent development and its potential future development. The region is characterized by a mountainous physiography, high plateau lands and low desert areas. In general, the region has a low precipitation with the exception of the alpine highlands. It is dominated by xerophytic arid land plants for the most part, again with the exception of the highlands where mesophytic communities have developed. The region is large, encompassing portions of New Mexico, Colorado, Wyoming, Idaho, Oregon and California, and all of Utah, Arizona and Nevada. Though the region is large and because of the relatively light precipitation, water is limited in the region. The water courses in the region are generally characterized as high gradient streams collected into great river courses as in the Colorado River or high gradient streams collected into the Great Salt Lake Basin. The streams in the highlands are generally clear, mountain streams collecting water from well-vegetated watersheds and confluing into larger cutting streams with relatively high silt loads. The silt loading is augmented by high spring runoff, also usually heavily silt laden.

The advent of white civilization into the basins initiated irrigation agriculture, grazing and mining activities. Thus by the turn of the century, the waters of most of the area had already been impacted. Imprudent mining practices, including hydraulic mining, heavy grazing and irrigation diversion combined to substantially change the quality of the water, particularly in the lower regions. Most of the change was characterized by increased silt loads of the streams with consumptive uses relating predominantly to irrigation practices. Increased salt concentrations in the streams also occurred through irrigation return flows and leaching of minerals through surface runoffs.

Population increases over the next half century resulted in development of urban centers such as Salt Lake City, Phoenix and Tucson, as well as numerous smaller communities throughout the basins, all contributing domestic sewage to the waters, further decreasing their quality. During the same period irrigation agriculture was intensified and some heavy industrial development occurred. During this period little was done by municipalities, industry, or mining interests and agriculture to stem the tide of pollution within the water courses.

It wasn't until the 1950's that it became apparent the population increases and the increased uses of waters in the region began to clash with the water supply. It became apparent that the water supply was not unlimited and full allocation of existing water supply was rapidly approaching. It also became apparent that water quality control was essential to extend the uses of water within the region. It was during this period that federal and state actions were initiated to effect water quality control in the form of pollution control. These control measures were directed principally toward point source pollution. Earlier, several of the federal land management agencies had instituted rangeland and watershed improvement programs with the principal goal of stabilizing watersheds deteriorated by grazing practices. By the 1960's with the advent of the Water Quality Control Acts, considerable progress had been made toward clearing up the pollution picture, although by no means did the water quality achieve that of pre-white man civilization.

At the present time most of the major municipalities in the region are on some level of waste treatment. Most of the industries are complying with water quality treatment regulations, and watersheds in general have improved to the point where significant inroads have been made on pollution of the streams in the region. However, at the present time pollution does still exist. Numerous small communities still have yet to develop treatment systems. Many of the larger communities have yet to develop tertiary systems. Closed system treatment for industry is still an ideal. Irrigation practices in many areas leave a lot to be desired.

During this period of development the need for water has increased steadily to the point where it is now almost completely allocated within the region. Yet population projections for the year 2000 indicate that even greater demands will be made on the water which is currently under use. The need for continued efforts in water quality control has never been greater. Though the 1972 Amendment to the Water Quality Act calls for a stoppage of all point source pollution by 1985, considerable question remains in the minds of many as to whether it is technologically and/or economically feasible. Even if the 1985 ideal is achieved, it controls only the point source pollution and not the nonpoint sources and herein lie some of our future pollution problems in the Rocky Mountain Region.

With the advent of the philosophy of energy self-sufficiency, a great demand is going to be placed upon the fossil fuel resources of the basins. Oil shale and coal development are perhaps the two primary sources for concern here. The demands created by increased populations on fuel resources are compounded further by a need to increase food production. These two elements alone could have serious implications on the pollution environment in the next 25 to 50 years in the Rocky Mountain Region. Both oil shale and coal development require what can only be termed as a consumptive use of water, contributing to the dewartering problem in the basin. In addition, oil shale development has a high salinity-leachable component while coal development has a high acid component. Those two components coupled with dewatering in the system will result in deterioration in water quality to a point where many downstream users will be affected. Development of the oil and coal industries in the region also have population demands; that is, one can expect new towns or augmented old towns to develop along with their attendant services including transportation which in turn causes surface perturbations resulting in increased surface runoff and siltation. In addition, fossil fuel generating plants in the region provide an element of atmospheric pollution yielding noxious components which ultimately arrive in the water courses of the system.

The pressure to increase food production will also cause a greater demand on water for irrigation purposes resulting again in high salinity irrigation return flows which can only be termed as a form of consumptive use since increasing salinity in the water makes it less potable and decreases its utility for continued irrigation use. Also the pressure to increase food supplies will undoubtedly place greater demands on meat and fiber production which in this region means greater utilization of the surface resources on the watersheds. All this could ultimately undo the improvements which have occurred over the last 50 years.

Taken together these few examples of developments can result in an increase in nonpoint source pollution throughout the region to a point where water quality can be deteriorated even beyond those levels that would have been achieved by point source pollution alone.

The basic conclusion one must arrive at with the impending forces for development is that development itself is constrained by the availability of usable water. Development within the available water resources can be maximized with water quality control. Water quality control within limits can be realized with improved control technologies and with wise land use management. Land and water use management are not inseparable especially when extra regional forces place demands upon resources within the region. It is implicit in management that when recognizable future demands are placed on resources within the region, steps must be taken to optimize the production of those resources, water included. A land use/water use planning function is called for on a regional basis. Limits have to be set in terms of population increases and in terms of industrial and resource development within the region so that the resources of the region can be maintained not only for the regional population but for the nation at large.

INSTITUTIONAL ASPECTS OF ENERGY-WATER DECISIONS IN THE PACIFIC SOUTHWEST REGION

by

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A REGION UNDER STRESS

By definition, a region is bound together with certain common problems, perspectives and interests. The extent to which the Pacific Southwest is, in fact, a region is increasingly questionable. While it might be logical to suppose that shared experience with water scarcity would provoke a common interest, we all know that allocation of water has prompted fierce competition within the region. Arizona v. California was the most extended legal conflict, in terms of time, ever before the Supreme Court. Interstate suspicions, in part, have prevented the formation of a Pacific Southwest River Basin Commission under the Water Resources Planning Act of 1965. Socially, economically and politically the region is becoming increasingly diverse. Consequently it is most realistic to focus upon states as the basic political entities in examining institutional aspects of energy/water decisions.

Southwestern states themselves are divided. There are sharp divisions over who will get and pay for what in terms of natural resources. Fast growing metropolitcan complexes such as Los Angeles, Phoenix, San Diego, Salt Lake, Albuquerque, Las Vegas and Tucson have enormous appetites for natural resources and increasing sensitivity about bearing an inordinate share in the cost of their development. Witness the current resistance of the city of Tucson to the signing of contracts for the Central Arizona Project. Indian tribes, once passive participants in resource allocation and development decisions, are claiming more resources to themselves and more returns for the development of lands for others. While some political officials still view growth and development in the West as both good and inevitable, others, particularly environmental groups, have come to have second thoughts about the impact upon quality of life.

Energy development problems, questions of what sources to develop, when and how much, are bound to exaccerbate the stress within states in the region. Lifestyles in Western cities are enormously energy consumptive. Tol illustrate, while the nation as a whole invests 25 percent of its fuel in transportation, the state of Arizona consumes close to 37 percent. Building structures are sprawled across the landscape with work places far from dwellings. There is little provision for mass transportation. Further, increases in population and personal income in this growth region have spurred consumption of electrical energy which outstrips the rest of the nation. Urban areas within the region are bound in the future to exert enormous pressures for energy development. Other acreas within the Pacific Southwest region have vital resources of coal, clean air and low population densities. These will be looked to by urban areas for new energy supplies. Since energy development is water intensive, the old arguments about realloca-tion from agricultural to municipal and industrail uses are apt to become more intense.

Energy problems are also likely to sharpen interstate conflicts. Coal development through thermal electric power plants and coal gasification are the backbone of the administration's "Project Independence." Coal's extraction and use in areas where it can be found in profusion, such as the Four Corners area, will have enormous impact upon population distribution, air quality, water supply and quality and land use. To what extent should regional areas be compensated for becoming resources suppliers for the rest of the country? Such questions are bound to produce controversy with interests outside the region. Although there is considerable debate about how water-consumptive oil shale development in the upper Colorado Basin will be, there is every reason to believe that in a water-short river system, increased water consumption in the upper basin will cause conflict with lower basins states. In sum, the forces which fragment the Pacific Southwest and militate against a regional assessment and viewpoint and even threaten the coherence of states are likely to become more numerous and powerful.

INSTITUTIONAL ARRANGEMENTS FOR WATER DECISION MAKING IN THE PACIFIC SOUTHWEST

Traditionally the focus in water resources decision making has been at the federal level. Although local backing was always important in giving impetus to a project, the initial planning and selection of features to meet various objectives has come from federal agencies, particularly the Bureau of Reclamation. Procedures for evaluation of projects, such as benefit-cost analyses and multiple-objective planning have been imposed at the federal level and monitored by federal agencies such as the Office of Management and Budget. The national legislative body has made landmark decisions about water allocation and development: The Boulder Canyon Project Act, The Upper Colorado Storage Project Act and the Colorado River Basin Act. Individual congressmen and senators, strongly motivated by constituency concerns, provided a lead in shepherding these bills through the legislative process. However, it was necessary to build the consent and support of congress as a whole in order to be successful.

The federal government historically dominated water development because it had most of the resources and because interests in the region believed they were advantaged by federal development. The federal government is advantaged in times of financing resources and has had a hegemony on planning and technial expertise. Typically, state water agencies have not been able to field experts either in the numbers or skills available to the Corps of Engineers, the Bureau of Reclamation or the Soil Conservation Service. States have usually been weak and under-represented partners in joint federal-state planning efforts. In the past, states have not especially resented a little-brother role. Water projects have been conceived of as federal largesse, and the states have viewed their task as one of supporting project proposals in the federal arena.

Marked changes have occurred in the institutional arrangements for water resources decision making in recent years. States have asserted a claim to an active role in the selection and development of project proposals within their borders and an equal voice with federal agencies in regional planning efforts. This is partly due to greater institutional capability on the state level. At the time of the passage of the Planning Act of 1965, only the state of California had a full-fledged water planning program with professionals with a broad range of expertise. Table 1 indicates the increase in numbers of professionals in water planning agencies between 1965 and 1973.

In addition, state water planning agencies, traditionally mainly hiring engineers, have come to employ professionals from diverse backgrounds including economists, life scientists and physical scientists. The growing emphasis of western states upon a state role in water resources is reflected in increased state expenditures for comprehensive water and related land-use planning. Table 2 indicates impressive augmentation of state expenditures between 1965 and 1973.

The improved state capability in water resources development has been accompanied by a changing state attitude. States are no longer hesitant to look the federal water project gift horse in the mouth. The old pressure upon each state to develop its water allocation as quickly as any project proposals can be justified and pass the benefit-cost test is less great today. Instead, states are setting priorities for federal agencies about which project proposals to develop first. The conservation movement, which once had access to water resource decisions only on the national level and when national parks or other scenic values were endangered, now has become the envrionmental movement with strong grass-roots support and some access to local and state governments. When proposed water projects have environmental opposition, state political leaders are now wary of giving support.

States have asserted the right to a larger voice in regional water planning efforts. State agencies had an important role in the West-wide study of the Bureau of Reclamation. Individual state agency officials have leadership positions in the Pacific Southwest Interagency Committee.

In summary, what was once a federal decision making process in water resources development has become a joint process. State agencies today often recognize their own individual interests and possess the necessary resources to assert those interests.

INSTITUTIONAL ARRANGEMENTS FOR ENERGY DECISION MAKING IN THE PACIFIC SOUTHWEST

While the federal government has historically dominated water development decision making in the Pacific Southwest, much energy decision making has been centered within private industrial organizations. Planning to meet energy demand has been an industry affair, with past patterns of use projected into the future of industry planners. Agencies, such as the Federal Power Commission, which estimate future energy use ordinarily get

TABLE 1

NUMBERS OF PROFESSIONAL STAFF IN STATE WATER RESOURCES PLANNING AGENCIES, 1965-1973

State	Number in 1965	Number in 1973
Arizona	1	16
California	256[a]	224
Colorado	17	19
Nevada	3[b]	4
New Mexico	11[a]	23
Utah	3	15
Wyoming	3[b]	5

a. 1967 figure

b. 1968 figure

Source: Reponse to survey questionnaire sent to state agencies. For more detailed data see Ingram, Bradley, Ingersoll, "An Evaluation of Title III Water Resources Planning Grants to States," U.S. Water Resources Council, Washington, D.C., October 1973.

TABLE 2

EXPENDITURES OF SELECTED WESTERN STATES FOR WATER AND RELATED LAND-USE PLANNING, 1965, 1973

State	Fiscal Year 1965	Fiscal Year 1973	Percent Increase
Arizona	87,800	350,000	246
California	7,587,000	7,968,000	5
Colorado	171,789	662,266	286
Nevada	0	112,906	
New Mexico	0	76,500	
Utah	39,705	124,138	213
Wyoming	0	122,887	

Source: Survey questionnaire responses of state water resources planning agencies. For more detailed responses see Ingram, Bradley and Ingersoll, op. cit.

their basic data from industry. Costs and profits to private industry have determined which energy resources are developed where governmental institutions are beginning to have some input into energy development site selection, but the choice is often simply an approval or rejection of locations selected by industry. The setting of rates which can be charged by energy producers is frequently regulated by government. The major concerns of regulators have been least cost to consumers and fair rate of return to regulators, not the management of energy demand.

The long-term gap between energy supply and demand has prompted increasing governmental concern in recent months. The federal government has assumed a greater role in decision making. The Nixon administration has committed itself to "Project Independence" whereby the nation must develop substitutes for foreign oil imports. Oil reserves in Alaska and offshore in continental waters are to be developed; oil shale, long uneconomic, is slated for development; the substantial western coal lands are expected to be stripped and gasified or burned in thermal electric power plants. Under this "Project Independence," massive investments are to be made in energy research.

Because many of the energy resources are on federal land, particularly administered by the Bureau of Land Management, the federal government is a necessary participant in energy decision making. Further, possible federal passage of national regulations in the fields of surface mining, reclamation and power plant siting may pre-empt subjects previously left to states. In the last few months there have been a number of indications that actions taken on the federal level may affect state positions in water. New federal studies of water required for energy development are slated to be underway soon. Legislation has been introduced to provide for specification of federal and Indian water rights.

State governments in the West have been poorly organized and equipped to deal with energy. While water resource planning agencies have emerged in most western states to put together a state water plan and act in behalf of each state in interestate negotiations, no counterpart exists in the field of energy. The state fuel and energy offices which sprang up during last winter's energy crisis focused upon immediate concerns of negotiating fuel allocations with the Federal Energy Office and dealing with long lines at gas stations. Practically no long-term planning took place. The more traditional state agencies which deal in energy usually fragment authority according to specific resources: petroleum, hydropower, atomic energy, etc. In Arizona, for example, at least seven state agencies are involved in one or another subject area. The orientation of these narrowly focused agencies is frequently promotional. Further authority over even a single form of energy, such as electric power, is often widely dispersed. Table 3 lists the possible state organizations which may be involved in licenses and approvals for an electric generating station.

Perhaps the most important state agency in the field of electric energy is the state public utility commission. Table 4 lists the regulatory bodies which exist in Western states.

TABLE 3

POSSIBLE STATE AGENCIES WITH LICENSING AND APPROVAL REQUIREMENTS

Environmental Protection Agency (water resources commission, air quality board, etc.)
Department of Natural Resources
Department of Fish and Wildlife
Highway Commission
Public Utility Commission
Department of Public Health
State Police
Office of Parks and Recreation
State Planning Commission (wetlands agency, etc.)
Department of Transportation
Industrial Commission

Source: Association of the Bar of the City of New York, Special Committee on Electric Power and the Environment, "Electricity and the Environment: The Reform of Legal Institutions," 1972, p. IV 13-14.

TABLE 4

STATE PUBLIC UTILITY COMMISSIONS
WITH ELECTRIC LIGHT AND POWER FUNCTIONS

States	Regulatory Authority
Arizona	Corporation Commission
California	Public Utilities Commission
Colorado	Public Utilities Commission
Nevada	Public Service Commission
New Mexico	Public Service Commission
Utah	Public Service Commission
Wyoming	Public Service Commission

Source: "The Book of the States 1972-1973," Lexington, Kentucky, The Council of State Governments, 1972, p. 557-558.

In general, state regulatory commissions in the energy field are underfinanced and understaffed. Without the capability or expertise to collect data, they cannot plan. In rate cases, commissions must look for outside information. The most complete and sophisticated inforamtion is ordinarily submitted by utilities, not consumers and environmentalists.

Typically, state water agencies are remote from energy decision making. Their involvement tends to be tangential such as commenting upon environmental impact statements for federal leases of coal and oil shale reserves. Obviously, the state role here is to react to proposals negotiated at the federal level.

The establishment of power plant siting bodies in many states affords some institutionalized access of state water agencies to siting decisions. According to a Southern Interstate Nuclear Board study made in 1972, all but Colorado among western states had at least expressed some interest in state action on power plant siting.[1] While the establishment of siting agencies in a state is an important step forward, they tend to be unwieldly and possess few organizational resources. In Arizona, for instance there are 18 members of the Power Plant and Transmission Line Siting Committee of which the Arizona Water Commission is but one. The Committee has little money and staff and operates under strict time restraints.

The state of California has very recently gone considerably beyond simply establishing a siting body toward an agency with authority to chart a comprehensive state energy policy. An Energy Resources Conservation and Development Commission appointed by the governor will set standards for home appliances, establish energy saving rules for new buildings, decide on power plant siting and speed development of new energy sources.[2] Since the law will not become operative until next year, it is impossible to guess whether the water implications of energy will be taken into account and whether the legislation will work.

Despite the beginnings of institutional change on the state level, it is still fair to conclude, as Norman Evans has, "state polices on energy resource development are lacking."[3]

CONCLUSION

Over a number of years the states in the Pacific Southwest have developed institutional capability to participate jointly with the federal government

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[1]Southern Interstate Nuclear Board, "Power Plant Siting in the United States", 1972, A State Summary, 2nd Revised Edition, Atlanta, Southern Interstate Nuclear Board, September 1, 1972, p. 1-2.

[2]"California Passes its Own Energy Law", Business Week, July 1, 1974.

[3]Evans, Norman A., "Regional Energy-Water Problems, Colorado River - Great Basin", in Proceedings of a Conference, The Role of Water in the Energy Crisis, Ocotber 23-24, 1973.

in the allocation and development of water resources. States contribute to the funding of state planning efforts, and state water planning staffs have grown in numbers and expertise. Pacific Southwestern states have asserted the right to a real voice in regional water planning activities. It is ironic that at the very time that the states in the region have developed institutional capability in water, energy has become a central issue.

State energy agencies have not undergone the institutional development which has occurred in water. Authority is fragmented among numerous energy agencies with narrow jurisdictions and few organizational resources in terms of staffing, funding, etc. While energy choices will have a great impact upon the allocation and use of water resources, state water agencies are usually remote from energy decision making. They are simply one of the number of state agencies whose involvement often comes too late and is too limited to have much impact. No overall state energy policy exists which sets criteria for evaluating the impact of energy development proposals upon water, air and land resources.

If the Pacific Southwestern states are to guide the future development of their own resources, appropriate institutional arrangements must be designed. Arenas must be created at the state and regional level where difficult resource tradeoffs can be assessed and decisions made. The opportunity and importance of institutional research is very great.

DISCUSSION REPORT

Sol Resnick
Chairman
University of Arizona

Joseph W. McCutchan
Reporter
University of California, Los Angeles

Chairman Sol Resnick opened the meeting by saying that the Colorado River is already oversubscribed and that the River has known salinity problems; so, when we put "Project Independence" on top of this, the "problems almost blow your mind."

The program was well structured. We initially had three presentations, and I recommend them for study since they contain the factual information presented.

Calvin Clyde of Utah State University presented slides: (1) defining our region, (2) showing average annual surface runoff, (3) showing the principal rivers and drainage basins, (4) the principal coal deposits, (5) the principal oil shale deposits, (6) the oil fields in the area, and (7) the gas fields. He then repsented the 1970 total energy flow chart for the United States and noted that in Region VII there is room in all states for additional hydroelectric development. He believes this development should be pursued eagerly.

He noted that at present about two-thirds of our energy comes from natural gas and petroleum and that only about one-third comes from coal. This needs to be turned around. However, to do so will take drastic changes. One problem is that the customers want their "energy" in the most convenient form and as we know from thermodynamics, to convert thermal enrergy from gas, oil, or coal to electrical energy carries with it the inherent limitation of Carnot efficiency which is less than fifty percent. Furthermore, the actual production of energy is not the only water-using activity causing concern. Water will be needed to supply the new towns which must be built near the coal and oil shale fields.

Gilbert Cochran, University of Nevada, presented his paper on Management and Conservation in the California, Colorado River, Great Basin Region. He stated that goals and objectives are essential if we are to manage any project. He said, "the Colorado River is bankrupt already," and then went on to present figures to prove this point. He concluded that a systematic analysis of this problem is necessary to develop a plan for this region. The River Basin states cannot simply turn their water resources to energy production without first analyzing the impacts of this reallocation on our regional, national and international commitments.

John Neuhold, Utah State Universtiy, then spoke of "Pollution Past, Pollution Present, and Pollution Yet to Come." He said that since the passage of the Water Quality Act, many of the point sources of pollution have been eliminated so that now the primary sources of pollution are the nonpoint sources.

In the Colorado River Basin we are on the threshold of "Pollution Yet to Come." The technology to efficiently recover energy from oil shale and coal are really unknown. The pilot plants being built will hopefully provide this information, but it will take time.

Helen Ingram, University of Arizona, presented her paper which was entitled "A Region Under Stress." She said, if the Colorado River concept ever existed, it is certainly fading. Instead of a unification of purpose, it is a fragmentation. Urban areas in the Southwest have a tremendous appetite for natural resources. The energy problem is going to magnify our differences and our conflicts. Up to now, the lower basin has depended on the slow development in the upper basin in order to pay out some of its projects. The states are exerting a more active role. They are setting priorities for federal agencies about which projects to develop first.

John Neuhold commented that this Project Energy Independence was "kicked-off" by commodity oriented type people who sought a broad input. Upon studying the needs of society, their conclusion was that the greatest "need" of society was to be found in the people themselves -- their needs, their desires, their values.

It was questioned if these needs, desires and values were the same in all the states involved. To balance this discouraging thought, it was noted that this region has one thing very much in common, a Western Ethic (which was not defined).

Helen Ingram is convinced that we need some regional decisions. However, most regional institutions walk a very narrow path between areas of support and politically viable solutions to their problems.

Someone said that at a recent meeting the Governor of Colorado had said that we should reopen the Colorado River Pact allocation question.

A response from the floor indicated that importing water from the Columbia or some other northern source to augment the Colorado River would be a more workable solution than reopening the Colorado River Pact.

Question - What kind of institution exists within the states that can tax development on federal lands? It seems the rate of charge for projects on federal lands is based on:

(1) fair rate of return

(2) equal service to everybody.

Comment - What the states can do best is to help with site selection for the various proposed projects.

A suggestion was made that instead of talking about constraints, let us ask, how much water is needed to accomplish these projects. When we have the detailed water requirements, then we will be able to take a stronger stand on the queston of water allocations.

As of now, we can agree only that regionally we want the greatest good for the greatest number of people.

APPENDIX A

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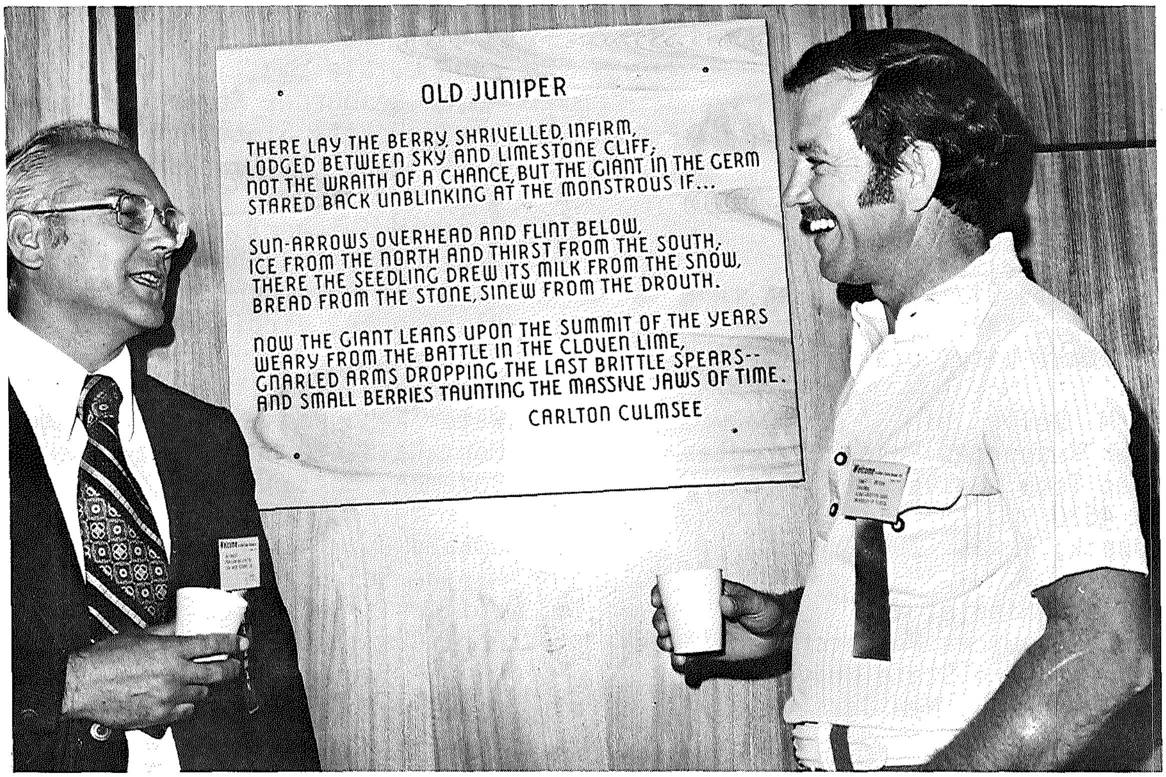

Local coordinator Jay Bagley discusses conduct of meeting with Chairman Ernie Smerdon at coffee break.

APPENDIX B

RESOLUTIONS

R-1

RESOLUTION PASSED AT THE 1974 ANNUAL MEETING
UNIVERSITIES COUNCIL ON WATER RESOURCES
LOGAN, UTAH July 31, 1974

RESOLUTION ON THE ORGANIZATION OF THE OFFICE OF WATER RESEARCH AND TECHNOLOGY

WHEREAS, the Universities Council on Water Resources (UCOWR) at its 1974 Annual Meeting was informed by Assistant Secretary Horton that the Office of Water Research and Technology had been established on July 26, 1974; and

WHEREAS, Assistant Secretary Horton in making his announcement extended an invitation that UCOWR appoint a special committee to advise his office on items concerning the development of policies and programs of the new organization and on other matters of mutual concern; and

WHEREAS, the reorganization as proposed and the advisory role as suggested are of vital concern to the universities; and

WHEREAS, UCOWR supports the reorganization and welcomes the opportunity of moving into a new era of Department-University cooperation;

THEREFORE, BE IT RESOLVED that UCOWR commends Secretary Morton and Assistant Secretary Horton for recognizing the increasingly important and vital role of water resources research and technology in the nation's future and for their action in establishing the new Office of Water Research and Technology;

THEREFORE, BE IT FURTHER RESOLVED that UCOWR recommends that appropriate action be taken as soon as possible to implement the advisory relationship with the office of Assistant Secretary Horton so that the development of the new organization can be effected in the near future.

R-2

RESOLUTION PASSED AT THE 1974 ANNUAL MEETING
UNIVERSITIES COUNCIL ON WATER RESOURCES
LOGAN, UTAH July 31, 1974

RESOLUTION ON
INTEGRATED WATER PLANNING WORKSHOP

WHEREAS, effective water resources planning and management requires cognizance of both water quality and water quantity; and

WHEREAS, water quantity and water quality planning and management have developed along separate parallel lines and the tendency has been to maintain this separation; and

WHEREAS, the Congress in Sections 208 and 209 and elsewhere in the Water Quality Act of 1972 (P.L. 92-500) has indicated its desire to strengthen the coordination of water quantity and quality planning and management; and

WHEREAS, there is no clear indication that the effective integration of water quantity and quality planning and management is taking place among the concerned federal or state agencies; and

WHEREAS, the Universities Council on Water Resources (UCOWR) believes that effective water resources planning and management is essential to the nation as it strives to meet continuous and growing problems in water resources, environmental and energy matters; and

WHEREAS, this subject is highly relevant and timely to the work of the National Study Commission on Water Quality; and

WHEREAS, UCOWR supports the activities of its Committee on Education and Research in Water Quality in planning and seeking financial support for a workshop on integrated water planning;

THEREFORE, BE IT RESOLVED that UCOWR urges the Water Resources Council and other appropriate agencies to work with UCOWR to seek the cooperation of federal, state and other agencies and private sector interests, and to plan and conduct a workshop during 1975 on ways to effectively implement coordinated water quality and water quantity planning processes including technical and institutional matters.

R-3

RESOLUTION PASSED AT THE 1974 ANNUAL MEETING
UNIVERSITIES COUNCIL ON WATER RESOURCES
LOGAN, UTAH July 31, 1974

RESOLUTION ON METROPOLITAN WATER RESOURCES PLANNING AND MANAGEMENT WORKSHOP

WHEREAS, effective metropolitan water resources planning and management is one of the foremost areas of concern in water resources today; and

WHEREAS, the interaction of universities and metropolitan area institutions, by meams of research and information transfer, can make important contributions to effective metropolitan water planning and management; and

WHEREAS, a significant amount of research on urban-metropolitan water planning and management is now under way at various universities throughout the country; and

WHEREAS, there is need for transfer and exchange of information among those carrying out the research and those concerned with actual planning and management of metropolitan water resources; and

WHEREAS, workshops have been found to be an effective means for achieving such information transfer and exchange; and

WHEREAS, the Universities Council on Water Resources (UCOWR) supports the activities of its Committee on Education and Research in the Social Sciences and its Committee on Education and Research in Hydrology in planning and seeking financial support for a workshop on metropolitan water resources planning and management;

THEREFORE, BE IT RESOLVED that UCOWR requests that the Office of Water Research and Technology, the Water Resources Council, the Environmental Protection Agency, the Technical Council for Water Resources Planning and Management of the American Society of Civil Engineers, and the Office of Land Use and Water Planning of the Department of the Interior provide financial support for such workshop.

R-4

RESOLUTION PASSED AT THE 1974 ANNUAL MEETING
UNIVERSITIES COUNCIL ON WATER RESOURCES
LOGAN, UTAH July 31, 1974

RESOLUTION ON
RECONSIDERATION OF THE EXTENSION PROVISIONS
OF THE FEDERAL REPORTS ACT OF 1942 TO UNIVERSITY RESEARCH

WHEREAS, in a recent communication to the Water Resources Research Institutes a directive was issued by the Office of Water Resources Research that all research with federal funds contemplating the use of questionnaires and interviews addressed to more than ten persons would be subject to clearance of those forms by the Office of Management and Budget; and

WHEREAS, this directive is based on a recent interpretation by the Office of Management and Budget which extends the application of the Federal Reports Act of 1943 in OMB Circular A-40 to university research grantees and contractees; and

WHEREAS, research by social scientists and others using survey methodology will be severely hampered by the resulting excessive delays and by increased costs in data gathering; and

WHEREAS, such extension of these requirements presents a serious threat to the freedom of inquiry; and

WHEREAS, most universities have the Health, Education, and Welfare approved survey review procedures which are internally and professionally supervised; and

WHEREAS, such surveys conducted by universities do not coerce respondents to participate and also have adequate safeguards to maintain the privacy of the respondents; and

WHEREAS, such requirements present a serious threat to research in the field of water resources planning and management;

THEREFORE, BE IT RESOLVED that the Universities Council on Water Resources request that the Office of Water Research and Technology ask that the Office of Management and Budget reconsider its recent interpretation that the provisions of the Federal Reports Act apply to university research grantees and contractees.

R-5

RESOLUTION PASSED AT THE 1974 ANNUAL MEETING
UNIVERSITIES COUNCIL ON WATER RESOURCES
LOGAN, UTAH July 31, 1974

RESOLUTION ON BEHAVIORAL AND INSTITUTIONAL KNOWLEDGE TO ADVANCE WATER QUALITY ENHANCEMENT

WHEREAS, the Congress of the United States has now embarked the nation on a new course to the attainment of waters suitable in quality for swimming and valued fishery and wildlife habitat; and

WHEREAS, the National Study Commission on Water Quality has identified as of critical importance institutional arrangements, the formal and informal rules, the organizational characteristics and behavior, the interpersonal and intergovernmental linkages, the incentives and disincentives, the rights and privileges that affect the attainment of water quality; and

WHEREAS, any implementation of the National Water Commission Report will require substantial further consideration of similar institutuional factors; and

WHEREAS, a review of behavioral and institutional knowledge pertinent to water quality enhancement shows that our level of understanding is critically deficient at a time where major reassessment of policy is underway;

THEREFORE, BE IT RESOLVED that the Universities Council on Water Resources offers its assistance and urges those who conduct and fund such research be requested to encourage the identification of priority research topics and expand the funding for behavioral and institutional research and application of knowledge to current and anticipated problems of water quality enhancement.

R-6

RESOLUTION PASSED AT THE 1974 ANNUAL MEETING
UNIVERSITIES COUNCIL ON WATER RESOURCES
LOGAN, UTAH July 31, 1974

RESOLUTION ON INFORMATION TRANSFER

WHEREAS, decision makers are constantly seeking data and information needed for resolving water resources problems; and

WHEREAS, there is currently available a significant amount of technical and scientific information and experience gathered from research conducted by the university community; and

WHEREAS, the 1972 Amendment to the Water Resources Research Act of 1964 authorizes information dissemination as an intergal part of research programs of state water institutes and centers; and

WHEREAS, the state water institutes and centers have insufficient funds to carry out this responsibility and there has been an absence of a national effort to give assistance to various state programs;

THEREFORE, BE IT RESOLVED that (1) the Office of Water Research and Technology add to their senior staff an information specialist to provide leadership within the Office of Water Research and Technology and assistance to the universities in the development of effective programs of information transfer; (2) funds be made available by the Office of Water Research and Technology to universities for implementing appropriate programs for information dissemination; and (3) universities be encouraged to establish an information dissemination program designed to facilitate the transfer of research findings in water resources to users.

R-7

RESOLUTION PASSED AT THE 1974 ANNUAL MEETING
UNIVERSITIES COUNCIL ON WATER RESOURCES
LOGAN, UTAH July 31, 1974

RESOLUTION ON NATIONAL WATER RESOURCES SCIENTIFIC INFORMATION DISSEMINATION PROGRAM

WHEREAS, the General Accounting Office has noted the concern of the Congress and the President over the limited use of the results of water quality research and development program sponsored or supported by federal funds; and

WHEREAS, the maximum use of federal research and development accomplishment requires that results be available to potential users in a form that encourages use of the information; and

WHEREAS, the Water Resources Scientific Information Center (WRSIC) of the Office of Water Research and Technology, U.S. Department of the Interior, is recognized as the major federal center for water resources research information including water pollution; and

WHEREAS, other agencies appear to be establishing overlapping or duplicative information storage and retrieval systems despite the demonstrated operational capability of WRSIC; and

WHEREAS, increased attention to information dissemination and transfer needs and services is essential to an effective national water resources program; and

WHEREAS, the Office of Water Data Coordination functions successfully to avoid duplication of and ensure most efficient use of water data but no corresponding coordination exists in the field of scientific information on water;

THEREFORE, BE IT RESOLVED that the Water Resources Scientific Information Center of the Office of Water Research and Technology, U.S. Department of the Interior, be designated the National Water Resources Scientific Information Center to be used by all federal agencies in support of their research, development, planning and management programs and that the Office of Water Research and Technology take immediate action to publicize the services of the Center, provide the necessary staff position to provide leadership for a national water resource information dissemination program, and take steps to fully implement complementary university information dissemination activities authorized by the Water Resources Research Act as amended including necessary cooperation with other agencies.

R-8

RESOLUTION PASSED AT THE 1974 ANNUAL MEETING
UNIVERSITIES COUNCIL ON WATER RESOURCES
LOGAN, UTAH July 31, 1974

RESOLUTION ON
NATIONAL STUDY COMMISSION ON WATER QUALITY

WHEREAS, the National Study Commission on Water Quality is conducting a study of major significance on the appropriate management of the quality of the nation's water environment; and

WHEREAS, the Universities Council on Water Resources (UCOWR) is an organization of seventy-nine universities, each concerned with education and research in water research; and

WHEREAS, comments by the academic community on the reports, both interim and final, of the Commission could be expected to aid public and congressional consideration of the issues studied;

THEREFORE, BE IT RESOLVED that UCOWR recommends that the National Study Commission on Water Quality consider using UCOWR in its review process and as part of the review process UCOWR offers to hold a workshop on issues raised by the Commission in its draft report.

R-9

RESOLUTION PASSED AT THE 1974 ANNUAL MEETING
UNIVERSITIES COUNCIL ON WATER RESOURCES
LOGAN, UTAH July 31, 1974

RESOLUTION TO WATER RESOURCES COUNCIL ON RESEARCH RELATED TO PLANNING

WHEREAS, the National Water Commission evidenced justified concern over the need to develop closer ties between research and planning; and

WHEREAS, the National Water Commission recommended that the Water Resources Council (1) should direct that water resources planning studies include an assessment of research needed to support planning objectives and a recommended research program to develop the scientific and technological base necessary to cope with future problems; (2) should review planning reports for needed research as part of the customary Council review to aid that agency in preparing periodic assessments of needed research with priority recommendations to support objectives of the Water Resources Planning Act; and (3) should also develop guidelines for field planning entities to assist in reflecting technological impacts in both short- and long-range water resources planning; and

WHEREAS, the Commission's recommendations are consistent with the objectives of the Water Resources Act and would contribute to the identification of research needs, enhance both research planning and programming and the generation of needed research on water resources planning; and

WHEREAS, these constructive and important recommendations could be undertaken without new authority or significant new resources;

THEREFORE, BE IT RESOLVED that the Universities Council on Water Resources recommends that the Water Resources Council implement the Commission's recommendations as specified above in consultation and collaboration with the Office of Water Research and Technology, U.S. Department of the Interior.

R-10

RESOLUTION PASSED AT THE 1974 ANNUAL MEETING
UNIVERSITIES COUNCIL ON WATER RESOURCES
LOGAN, UTAH July 31, 1974

RESOLUTION ON

THE SAFE DRINKING WATER ACT OF 1973

H.R. 13002

WHEREAS, a resolution by the Universities Council on Water Resources (UCOWR) at its 1970 Annual Meeting at Virginia Polytechnic Institute and State University, Blacksburg, Virginia, contributed to initiating the deliberations since held by Congress on safeguarding the purity of the nation's drinking water supply; and

WHEREAS, UCOWR reiterated its support for a pure drinking water bill at its 1971 Annual Meeting at Oregon State University, Corvallis, Oregon; and

WHEREAS, the Senate of the United States approved the enactment of S.433 June 22, 1973, during the first session, 93rd Congress; and

WHEREAS, the Safe Drinking Water Bill has been reported favorably by the House of Representatives, Committee on Interstate and Foreign Commerce;

THEREFORE, BE IT RESOLVED that UCOWR expresses its appreciation to the Chairman and members of the House Committee on Interstate and Foreign Commerce and the Senate of the United States for their endeavor in promoting the enactment of this legislation.

R-11

RESOLUTION PASSED AT THE 1974 ANNUAL MEETING
UNIVERSITIES COUNCIL ON WATER RESOURCES
LOGAN, UTAH July 31, 1974

RESOLUTION FOR UCOWR TO SUPPORT AN ADVISORY COUNCIL ON SCIENCE AND TECHNOLOGY

WHEREAS, the former Office of Science and Technology provided an effective coordinating function for federal research and the total national water resources research effort; and

WHEREAS, the Office of Science and Technology provided a mechanism whereby important water resources research needs could be brought directly to the attention of the Office of Management and Budget and other White House units; and

WHEREAS, the Office of Science and Technology provided a valuable mechanism for extending and strengthening the relationship between the university community and the federal agencies concerned with water resources research; and

WHEREAS, prominent spokesmen for science have recently recommended a resumption of the functions of the Office of Science and Technology by the establishment of an Advisory Council on Science and Technology to be located in the White House;

THEREFORE, BE IT RESOLVED that the Universities Council on Water Resources expresses its support for the establishment of an Advisory Council on Science and Technology to the President of the United States and to the President of the National Academy of Sciences and the National Academy of Engineering.

R-12

RESOLUTION PASSED AT THE 1974 ANNUAL MEETING
UNIVERSITIES COUNCIL ON WATER RESOURCES
LOGAN, UTAH July 31, 1974

RESOLUTION ON INVITATION TO UNIVERSITY FACULTY IN THE WATER RESOURCES FIELDS TO SPEND LEAVES IN PUBLIC AGENCIES

WHEREAS, the Universities Council on Water Resources (UCOWR) members and federal and state water resource agencies have in unique ways the need for scientifically sound methods for realizing desirable water resources goals; and

WHEREAS, federal and state water resource agencies frequently experience important unfulfilled needs for specialized professional workers in the water resources fields; and

WHEREAS, many faculty of UCOWR members in diverse water resources fields may be interested in a leave in professionally rewarding federal service; and

WHEREAS, the Director, Water Resources Council (WRC), has invited professional staff of UCOWR member universities to consider challenging assignments in WRC; and

WHEREAS, the mutual benefit of such an arrangement may apply similarly to other public agencies;

THEREFORE, BE IT RESOLVED that UCOWR encourages administrators of public agencies concerned with water resources to adopt the policy of inviting water resources specialists of universities to spend leaves in agency assignments.

R-13

RESOLUTION PASSED AT THE 1974 ANNUAL MEETING
UNIVERSITIES COUNCIL ON WATER RESOURCES
LOGAN, UTAH July 31, 1974

RESOLUTION ON
SUPPORT FOR INTERNATIONAL ACTIVITIES

WHEREAS, the United States has established a recognized international leadership in water resources studies; and

WHEREAS, this leadership can only be maintained through active and widely based contacts with our foreign associates; and

WHEREAS, some essential contacts and valuable exchanges of ideas occur at international conferences;

THEREFORE, BE IT RESOLVED that the Universities Council on Water Resources urges federal agencies to provide support for international conferences and seminars which promise worthwhile exchange of ideas and evaluation of advances in water management and planning.

R-14

RESOLUTION PASSED AT THE 1974 ANNUAL MEETING
UNIVERSITIES COUNCIL ON WATER RESOURCES
LOGAN, UTAH July 31, 1974

RESOLUTION OF APPRECIATION

TO UTAH STATE UNIVERSITY

WHEREAS, Utah State University provided outstanding services and excellent facilities for the 1974 Annual Meeting of the Universities Council on Water Resources (UCOWR) in the tradition of western hospitality; and

WHEREAS, Dr. Jay Bagley, Anne Humble and the local arrangements committee working with Dr. Dallas Holmes and the Conference Institute staff arranged formal sessions, social functions and family activities that contributed to a productive and enjoyable meeting;

THEREFORE, BE IT RESOLVED that the Council expresses its sincere appreciation to President Taggart and Utah State University for hosting the 1974 UCOWR Conference.