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Prepared by

LINSLEY, KRAEGER ASSOCIATES
527 Bayview Drive
Aptos, California 95003

Prepared for

Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, California 94304

EPRI Project Manager
E. G. Altouney

Supply Program
Energy Analysis and Environment Division

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Prepared by
Linsley, Kraeger Associates
Aptos, California

ABSTRACT

A workshop was held to develop recommendations on research needed to help the electric utility industry meet its needs for water. Seven priority research areas were defined and twenty other research topics identified. These are described in this report. The major emphasis of the suggested research is in the socio-economic and legal aspects of water use for electric energy production. Several papers which were presented as a basis for discussion are reproduced in full. These include papers by Linsley (Water Availability), Ortolano (Public Participation in Planning), Gjelde (Economics), Love (Social Effects Assessment), and Trelease (Water Law). The priority research topics are:

1. Alternate sources of cooling water,
2. instream water requirements,
3. public participation in planning,
4. estimates of potential hydroelectric energy,
5. slurry transport of coal,
6. strategies for coping with drought, and
7. the socio-economic basis for resource allocation.

PREFACE

On March 19-21, 1980 the Electric Power Research Institute (EPRI) convened a Workshop on Water Supply for Electric Energy to review the problems of the electric utility industry with respect to water and to outline a program of research in the water-supply area. Water is both a source of energy at the hydroelectric power plant and an important element in the heat-rejection process at thermal power plants. The goal of the workshop was to suggest a research program that will assist the utilities in securing water needed for new plants.

Thirty-six scientists from the utilities, government, industry, and academia joined with representatives of EPRI in the workshop. The workshop was organized by Dr. Edward G. Altouney, Project Manager in the Supply Program of the Energy Analysis and Environment Division, in cooperation with Ray K. Linsley, consultant and partner in Linsley, Kraeger Associates. This document is a report of the proceedings of the workshop.

In these proceedings, the reader will find a list of seven priority research areas as identified by the participants and a list of twenty other important research areas. The papers presented on the second day of the workshop to stimulate discussion on needed research are reproduced in full. Papers describing current EPRI research in water-related areas are only summarized in Section five, since full details are to be found in other EPRI reports.

The organizers of the Workshop on Water Supply for Electric Energy extend their sincere thanks to the participants in the workshop. They have contributed much to the work of EPRI and, hence, to meeting the needs for energy during the critical years ahead. Special thanks to Kathy Davis whose advice and assistance in the logistics of the workshop contributed greatly to its success and to Sally Large who reduced the proceedings to paper accurately and swiftly.

Additional comments and suggestions on the subject of the workshop are welcome at any time. There will be more meetings in the future since the research program which develops out of the suggestions of the workshop will require regular oversight.

CONTENTS

Section 1
SUMMARY

Water is vitally important to the electric utility industry. About fifteen percent of the nation's electric energy is generated by hydroelectric plants, thus reducing the need for an equivalent fuel source. Water, an efficient and relatively low-cost coolant, is the preferred coolant for steam-electric power plants. It is, however, becoming increasingly difficult to secure an adequate supply of water for either hydroelectric generation or cooling in all parts of the United States. Physical water shortages, land-use constraints, competing water demands, water quality control requirements, and many other factors limit the availability of water. The topic of water supply for electric energy is, therefore, quite properly of interest to the Electric Power Research Institute.

Relatively intensive research on water problems in general began in the United States in 1964 with the passage of the Water Resources Research Act. This does not deny the importance of more than a century of research and design experience gained in actual use of water for many purposes including electric power generation. However, problems change with time. Changing technology, differing public attitudes, and shifts in the world economy all bring new problems to the fore. The world crisis in petroleum production has caused a resurgence of interest in hydroelectric power, including low-head and low-capacity plants which would have been considered uneconomic only a few years ago. Increasing concern for the environment, more intensive competition for scarce water resources, and new technology have created a new set of problems with respect to water with which all planners must cope.

The workshop reviewed ongoing water-related research at EPRI (Section 5) to define the boundaries of areas which need not be reworked. This was followed by a series of papers dealing broadly with water availability (Section 6), public participation in the planning process (Section 7), the economics of water use for energy (Section 8), social effects analysis (Section 9), and legal problems of water use for energy (Section 10). These papers are reproduced in full in the proceedings.

Following the background discussions, workshop participants were divided into task groups and asked to develop lists of research needs with priority assigned. Out of these lists and a plenary discussion session a list of seven priority research areas has been formulated (Table 1-1). These research areas represent problems which are encountered to some degree by almost all utilities in the country. These topics define rather broad research areas which are further subdivided and the nature of the required research discussed in Section Three.

Table 1-1

PRIORITY RESEARCH AREAS

1. Alternate sources of cooling water
2. Improved definition of instream water requirements
3. Public participation in the planning process
4. Estimates of potential hydroelectric power
5. Water for slurry pipelines
6. Strategies for coping with drought
7. The socioeconomic basis for resource allocation

Table 1-2 presents a list of twenty research topics which were suggested by the task groups. These topics are considered to be important but of lesser urgency than the topics of Table 1-1. The topics of Table 1-2 tend to be of more local or regional interest than the priority topics. Some utilities may find one or more of the "important" topics to be more urgent than the "priority" topics because of special conditions which exist within their operating area.

It is clear that there are urgent and researchable problems which bear on the availability of water to meet the needs of the utilities for both cooling water and hydroelectric generation. A large part of the needed research is in the social, economic and legal areas which impinge upon--indeed may control--the technological decisions of the future. In many cases this social, economic and legal research is not exclusively tied to water problems, but may have value in other aspects of utility planning and operation.

None of the topics suggested herein are totally unresearched. In planning for specific research projects care should be taken to avoid repeating work already done. Hence, in many cases, a literature survey is recommended as part of the research need.

Table 1-2

OTHER IMPORTANT RESEARCH PROJECTS

SUPPLY OF COOLING WATER

1. Socioeconomic comparison of coastal and inland siting for thermal power plants
2. Improved estimates of water requirements for alternative cooling methods including consideration of risk

LEGAL STUDIES

3. Investigation of the impact of preference rules in state water codes
4. Legal and economic considerations affecting the concept of water banking

SOCIAL AND ECONOMIC STUDIES

5. The value of water in comparison to cost
6. The economic costs of environmental regulation
7. The social effects of project construction
8. The socioeconomic effects of energy development
9. The societal costs of short-term capacity shortages
10. Potential multi-purpose uses of power reservoirs
11. Social effects assessment after the fact--was the initial assessment reliable?

HYDROLOGIC STUDIES

12. Improved methods of estimating evaporation from cooling lakes and towers

MISCELLANEOUS

13. Continued extension of the EPRI Water Supply Computerized Information Directory
14. Water use requirements in hard path vs soft path technologies
15. Water export vs energy export from a river basin
16. The flexible design of energy systems
17. Compatibility requirements of water for thermal injection
18. Public perception of catastrophic events
19. Regional assessments of environmental/hydroelectric conflicts
20. Water conservation methods in agriculture

Water is in short supply in many areas of the country. The desert areas of the southwestern United States are clear examples with current use exceeding locally available supplies. As time passes and demands increase, it is expected that this shortage will spread eastward into the southern great plains. Even in those areas which are normally considered to be humid, problems of shortage arise -- witness the drought of the mid-60's in the northeast, or the difficulty of finding large amounts of fresh water in Florida. If the demand is large enough, problems of inadequate local supply can be found in almost every state of the union.

Where actual physical shortage does not exist, legal shortage can be found. South Dakota and Wyoming have passed laws curbing and controlling water appropriation by the coal mining industry. Montana forbids the change to industrial use of any agricultural appropriation exceeding 15 cubic feet per second, and has defined the basic water right so that the use of water to export coal from Montana is not a beneficial use. The concerns which led to such restrictions need to be analyzed from social, economic and environmental perspectives.

Section 2

OPENING REMARKS

René Malès*

ROLE OF THE WORKSHOP

I am delighted at the opportunity to welcome you to this EPRI workshop on Water Supply for Electric Energy. We sincerely appreciate your willingness to come here to help EPRI staff do three things: first, to identify the issues in what we believe is a very critical area for the electric utilities; second, to think through with us what are researchable topics in this area; and third, to help us define what EPRI's role in these areas should be.

If you have glanced at the program it is quite clear how we are going to go about this. Essentially, on the first day we are going to have presentations by the staff of past, present and prospective research at EPRI having to do with the subject of water supply.

On the second day, experts within and outside the utility industry will review for you what they see to be important issues from their own experience and their own research. Then, smaller groups will work through these ideas that you have heard during the program. Finally, on the last day the hope is to begin the synthesis by discussion by the group as a whole. But most importantly, the last day initiates the work of Ray Linsley who is here to coordinate this workshop. His job is to bring together the synthesis and present it to the EPRI staff.

There is a fifth step; the final distillation of this information by EPRI's staff and interpreting these ideas into a series of proposals or projects. These then

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*Director, Energy Analysis & Environment Division, Electric Power Research Institute.

have to be taken to our own internal advisory committee to make sure they fit within our priorities and our funding. Ed tells me that the biggest hurdle is to get it by my desk for signature after this entire process.

But I don't want to minimize the importance of the first four steps that we are taking in the next few days. It is important to assure that EPRI is making meaningful contributions to this area. The only way that we can assure ourselves of that is to make sure we're addressing the right topics.

ROLE OF EPRI

It is appropriate to review with you what EPRI's role is and why it should be interested in water resources. In order to do that, let me step back historically. Most of you will remember that EPRI was created in 1972. It was viewed as necessary for the utilities to control their technical destinies by developing technologies which would lower costs, reduce the impact on the environment, broaden fuel options, and improve the consumer's use of energy either directly, by better appliances, or indirectly, by better energy systems within the electric utility sector.

After a couple of years of operation, it became quite clear that the economic and environmental setting in which such R & D decisions were made were crucial to making optimum, or at least good, R & D decisions. For that reason, the Energy Analysis and Environment Division was created to advise EPRI on the setting in which the technology would eventually have to operate so that we could make the right R & D choices. Today we have additional objectives in the Division. But this is the principal objective in relation to the water supply question.

Water supply is a clear example of the kind of information which will affect R & D choice. Let me just give you a few simple examples. We are working on alternatives to once-through cooling systems. In fact, even working on the completely dry cooling. The amount of water available, the kind of water available, and the alternatives available will, in large measure, determine the relative funding of these technologies.

Similarly, the location of plants is becoming dependent in some measure on water availability. Not only is the question that of the physical resource of the water molecules trickling by, but the access to those resources that is the water

rights. There are some alternatives to avoid a substantial amount of water use, dry cooling, for example. However, for a synthetic fuel in which water becomes a chemical agent reacting with the coal to make a gas or a liquid, then water becomes an important criteria in determining the location of such plants.

INCREASING IMPORTANCE OF WATER

It sometimes seems strange, when we've been using water for such a very long time, that suddenly it has become so terribly important. Maybe that's not true for those of you who have been spending your whole career in the area of water research or water management. Certainly to the general public the question of water has increased in importance in the last decade or so. Why is that true?

One reason is the increasing intensity of use which comes from greater numbers of people, greater services that water has to perform, different uses that water is being put to.

Another reason, it seems to me, is that we have come to the point in the U.S. when all water rights have been allocated either explicitly or implicitly. No longer can somebody take a substantial fraction of the flow of a stream and use it for his own purposes. It now involves a great deal of permitting which involves some trade-offs, some contention over the allocation of those water rights.

Another reason why the use of water has become such an important criteria is that water quality is recognized as valuable and use may change water quality. There are two ways in which quality is perceived as important. First, water quality affects the use that can be made of water, whether in an industrial process or for human consumption. Second, people have taken a different view on the acceptability of the quality of water resources. The stream that meandered through the industrial city with slicks of oil and garbage running in it is no longer acceptable. In fact, we have spent a great deal of money to clean those streams.

WATER SUPPLY ISSUES

What are the issues to be examined? I will propose several with some trepidation because probably I am the least knowledgeable one in this whole room on the question of water issues. For convenience, I have divided the issues into three areas.

First, it seems to me important to recognize that water use, except possibly for fusion, is merely a transportation of that H_2O molecule from one location to another. Let me make that very clear. For example, in evaporative cooling, literally all you're doing is making the water molecule fly in the air and come down somewhere else. It is true that if it comes down in the middle of the ocean its availability and quality are changed. But it still comes down somewhere. Even in the case of gasification, in which the water is used for its chemical constituency binding the hydrogen atom with carbon as opposed to oxygen, we transport that new molecule and burn it somewhere else and recreate the water. So, all we have done is transport the water from one location to another.

It is important to note that water use may also affect its quality. This may involve the addition of chemical contaminants, thermal effluents, or the mixing with lower quality water. Sometimes water use can improve its quality.

Second, it is important to recognize that water exists in several different natural states. Ownership is important. Water rights are generally allocated. A new user has to gain his right to use the water. There is some hierarchy of perceived value assumed by the society in the United States. Most important is drinking water. Next in importance is the use for farming. In some areas, that may be the first priority. Industrial uses, cooling, waste, and chemical uses follow down the line of importance.

Not only is ownership one of the characteristics of water occurrence, but water quality is another important characteristic. Quality, however, differs depending on the end use to which it will be put. Salt is generally viewed as a contaminant. Around the Bay Area, producers of salt via evaporation of sea water see it as a valuable resource. A French entrepreneur found that a special water with a gaseous contaminant had a value. It was labeled Perrier and now sells at a premium. Maybe contaminants are not so bad, after all. It depends on the use you want to make of the water.

The question of location also involves physical proximity. This is particularly so because of the difficulty and cost of transporting large volumes of water long distances. Therefore, long-range transport is usually done for high volume end uses. Normally, the plant is brought to the water rather than the other way around. Also it is important to recognize that water is not of equivalent accessibility. That is, we have surface water, shallow aquifers and deep aquifers.

The third major issue that I propose we consider is that technology can affect the amount and quality of water needed for a given end use. To use the example of steam raising and the need to cool that steam at the back end of the turbine. This has been done with open-cycle cooling. There is no technical reason why we can't do it with dry cooling. There may be economic reasons.

Similarly, for irrigation, flooding is the most inefficient method of getting water to the crops. Drip irrigation is a much more effective way and lowers the total water requirement. Again, a technical change to effect a difference in the use. The coal slurry pipeline has been of concern because of the water it will transport from one area to another. One way of solving this problem is to have a closed system. It is not inexpensive and possibly it is uneconomical, but it is technically feasible.

Similarly, in the hydro-electric field, a dam can be constructed to simply provide power. Or, it can provide power and flood control, water management, irrigation, and navigation. Again, the use of technology to combine resources might be one way of optimizing the water requirements.

The issues to examine revolve around three areas: use changes water location and quality; water ownership, quality, and physical location determine how water will best be used; and technology can be used to change these parameters.

SUMMARY

The problem we are facing is not identifying water scarcity per se, but rather what will relative water availability, institutional processes, and technical development lead to, and how should this affect the electric utility research and development effort.

Finally, our most important concern should be what information is necessary for EPRI staff to develop so it can give the right insights to the technology divisions and the utilities.

Again, I would like to thank you for participating in what I think is going to be a very important workshop. Water is clearly a critical element in any energy plan, and we now have the opportunity to insure wise decisions, at least at EPRI.

Section 3

PRIORITY RESEARCH RECOMMENDATIONS

Table 3-1 lists the priority research areas recommended by the workshop. These areas were included in the lists prepared by the three task groups and placed in priority order on the basis of the following scoring system:

- One point for each task group which included the topic in their list
- One point if the topic came up in floor discussion independently of the task groups
- One point if the topic was recommended in one of the papers presented to the workshop.

The seven research areas are discussed in greater detail below.

1. ALTERNATE SOURCES OF COOLING WATER

Cooling water for a steam electric plant might be obtained from several sources.

- Surface water
- Ground water
- Urban wastewater
- Agricultural return flows
- Poor quality water (brackish groundwater or streamflow, estuarine water, seawater)
- Purchase or condemnation of an existing water right
- Joint ventures with agricultural interests to conserve water

Workshop participants felt that an investigation of the advantages and disadvantages of each possible source would be helpful to a utility engaged in a search for water for a new plant. The investigation might also disclose specific research topics which could be studied, e.g., pretreatment of municipal wastewater. The investigation should consider:

- Legal constraints on use of water from each source
- Social, economic, environmental and health impacts of use of each source
- Pretreatment requirements
- Ultimate disposal problems
- Relative costs of the different alternatives
- Availability of water from various sources

TABLE 1. PRIORITY RESEARCH AREAS

1. ALTERNATE SOURCES OF COOLING WATER

2. IMPROVED DEFINITION OF INSTREAM WATER REQUIREMENTS

3. PUBLIC PARTICIPATION IN THE PLANNING PROCESS

4. ESTIMATES OF POTENTIAL HYDROELECTRIC POWER

5. WATER FOR SLURRY PIPELINES

6. STRATEGIES FOR COPING WITH DROUGHT

7. SOCIOECONOMIC BASIS FOR RESOURCE ALLOCATION

The research should begin with a literature and experience search to identify those characteristics of each source which have already been investigated and to document these findings. This search should also identify specific research topics which have not been investigated or for which additional work seems to be needed.

This would be a major project and it will probably prove desirable to subdivide the work into separate investigations of the legal, economic, social, ecologic, and technical aspects of each source to assure proper expertise on each team and to accelerate the completion of the first phase research.

2. IMPROVED DEFINITION OF INSTREAM WATER REQUIREMENTS

There seems to be agreement across the nation that there should be some type of reservation of water to meet instream needs. This water would serve fish and wildlife, riparian vegetation, aesthetic values, the need for fresh water in estuaries, and other specific needs. The actual water requirement for these purposes for each stream has not been well defined, and the legal structure to provide such reservations varies from state to state. In some states there is no provision in water right law to protect instream uses. Elsewhere there are water codes which are quite specific as to instream reservations.

There is a need to develop a better understanding of instream requirements and the ways in which the water can be provided. Utilities will benefit from the research because they will be informed on what may, in some river basins, prove to be a serious constraint on water use. If the instream allotment is too small, serious ecologic problems may result which could create future problems for water users. If the instream allotment is too large serious economic loss may result.

The immediate research need is for a comprehensive literature search to define current knowledge on the following topics:

- Existing laws regarding instream flow requirements
- Technical specifications for the water requirements for aquatic life
- Requirements for recreation
- Requirements for water quality maintenance
- Requirements for navigation
- Freshwater requirements for estuaries, riparian vegetation, and flood plain wetlands

On completion of the literature search, important gaps in understanding of in-stream requirements should be identified and specific research initiated to fill these gaps.

3. PUBLIC PARTICIPATION IN THE PLANNING PROCESS

Experience (Section 7) has shown that involving the public in planning at an early stage may be helpful in eliminating (or reducing) opposition to a project and, in some cases, may result in a better project design because of information received from the public which might have been otherwise unavailable. Research in this area should include:

- A literature survey to identify methods for achieving meaningful public participation which have been used in the past, the record of success or lack of it for each method, and the conditions under which particular methods are most likely to succeed;
- a survey of utility experience with public participation and identification of features that are specific to the utility industry;
- conduct of field experiments during planning of actual projects to test new ideas evolving from the previous surveys; and,
- preparation of training programs for utility staff who will be involved in public participation efforts.

4. ESTIMATES OF POTENTIAL HYDROELECTRIC ENERGY

There was a clear feeling during the workshop that there is a high probability that the current national survey of hydroelectric power potential may not yield reliable answers. The feeling was based on the impression that the survey may not recognize all of the constraints that actually exist on hydro installations and will lead to an overestimate of the potential for future hydroelectric development. EPRI might undertake two actions:

- Meet with leaders of the national survey to discuss ways of assuring reliable assessments of potential energy yields, and
- Support a study to verify the results obtained from the national survey. The verification would probably consist of detailed studies of selected river basins for comparison with the results of the national inventory.

5. WATER FOR SLURRY PIPELINES

Since there will be an increased use of coal as an alternate to petroleum and probably nuclear fuels, an important factor will be the cost of transport of the coal to the point of use. Slurry transport appears to offer one possible transport mode at reasonable cost for certain conditions. However, as presently used, slurry transport also requires the export of water with the coal. Because of this some states have already erected legal barriers to the use of water for slurry transport systems. The following research topics are suggested within this area:

- A survey of the legal constraints on use of water for interstate slurry transport, and possible legal remedies against these constraints.
- Exploration of innovative systems for slurry transport. For example, a slurry pipeline might use water from the state receiving the coal in a continuous closed loop system.
- Possible use of poor quality water for slurry transport.
- Feasibility of other liquids (oil or methanol) as transport media.

6. STRATEGIES FOR COPING WITH DROUGHT

The possibility of drought is always present and casts a shadow on the utility of hydroelectric power installations. In some cases drought may restrict thermal plants by limiting availability of cooling water. The participants in the workshop felt that it was important to know more about possible ways one might cope with drought. Specific suggestions include:

- Develop an improved basis for estimating the probability of drought for use in project planning.
- Develop improved strategies for use in making operational decisions during a drought.
- Use of inflow forecasts to optimize energy production at hydroelectric plants.
- How can drought problems at thermal plants be avoided or mitigated?

7. THE SOCIOECONOMIC BASIS FOR RESOURCE ALLOCATION

Scarce resources are allocated under a complex of state and federal law and administrative regulations. Water rights, land use constraints, safety requirements, and water quality controls are examples of allocation mechanisms. Most public leaders would probably express the view that the current basis of allocation of water is optimal from the viewpoint of their state. Considering, however, that some of the controls were never intended as devices for water allocation and are

in some cases in direct conflict with other regulations, it is difficult to accept the conclusion that current allocation procedures are optimal from any viewpoint.

This research project contemplates an analysis of the actual basis of water allocation and the overall effects of this allocation procedure. A case study approach will probably be most fruitful, with an investigation of the constraints impacting specific projects and a determination of the socioeconomic consequences of these constraints. A study of several projects distributed throughout the country would indicate whether the current basis for water allocation is consistent between states, and whether these systems are individually rational. If the system now in use is open to improvement, the research should consider the way in which such improvement might be brought about.

Section 4

OTHER IMPORTANT RESEARCH

Table 4-1 presents a list of other "important" research topics. This list is a consolidation of the remainders of the lists from the three task groups after the priority topics are subtracted. While these topics are not included in the top priority list, the topics are important. As one participant said during the discussion "They are all important. We would not have suggested them if they were not important." The difference between the topics of Table 4-1 and those of Table 3-1 are to be found in one of the following points:

- Priority topics are generally broader. Other important topics may be of regional or local concern or of interest to a limited special sector of the utility industry.
- Priority topics are generally viewed as more urgent.
- Priority topics are expected to assist utility planning more than are the other "important" topics.

The subdivision into Priority and Other Important topics implies that there exists a third level of potential research which is, for the present, not viewed as urgent or important or may be of a very local concern. In short, these lists have been screened from a more extensive group of potential topics which were not considered important enough to discuss at this time.

The topics of Table 4-1 have been grouped into subject matter areas for convenience only. The order of listing within Table 4-1 as a whole or within the subgroups has no special significance. The topics may be of differing levels of importance but no attempt has been made to compare them. It is more likely that the differences, if any, are in the local or regional view and that there are no significant differences in the overall national importance. The following sections amplify on the brief topical descriptions of Table 4-1.

1. SOCIOECONOMIC COMPARISON OF COASTAL AND INLAND SITING FOR THERMAL POWER PLANTS

Many existing thermal electric power plants are situated on the shore line of the oceans or estuaries. This siting made large amounts of water available for once-

Table 4-1

OTHER IMPORTANT RESEARCH PROJECTS

SUPPLY OF COOLING WATER

1. Socioeconomic comparison of coastal and inland siting for thermal power plants
2. Improved estimates of water requirements for alternative cooling methods including consideration of risk

LEGAL STUDIES

3. Investigation of the impact of preference rules in state water codes
4. Legal and economic considerations affecting the concept of water banking

SOCIAL AND ECONOMIC STUDIES

5. The value of water in comparison to cost
6. The economic costs of environmental regulation
7. The social effects of project construction
8. The socioeconomic effects of energy development
9. The societal costs of short-term capacity shortages
10. Potential multi-purpose uses of power reservoirs
11. Social effects assessment after the fact--was the initial assessment reliable?

HYDROLOGIC STUDIES

12. Improved methods of estimating evaporation from cooling lakes and towers

MISCELLANEOUS

13. Continued extension of the EPRI Water Supply Computerized Information Directory
14. Water use requirements in hard path vs soft path technologies
15. Water export vs energy export from a river basin
16. The flexible design of energy systems
17. Compatibility requirements of water for thermal injection
18. Public perception of catastrophic events
19. Regional assessments of environmental/hydroelectric conflicts
20. Water conservation methods in agriculture

through cooling and the plants were less costly than if more complex cooling systems had been used. Now, however, it is more difficult to secure the necessary approvals for such coastal sites and new plants tend to be sited in inland location where cooling ponds or towers must be used. In some instances these sites are substantial distances away from the load centers they are intended to serve. What are the socioeconomic costs of this shift in location? What are the compensating benefits? Is it truly in the national interest to avoid coastal location in favor of inland sites? Case studies of existing or proposed plants are suggested to determine the factors which control the socioeconomic balance.

2. IMPROVED ESTIMATES OF WATER REQUIREMENTS FOR ALTERNATIVE COOLING METHODS INCLUDING CONSIDERATION OF RISKS

Given the limitations on the availability of water for cooling, research has been pressed to devise less water consumptive cooling schemes. Generally these alternative systems are more costly. The specified water need for a new plant may play an important role in site selection and plant cost. Typically the utilities have been conservative in their specifications for water acquisition so as to be sure that an adequate supply of water is available at all times. What would be the consequences of a "sharper pencil?" If the estimates minimized the water requirements to cope with the unexpected and infrequent, costs would be lower, site selection possibly easier, and public opposition might be reduced. Techniques of risk analysis and hydrologic probability determination might possibly lead to more cost-effective design.

3. INVESTIGATION OF THE IMPACT OF PREFERENCE RULES IN STATE WATER CODES

Many water rights codes specify a preference list for water users. Domestic use is typically the highest preference with irrigation in second place in the western states and industry in the eastern states. (See Section 10.) Do these preference lists impose any important constraints on the utility industry? Would the utility industry be better off if they received special mention in the lists and were closer to the head of the line? These questions go to the question of how the water rights code is actually administered and how the preference list is interpreted. A modest program of legal research is suggested to ascertain the answers to these and related questions. These answers may be directly helpful to a utility which is seeking a water right, merely by presenting a summary of precedents. They will also indicate whether there is a reason to work for changes in state water codes.

4. LEGAL AND ECONOMIC CONSIDERATION AFFECTING THE CONCEPT OF WATER BANKING

The idea has been advanced that water rights might be leased or banked. Under this system the holder of a right could lease this right to another person for one or more years to meet a specific need as, for example, during a drought. When the lease is complete the right is returned to the original owner for such use as he wishes to make of it. Thus a rancher might use water to irrigate pasture but when the water is needed elsewhere he could lease it to an other user -- a city needing to augment its supply or a utility requiring additional water for cooling. The lease transaction would, of course, be financially satisfactory to the lessee and lessor. This project contemplates an investigation of state law and administrative practice in several states to determine whether water banking could be used under present code, the constraints and limitations which would be imposed, and the changes in code required to make water banking practical. The proposal is an alternate to outright sale as a means of water right transfer and might prove quicker and more attractive, especially for water required only rarely.

5. VALUE OF WATER IN COMPARISON WITH COST

Typically the designer of a power plant is concerned with cost of water, which may influence some features of the design. Generally, however, the cost of water is so low that it is not a deciding factor in system costs. There is another money measure for water, its value. Value measures what the water is worth in a specific use. Essentially it measures the productive ability of water. One measure of the value of water to a utility might be the sale price of the energy generated per unit volume of water consumed at a specific hydroelectric plant. Water consumption at hydroelectric plants is usually quite small since the only loss of water is by evaporation to the atmosphere. Dry cooling is less efficient than wet cooling for a thermal power plant. There is some additional energy generated when wet cooling is employed and the selling price of this energy per unit volume of water evaporated in the cooling process is the value of the water.

The value of water usually far exceeds its cost. Allocation of water and other resources should be based on the value of the resource among competing users. Numerous studies of the value of water have been made, mostly without considering the energy industry specifically. Generally such studies cite values in terms of regional averages over a particular industry or class of industries. For many uses including energy, the value of water is very site specific. For example,

elevation may be a very important factor in water value. This research project proposes the development of a basic methodology for determining the value of water in a specific situation so that the utilities may make such estimates when needed for specific projects. Information gained during the study may have other uses to the utility industry as well.

6. ECONOMIC COSTS OF ENVIRONMENTAL REGULATION

Few would argue against the assertion that environmental regulations impose costs on individuals and the public as a whole. Whether these costs are balanced by resulting benefits would likely prove the basis for an extensive debate. The debate would be helped by a better understanding of the costs imposed by the regulation. This project proposes a detailed investigation of the costs imposed on the utility industry by existing environmental regulations. It is intended that the study be broadly based. Costs imposed on the utilities because of high cost of capital which is in turn related to environmental regulation should be considered as well as any other secondary and indirect impacts. The impacts of these costs on the consumers should also be estimated. Analysis of the benefits is much more difficult because many of the benefits of environmental controls are intangible (non-quantifiable). Beyond this the benefits are diffused through many people over large areas and are correspondingly difficult to assess. Consequently, this study proposes to emphasize only costs with the thought that in the process of identifying costs, there will be some clarification of the benefit issue.

7. SOCIAL EFFECTS OF PROJECT CONSTRUCTION

The construction of a large energy facility has major social impacts. In some situations a "boomtown" may be created near the project site, straining local facilities and social networks. In other situations the construction effect will be more modest and even provide distinct social and economic benefit to local communities. A basis for predicting the magnitude and types of effects associated with construction and methods of mitigating the expected problems is needed.

8. SOCIOECONOMIC EFFECTS OF ENERGY DEVELOPMENT

Development of major energy projects can enhance the local economy through direct payroll which, in turn, supports local retail businesses and service organizations. The available energy may induce the establishment of other industry still further expanding the local economy. Energy projects may induce costs for new services both locally and regionally.

What are the local and regional socioeconomic effects? How are they divided between local and regional? Who are the beneficiaries of the increased economic activity? Who will experience economic costs because of the project? Some thorough studies of selected projects would help to answer these (and other) questions and provide information useful in presenting a case for new projects in the future. In this case the benefits should be net benefits after induced costs are deducted.

9. SOCIETAL COSTS OF SHORT TERM CAPACITY SHORTAGES

What are the socioeconomic costs arising out of short-term capacity shortages? During drought it is expected that cutbacks in hydro production may occur and that these cutbacks can be offset by throwing more load on thermal plants. Thermal plants can also be forced to operate at reduced capacity during droughts if insufficient cooling water is available. In severe conditions, some form of rationing, brown-outs, etc. may be necessary to cope with the inability of the system to meet the demand. Similar conditions have been encountered in the water supply field. The results of the proposed study could be helpful in many ways. The costs of short term capacity shortages are relevant to the analysis of risk in sizing installations, determination of water requirements for thermal plants, evaluating the impact of instream uses, and other situations. It is proposed that up to four regional cases be studied to determine what the costs to society as a whole would be if the system could not meet demands for periods up to several weeks. The investigations should be thorough and consider both economic costs to the area resulting from restrictions on available energy and also intangible social and environmental impacts.

10. POTENTIAL MULTI-PURPOSE USES OF POWER RESERVOIRS

The utility industry owns a large number of reservoirs for hydroelectric plants, cooling water, etc. What other uses of these reservoirs are feasible? Multi-purpose use might:

1. Enhance the economic feasibility of a project by providing additional income;
2. represent mitigation of environmental impacts of the reservoir or other facilities in the system;
3. improve the public image of the industry.

It is essential, however, that the additional uses be compatible with the primary purpose -- energy production -- and be consistent with proper guidelines for safety, water quality management, etc. The analysis should be pointed at finding

the secondary uses which are feasible, perhaps on a regional basis; defining the modifications, if any, required to make the reservoir usable for these secondary uses; and evaluating the benefits to the electric utility of providing for such multi-purpose use in new or existing reservoirs.

11. SOCIAL EFFECTS ASSESSMENT AFTER THE FACT--WAS THE INITIAL ASSESSMENT RELIABLE?

Social effects assessments are becoming relatively common in connection with major projects, particularly those which have attracted high public interest. However, social effects assessment is a relatively new venture for the sociologist and there is little formal basis for judging the reliability of the assessment or of the predicted effects. There are believed to have been assessments made as much as ten or more years in the past which could now be the basis for a study to determine whether these assessments were on target. By comparing several cases, it may be possible to identify procedures which were consistently more successful than others, determine those aspects of the assessments which were more reliable and those for which reliability was low, identify the external factors which caused actual effects to differ from those projected and probably to reach other useful conclusions. Such studies should improve on the reliability and credibility of social effects assessment in the future.

12. IMPROVED METHODS OF ESTIMATING EVAPORATION FROM COOLING LAKES AND TOWERS

The water requirement for a cooling system is largely the makeup water required to replace that evaporated during the cooling process. Consequently accurate estimates of water requirements for cooling systems are very much dependent on accurate estimates of evaporation losses. Since the cooling system is being planned, it is not available for testing or direct measurement of evaporation loss. On the other hand since the evaporation loss is a function of local conditions as well as the specific physical details of the cooling system, transfer of estimates from other similar cooling systems may not prove reliable. Local wind, solar radiation, temperature, humidity and possibly other factors are relevant. Hydrologists have been concerned with evaporation losses from lakes and from the soil since this is a key step in the natural hydrologic cycle. Adaptation of existing hydrologic procedures to the special case with forced evaporation would appear to be feasible. With such an adaptation it would then be possible to calculate expected evaporation losses (water requirements) for a period of years and establish the water requirements on a probabilistic basis, essential to the concept of risk analysis.

13. CONTINUED EXTENSION OF THE EPRI WATER SUPPLY COMPUTERIZED INFORMATION DIRECTORY

The EPRI WSCID has been brought to first stage operating level. Soon arrangements will be made to permit utility access to the system and the information stored within it. It is certain that the existing data contained in the WSCID is not inclusive of all useful information. It is suggested that a survey of utilities and related users be made to determine what additional information could be helpful. Two suggestions made during the workshop were: (1) information on current legal cases and decisions, and (2) information, experience and data accumulated by utilities dealing with unusual problems which could be beneficial if it were available to other utilities.

14. WATER USE REQUIREMENTS IN HARD PATH VS SOFT PATH TECHNOLOGIES

Many new technologies for the production of electricity have been proposed. These technologies are presumably able to conserve on fossil fuels. Are they also conservative of water? There is some evidence that geothermal power in some configurations requires much more water than conventional thermal plants. It is recommended that studies be made to determine the water requirements of the soft path technologies -- geothermal, solar, etc. This information should be valuable in preliminary planning for use of these new technologies and may in some cases be an important factor in siting.

15. WATER EXPORT VS ENERGY EXPORT FROM A RIVER BASIN

The subject of interbasin transfers of water has been a matter of discussion (and conflict) during recent years. The Pacific Northwest has vigorously opposed the transfer of Columbia River water to the Pacific Southwest. However, the people of the Northwest have not opposed the transfer of energy produced in large part by the same water. Is an energy export a preferred solution to the water export problem? Is it equivalent in utility to the receiving region? What are the economic impacts of the energy transfer as compared to a water transfer considering both the value of the medium transferred and the cost of the transfer itself? What are the environmental consequences of energy export vs water export?

16. FLEXIBLE DESIGN OF ENERGY SYSTEMS

It is often proposed that design of a system of any kind which is to be functional over several decades into the future should be planned to be flexible. This means that the system should be adaptable and able to serve the needs of the future as

well as the present. Since our forecasts of the future are always uncertain we should plan so as to be ready for a range of alternative futures. Staged construction is a common type of flexible design. New plants or new units are installed as the need arises and if the expected need fails to develop (or an alternative system more effectively meets the needs) the expansions are not built. It is suggested that some explorations into the logic of flexible design be made, with the intent of determining time scales which are appropriate, increments of size that are economic, types of systems appropriate for flexible design, and the accuracy of projections of future requirements as a guide to planners working on system expansion.

17. COMPATIBILITY REQUIREMENTS OF WATER FOR THERMAL INJECTION

One method for development of geothermal power is to inject water into a high temperature zone so that the water is heated and returns to the surface as steam. What requirements should be imposed on the quality of the water to be injected? Can highly saline water be injected without causing problems of crystallization and plugging of natural channels of water movement in the formation? Will specific chemical constituents react with the native water or rocks to cause problems? Is sea water a suitable fluid for injection? Geochemical analysis of a specific case such as the Imperial Valley is suggested as a basis for developing some information on this problem.

18. PUBLIC PERCEPTION OF CATASTROPHIC EVENTS

Disasters of various kinds seem to invoke vastly different levels of concern among the public. It is not always the most probable, or the most destructive event, which is most feared by the public. There seem also to be clear regional differences in the public perception of disasters of many kinds. There may be reason to believe that the public is more concerned with disasters caused by the failure of a man-made facility such as a dam or a nuclear power plant than they are with more probable and possibly more destructive natural disasters such as earthquakes. A study of the social psychology of disaster with particular reference to dams and nuclear power plants may provide information that would be helpful in planning of new facilities. This study would complement the studies of public participation suggested in the priority list.

19. REGIONAL ASSESSMENTS OF ENVIRONMENTAL/HYDROELECTRIC CONFLICTS

A review and categorization of regional environmental concerns related to hydroelectric development is suggested. The aim of the study would be to determine what the specific environmental concerns are and how these might be avoided in planning or mitigated in construction. An understanding of the concerns, their relative importance from the public viewpoint, and the nature of suitable mitigation should be helpful to utilities in their planning and public participation activities. It is thought that this study might consist of a survey of utilities and environmental regulatory agencies to obtain current viewpoints. What environmental concerns do citizens regard as important and for what reasons? A review of past conflicts might also be useful in testing for possible changes or trends in public opinions.

20. WATER CONSERVATION METHODS IN AGRICULTURE

Irrigated agriculture is the largest consumer of water in the United States. A considerable effort has been directed to the development of techniques for reducing water use in agriculture. These techniques have, for the most part, been developed in areas where chronic water shortage made such developments mandatory for successful agriculture. The use of these techniques in other areas normally occurs only when the pressure of water shortage provides an incentive. The objective of this study is to develop a guide for utilities which describes the available conservation methods, tells where they are most effective, provides estimates of the costs of introducing the methods into existing farming practice, and summarizes other background data which the utilities might use in assessing the potential for water saving in agriculture within a specific river basin or project area. A literature and experience search is contemplated without field tests or other development work.

Section 5

WATER-RELATED RESEARCH AT EPRI

The research program suggested in Sections 3 and 4 emphasizes the supply aspects of water. EPRI already has research underway in several areas. The research arising out of this workshop should supplement and complement the on-going work. On the first day of the workshop, representatives of EPRI described the studies which are underway so that the other workshop participants would be aware of the current programs. Numerous EPRI reports describe completed research and several present overviews of current or future research programs. Consequently the papers presented on the first day of the workshop are not reproduced in full but merely summarized in this section.

Figure 5-1 is an organization chart of the Research and Development Group at EPRI. Water-related research is underway in three divisions -- Energy Analysis and Environment, Energy Management and Utilization, and Coal Combustion Systems. The Energy Analysis and Environment Division has a number of programs dealing with water. In the Environmental Assessment Department (Figure 5-2) the Ecologic Effects Program has as its goals:

1. Assessment of the impact of cooling systems on the ecology of streams and lakes,
2. exploration of the problems of fisheries management in cooling lakes, and
3. Evaluation of biofouling controls.

Dr. Ishwar Murarka described the activities of this program at the workshop. This research is intended to provide a basis for predicting impacts and proposing appropriate mitigation measures where necessary. Within the same department the Integrated Assessment Program seeks to develop methods for the overall environmental assessment of energy technology. This work was discussed at the workshop by Dr. Ronald Wyzga. The target of this program is the development of the assessment methodology. Specific inputs such as the impacts of cooling systems, costs of alternative technologies, and the many other factors that enter the assessment are the subject of research in other programs at EPRI or elsewhere.

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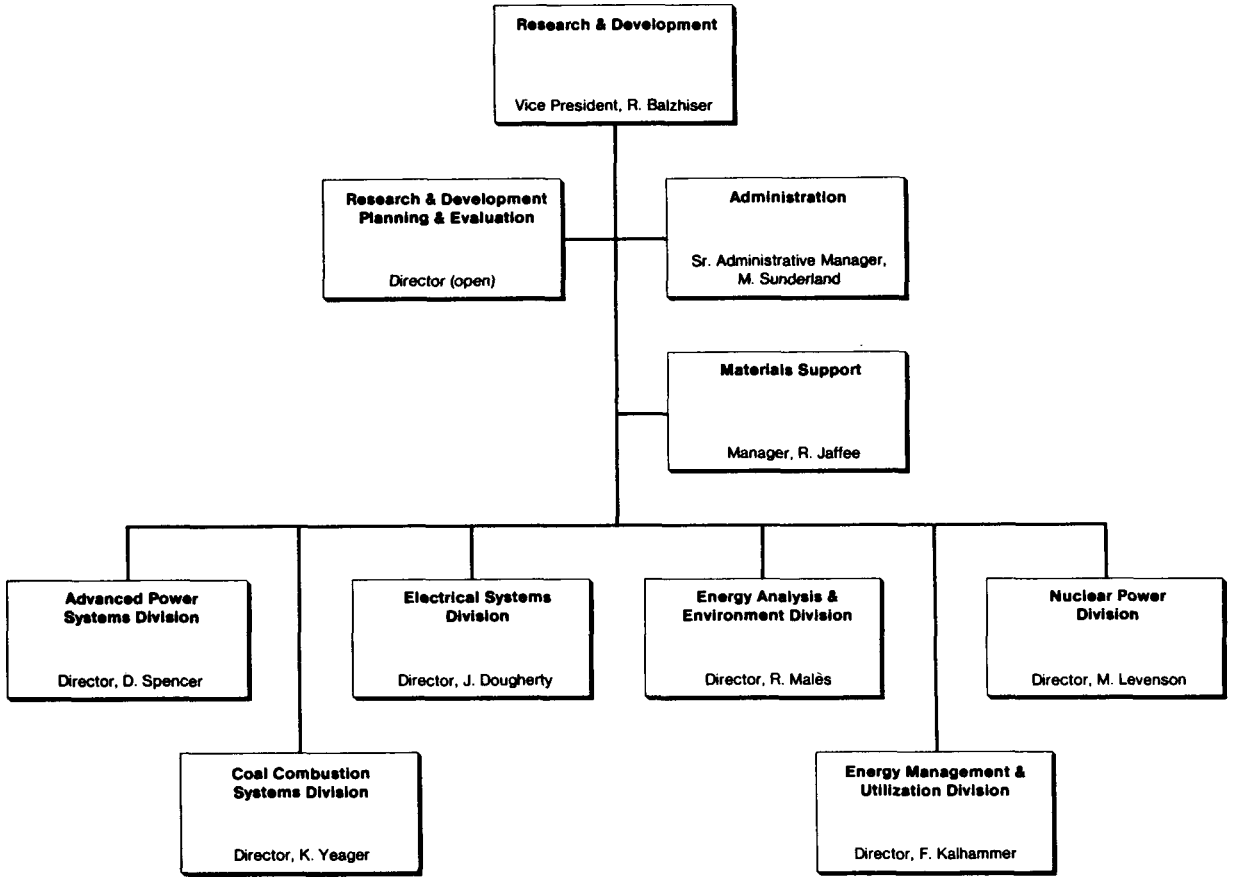

APPROVAL:

Vice President, R&D — Date

2/29/80

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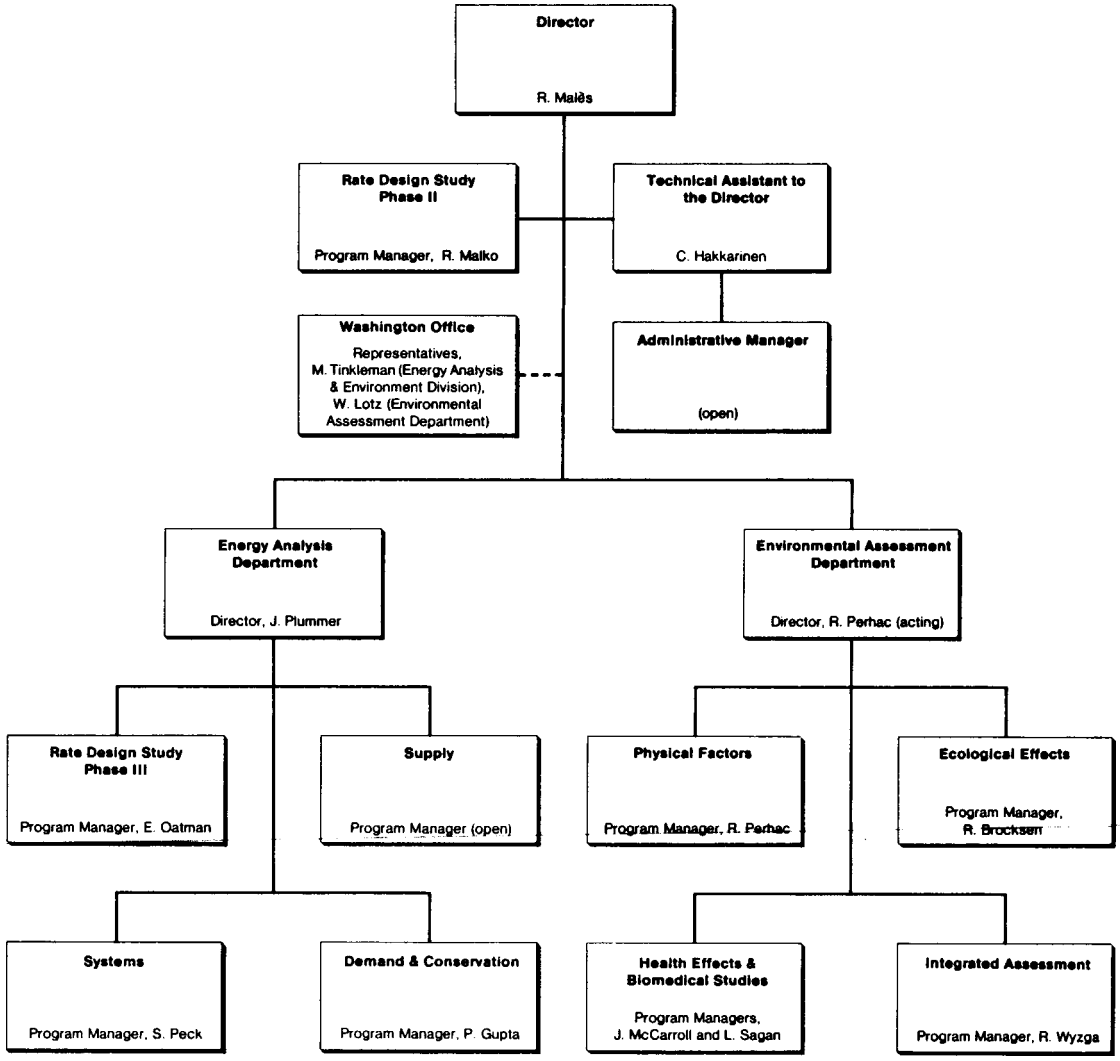

APPROVALS:

Director Date 2-18-80

Vice President, Finance & Operations Date 3/14/80

In the Energy Analysis Department, the Systems Program is working to include water as a constraint in a currently available national energy model. When developed, this modified model will permit estimates of the impact of limited water supplies on national production of electric energy, oil shale retorting, coal gasification, and operation of coal slurry pipelines. Both surface and groundwater are being considered and factors such as quality and cost will be included in the model. Dr. Dom Geraghty of EPRI assisted by Dr. Nathan Buras of Stanford University presented a description of this project. The Supply Program of the Energy Department is, through this workshop, in the process of developing a research program focussing on the supply of water for energy uses. Research already underway in the Supply Program includes development of the Water Supply Computerized Information Directory (WSCID) which was described to the Workshop by Dr. Edward G. Altouney with the assistance of Professor David E. Pingry of the University of Arizona, contractor on the model development. This directory will provide its users with a guide to sources of information on many aspects of water.

Research on hydroelectric technology is centered in the Energy Storage Program of the Energy Management and Utilization Division. This program has as its goals:

1. To advance the state of the art of hydroelectric technology;
2. to improve the performance, reliability, availability, and safety of existing and new units and structures;
3. to reduce capital, operating, and maintenance costs of hydroelectric facilities; and
4. to assess, evaluate, and improve utilization of hydroelectric resources and increase acceptability of hydroelectric facilities.

Mr. Antonio Ferreira described the activities under this program. Both pumped storage and small hydroelectric plants are included under this program as well as the more conventional installations.

The Coal Combustion Division is naturally interested in the task of heat rejection. Although they are working on alternate methods of cooling where water is unavailable, water is still the preferred coolant. Dr. John Maulbetsch, manager of the Water Quality Control and Heat Rejection Program, described the activities of this program to the workshop. The goals of the program are:

1. To reduce the requirement for high-quality make-up water,
2. to promulgate validated design guidelines for in-plant water quality control and discharge treatment,
3. to develop and demonstrate cost-effective water treatment technologies,

4. to reduce the cost of water-conserving cooling systems,

5. to predict and mitigate the environmental effects of plant-cooling systems,

6. to provide and improve the technical basis for selection and testing of conventional cooling equipment to assure adequate performance at acceptable costs, and

7. to develop safe and economic methods for disposal of sludge and ash.

Emphasis is on cooling technology with water conservation as a primary target. The research includes investigation of dry cooling towers and use of other fluids such as ammonia in closed loop cooling. Water cooling is still the preferred technology.

Section 6

THE AVAILABILITY OF WATER FOR ELECTRIC ENERGY PRODUCTION

Ray K. Linsley*

INTRODUCTION

Water is an important factor in the production of electricity. The water wheel, long a source of power for many tasks, was quickly adapted to generation of electricity. For this use a sufficient quantity of water is needed so that the value of the energy produced exceeds the cost of production and delivery to the consumer. Limited availability of suitable sites and relative economics of thermal generation have favored thermal plants and currently only about fifteen percent of United States energy production is from hydro plants.

However, thermal power plants use water to cool exhaust steam and increase the thermal efficiency of the unit. Since the cooling is accomplished through evaporation, the water consumption exceeds that for hydro plants. The thermal plant requires sufficient water to meet cooling needs and since such plants are normally in base-load service, this water must be available a high percentage of the time.

The rising costs of oil will make the hydroelectric plant relatively more attractive than in the past. At the same time the petroleum problem is encouraging greater use of coal. Coal poses a transportation problem and the slurry pipeline and the barge have attractive features under the right conditions. The slurry pipeline, in particular, raises some questions as to availability of water.

IS WATER A LIMITING RESOURCE?

For the United States as a whole about 24 percent of the available streamflow is withdrawn for various uses and one-third of this (8 percent of natural supply) is consumed. With consumption of only 8 percent, one might judge that there is

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*Professor emeritus of Civil Engineering, Stanford University; Partner, Linsley, Kraeger Associates.

really nothing to worry about. A similar comparison of the available flow with withdrawals and consumption for the 22 water-resources regions or the 106 subregions used by the U. S. Water Resources Council in preparation of the Second National Assessment (1) shows that in many of these regions or subregions, the water balance is already much less favorable than the national average and presumably the situation will deteriorate with time.

In the Rio Grande and Lower Colorado Regions, current water consumption exceeds the available supply which means, of course, that consumption is currently being met by imports of water. If one looks at subregions, there are 11 in which withdrawals exceed current supply and 7 in which consumption exceeds available water. The problems concentrate on the arid areas of the southwest, but a more detailed investigation discloses a variety of water problems in every state. Dobson and Shepherd (2) in a study of the water requirements of the National Energy Plan find problems in Florida, the Ohio River basin, and around the large population centers of the eastern seaboard.

Information of the type discussed above is useful for studies of national energy problems and water problems. The individual water user will find very little in these reports that he does not already know. Moreover, it can be said with considerable confidence, that there is water available for new uses in those regions where current consumption exceeds available supply. In those regions where there is an apparent surplus of water, a prospective user may find that the supply available for a specific project may be inadequate. The probability of finding water in the areas of indicated surplus is certainly higher than in the areas of current deficit. Nevertheless, a meaningful statement regarding the physical availability of water for a specific project requires a hydrologic analysis tailored to the specific need. There may be a need for some research in the area of hydrologic methodology.

FACTORS CONTROLLING AVAILABILITY OF WATER

Location

A project located near an important water source is much more likely to obtain the needed water than is a project in an area of shortage. This is a statement of the obvious.

Quantity Needed

Small amounts of water are generally more readily available than large amounts. This suggests that a useful line of research is to find ways of using less water for a specific task. Research on cooling methods which require less water is already underway, but reduced unit consumption requirements may be an answer to other water problems of the industry.

What Certainty Is Required

The availability of water varies from day-to-day and year-to-year. Unless the amount used is a very small part of a very large source, it is not possible to guarantee that the water will be available one hundred percent of the time. The lower the required degree of certainty, the more readily a water supply can be found. Possible research in this area might focus on the economics of planning for a certainty level that is less than unity for each plant. This would require a somewhat higher reserve capacity.

What Kind Of Water Is Needed

Water quality requirements may significantly affect availability. Generally, poor quality water is more readily available than high quality water. Ocean water, brackish tidal water, and wastewater are often available without constraint if they can be utilized. Possible research in this area would include an investigation of the process tolerance to pollutants, ways of treating water to make it useable, and problems of disposing of the water after concentration has been increased by evaporation.

GETTING PERMISSION TO USE THE WATER

The hydrologic studies discussed briefly above may establish that an adequate quantity of suitable water is available for a specific project. This does not mean that the water is in hand and the project can proceed. Many agencies may be required to provide approvals before the project can go forward. The Environmental Protection Agency may need to be assured that the project will not pollute either water or air. If it is a hydroelectric project, the Federal Energy Regulatory Commission will have to approve it. A dredging permit could be required from the U. S. Corps of Engineers. The State Utility Commission could be involved. The State Department of Fish and Game may set requirements for maintaining streamflow downstream of a reservoir or diversion. A state Water Rights

Agency may need to issue a permit or grant a right to the water before it may be used. Finally, of course, local county or city commissions may have to issue a use permit for the site before construction can begin.

The list above may not be all-inclusive but it serves to illustrate that water is not really "available" until many agencies have given their approval for its use or the facility which will be the place of use. In order to secure these approvals it is likely to be necessary to prove that the proposed use will not be environmentally damaging, that it will bring economic and social benefits to the community or the region, that downstream users will not be hurt by the new water use, and that the utility has conformed to all legal requirements. Can research help the utility in the process of obtaining approvals?

In many cases, research might help by providing a better understanding of an issue, thus permitting the utility to make a better case in support of a permit request. Alternatively, the research might provide a basis for altering the project in some way that removes an issue from contention. Some of these issues are the subject of the following papers.

Environmental Impacts

The research on the ecological problems of the heat rejection process which was discussed yesterday, is an example of research designed to better understand a problem. Obviously, this particular area does not need further consideration in this workshop. What about the ecologic problems resulting from rapidly varying flow (or no flow at all) downstream from a reservoir or diversion such as at a hydroelectric plant? It is my experience that the basis for remedial steps to protect fish is still very uncertain. How does a reservoir impact water quality? How can these impacts be predicted for a specific project? What can be done in the design of a project to minimize these impacts? There may still be a substantial area of possible research in these questions.

Economics And Water

Any project should meet the test that its benefits will exceed its costs. This is the basis of engineering economy and should require little or no additional research. On the other hand, such analyses usually require estimate of future costs and perhaps some research in this area is required.

The use of water for energy production may result in the water being denied to some other user. In fact, it is possible that in order to secure a water right, the utility may have to purchase one from an existing holder. Agriculture presently accounts for 47 percent of total U. S. freshwater diversion and 83 percent of total U. S. consumption. Hence, the most likely competitor is the agricultural user. Regardless of the kind of use which is competing, the utility should be able to answer the question "What are the economic consequences of diverting this water from some other use to power production on both the local (regional) and national level?" The utility needs to know the arguments which can be presented in support of such a transfer of water rights. Other questions which may be relevant include "How does the stream of benefits flow from an electric power facility to the ultimate recipients?" "What are the secondary benefits of electric energy?" These questions and others are discussed by Earl Gjelde in a subsequent paper.

The economic impacts are not the only result of using water for electric energy production. The economic impacts will be of social importance but there are other questions such as the impact of the project on employment locally as compared to the employment generated by the water in an alternate use. What are the consequences of the project to landowners or residents who may be affected or even displaced by the project? Does the project impact people some distance from the area? Who bears the costs and who gets the benefits of this particular project? Dr. Ruth Love discusses social impacts of water projects later in this workshop.

Legal Controls On Water Use

In the western states where water supplies are limited and demands for water for irrigated agriculture are high, a permit or water right must be secured from a state authority before any water may be used. In many of the states where water is not yet viewed as a limiting resource it is still necessary to secure a permit for use of water. What are the special legal problems of the utility in this permitting process? Does water law as presently written impose unnecessary difficulties on the prospective water user? Does current law recognize the special problems of 1980 and the decades ahead? Professor Frank Trelease will discuss the availability of water from the legal viewpoint.

Introducing The Public To A Project Plan

The prescribed procedures for obtaining almost any kind of a permit from a public agency usually require a public hearing. Such hearings often bring forth protesters but rarely provide the setting for reconciling opposing views. The federal water agencies have been required to involve the public in the project planning process at an early date. The aim is to allow public inputs to the process and public discussion with the planners so that the final plans are prepared with full knowledge of public preferences. The agencies have tried many techniques of public involvement. Not all of the approaches have worked but in many cases public concerns have been met and projects have moved forward smoothly and with negligible delay. There are differences between a federal agency and a public utility, but there are many similarities in the planning processes of agencies and utilities. Can some of the experience of the federal agencies be adapted to the problems of the utilities? Dr. Leonard Ortolano discusses this aspect of water availability.

CONCLUSIONS

While we rather naturally think first of the physical availability of water when someone asks "Is there water?", the answer to the question involves many factors. Physical availability is a necessary condition. The water must be there in adequate amounts. It must be of acceptable quality for the proposed use. Beyond these conditions, however, is the requirement that the prospective user secure the necessary permission to use the water. This may require consideration of economic, social, and legal constraints in addition to the hydrologic factors. Research into the typical problems involved in planning for water use, may help to simplify the planning process of the future and perhaps also to accelerate it.

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Section 7

PUBLIC INVOLVEMENT IN WATER USE PLANNING BY ELECTRIC UTILITIES

Leonard Ortolano*

INTRODUCTION

This presentation is based on the premise that individuals planning water supplies for electrical energy development will face many of the same problems and issues as individuals planning water resources developments for other purposes such as irrigation, flood control, etc. An extension of this premise is that, despite the differences in institutional settings, the experiences of the federal water resources development agencies in modifying their planning processes to accommodate public involvement are relevant to electric utilities. Throughout the 1970's the federal water agencies (especially the U.S. Army Corps of Engineers) have been in the forefront in terms of experimenting with innovative approaches to public involvement, and evaluating both their successes and failures to learn how to make public involvement a more useful component of their planning and decision-making processes. This paper reports on some of these experiments in the interest of delineating possible lines of research that could be pursued by electric utilities to increase the usefulness of their own public involvement activities.

A second premise that underlies much of the discussion below is that, in some cases, it may not be possible for a utility to make substantive increases in the effectiveness of its public involvement activities without modifying its overall planning procedures. This premise is elaborated using the experiences of federal water planners in the early 1970's. Many such planners found that their public involvement activities yielded new information after most of their planning

*Associate Professor, Program in Infrastructure Planning and Management, Department of Civil Engineering, Stanford University, Stanford, California 94305.

budgets had been spent. This, in turn, led to frustration: The planners became defensive about decisions they had already made and the representatives of different segments of the public (referred to herein as "publics") became unhappy about the planners' lack of positive response to their suggestions. These kinds of frustrations were often minimized by restructuring the entire planning process so that information from the public could be received at points in the process at which the planners could be responsive to that information.

In the interest of sharing some of these experiences from the water resources development field, the discussion begins with a description of the forces that motivated the water agencies to increase their public involvement activities in the early 1970's. Some of these motivating forces are also relevant to electric utilities today. The discussion then examines a few of the early research projects concerning the participation of the public in water resources planning and the realizations which resulted from that research. Following this, some of the water resources agencies' later, more sophisticated approaches to public involvement are considered. The discussion concludes by drawing on the experiences of the water resources agencies to suggest a possible research agenda concerning public involvement in water planning by electric utilities.

MOTIVATIONS FOR INVOLVING THE PUBLIC IN PLANNING

In the late 1960's and early 1970's the shift in public values relating to the environment had reached a point where agencies that were once thought of as serving the public interest were viewed as evil-doers who were "raping the landscape." The federal water resources agencies, especially the U.S. Army Corps of Engineers, were often viewed in this way. Critics charged them with not adequately considering the social and environmental impacts of their proposals, and with using project evaluation techniques based on economic efficiency criteria that were much too narrow to adequately reflect contemporary values and concerns.

In its extreme form, the nature of this criticism could be summarized as follows: Most of the important planning decisions (e.g., which alternatives to examine) were made by water agency planners in collaboration with special interest groups who stood to benefit from a water project. Although individual citizens and environmental group participated in the planning process through public hearings, these hearing had an insignificant influence on the direction of a planning study. Also, the opportunity that individual citizens and environmental groups had to

formally review a water resources agency's recommendation for action occurred at a late stage in the process. At this stage, criticism was viewed as obstructionism and was not taken seriously. The only way to participate effectively was via court action.

As might be expected from the foregoing, many of the projects proposed by the water agencies were subject to costly delays resulting from court actions. Thus, quite apart from any theoretical notions related to pluralism or the importance of having different perspectives heard in a democracy, the water resources agencies were motivated to involve the public early in planning in order to meet the criticisms head on and thereby get on with the job of carrying out various agency missions. In short, public involvement presented itself as a pragmatic response to the then common alternative of having dissatisfied publics stop or delay projects through whatever judicial or administrative means they could find.

Other factors motivating federal water planners at the field level to give serious attention to public involvement were the various planning regulations and guidelines that mandated such involvement. Recognizing the criticisms leveled by various citizen's groups and the problems associated with late stage court actions, the headquarters levels of some water resources agencies began to rewrite their planning regulations so that field planners would be encouraged to undertake more extensive public involvement activities. This was reinforced by the passage of the National Environmental Policy Act (NEPA), with its provisions for the public review of agency proposals. As time went on, the water resources agencies became more and more convinced that the job of performing environmental assessments could be done more effectively with extensive public involvement programs. Indeed, there was an increasing recognition that agency staff members could not make good decisions about which environmental impacts to study in detail without getting information on how various segments of the public evaluated different types of impacts. Thus, various increases in environmental assessment requirements reinforced the already existing motivations to involve the public in planning. The recent NEPA regulations of the Council on Environmental Quality (1978) place considerable emphasis on the linkages between public involvement and environmental assessment.

EARLY RESPONSES OF THE WATER AGENCIES

One thing that became very clear to many water resources planners in the 1970's was the limited utility of the one means of public involvement that had been used for many years, namely, the public hearing. Such hearings have the advantage of providing a formal, highly legitimized means of informing the public of the status of a study, but their formal ambience does not encourage two-way information transfer. Public hearings typically use a hierarchical ordering of presentations: first the agency representative, then the local Congressmen, then other federal agencies, and so on, ending finally with comments from individual citizens. Both the formality and the ordering of presentations are such that often times only the most tenacious and outgoing members of the public are heard. If public involvement programs were to be effective at providing processes for citizens, groups, and other agencies to receive and contribute information and to register their concerns, then it was clear that the public hearing, which was often mandated by planning regulations, would have to be supplemented with other techniques.

Because of the limited utility of the public hearing, some of the water agencies set out to determine and utilize alternative techniques for involving the public in planning. An important, early reference work was a report by Bishop (1970) which presented an overview of the advantages and disadvantages of what have come to be viewed as standard participation techniques (e.g. public hearings, public meetings and/or workshops, citizen "advisory boards" and "task forces," etc.). Bishop's work, as well as the review by Warner (1971), were important in that they provided convenient summaries of the state-of-the-art in public involvement techniques.

In addition to summaries of the state-of-the-art, a substantial number of research projects were conducted in which different public involvement techniques were used in the context of ongoing water resources planning studies. For example, Fulton, et al (1971) conducted a research project to "demonstrate and evaluate a new technique of citizen participation and involvement in community planning and natural resources management." The technique centered on the combined use of various information bulletins and questionnaires The questionnaires gave members of the public a chance to indicate their concerns, values and questions about the future of inland lakes in the Huron River watershed, and the information bulletins provided responses to these questions and concerns. Fulton

et al eventually conducted a series of follow-up meetings with small groups of community leaders to obtain insights into the effectiveness of the bulletins and feedback questionnaires.

Another experimental study was the one by Borton et al (1970) to assist the Corps of Engineers in improving its communications with the public and with other governmental agencies concerned with water resources. The public involvement program centered upon the following four-step approach: (1) identifying local opinion leaders ("influentials"); (2) providing influentials with mailed information (periodic reports and newsletters); (3) conducting numerous small group, informal workshops and (4) conducting large "public forum" meetings. Follow-up interviews and questionnaires were used to evaluate the effectiveness of the aforementioned public involvement techniques.

Still another of these early research efforts involved an ad-hoc evaluation of the public involvement procedures actually used by the Corps of Engineers in their water planning in the Upper Rock River Basin. This research, conducted by Bromley et al (1971) found the Corps' interactions with the public deficient in a number of respects (e.g., "public preferences were not revealed" and "public views were not used"). Bromley et al recommended the use of alternative planning procedures which would ameliorate the deficiencies they uncovered in their ad-hoc evaluation.

In addition to the research oriented studies of the type noted above, the water resources development agencies also conducted surveys (of varying degrees of sophistication) to assess the effectiveness of public involvement efforts used in their ongoing field activities. The report by Wolff (1971), although it was not conducted by an agency per se, is an example of this type of assessment of ongoing experiences in different field offices of an agency.

EMERGING REALIZATIONS OF THE WATER AGENCIES

On the basis of the various surveys and evaluations noted above, the water resources agencies gained insights into the nature of public involvement in water resources planning. Despite the differences in institutional setting, many of these insights are relevant to public involvement in electric utility planning.

One set of insights concerns the expectations of the public. For water projects of any scale at all, the public (both individuals and citizens groups) will not sit still for being informed of agency decisions by means of a formal public hearing in the late stages of planning. The public is now calling for opportunities to inform agencies of their values and concerns as well as opportunities to be informed of agency progress. In short, there is a much greater need to employ public involvement techniques that encourage a two-way information flow. Moreover, public involvement programs need to be structured so that they start relatively early in a planning process, well before the stage that a draft environmental impact statement (EIS) is circulated. Indeed, many water agencies circulate a "pre-draft" EIS document fairly early in the planning process as one of several methods used to get citizens and other government agencies involved in their planning (Ortolano et al, 1979).

Another set of realizations concerns what publics can be expected to contribute in the way of information. In the early 1970's, it was common to view the public as being capable of participating only in the evaluation of environmental and social impacts. Today it is more and more common to expect that publics can and will contribute to all four of the traditional planning tasks: (1) identification of concerns (problems, needs, etc.); (2) formulation of alternative plans; (3) analysis of environmental, social and economic effects of alternatives; and, (4) the ranking (or evaluation) of alternative plans. Moreover, there is a growing respect for the fact that publics can contribute two different types of information, namely factual information and "values" information. Agency technical specialists are accustomed to appreciating factual information e.g., the reservoir will inundate the habitat of an endangered species. Recently, they have become much more sensitive to the fact that publics often contribute important values information; e.g. "we citizens are angry that the reservoir will inundate the habitat of an endangered species."

The results of early public involvement research by water agencies also taught some lessons about reasons why people affected by proposed projects do and do not choose to participate in planning studies. When publics do take the time and trouble to contribute to planning studies, it is often because they feel that they are being taken seriously as contributors to the decision process; i.e., they feel that their views will influence the planning process, and possibly, the outcome of the study. One reason why people who might be expected to participate in a study

often don't is that they don't believe their views will count, i.e., they believe the agency will make up its mind, independent of whatever they say or feel. Sometimes people potentially affected by proposed projects don't take advantage of opportunities to influence planning because they simply are not aware that the proposals can affect them. [An illustration of this is reported by Wagner and Ortolano (1976).] These lessons from early research involving public involvement in water planning highlight the importance of making sure affected publics know of their stakes in the planning effort, and that those who participate in planning are given regular "feedback" regarding what is being done with the information obtained from public involvement programs.

A rather painful realization that was derived from these early public involvement research studies is that public involvement does not necessarily lead to the absence of controversy. Although it is true that well-designed public involvement programs often serve to build a consensus regarding which of several alternatives will be acceptable, this is not always the case. Value conflicts will not disappear just because representatives of all concerned publics have had a chance to be involved in planning. In recent years, there have been a series of efforts to deal with such conflicts using "environmental mediation," a conflict resolution technique that resembles the type of mediation used in labor-management disputes. Although it is too early to tell how generally useful this mediation strategy will be, some of the results thus far have been encouraging (see, e.g., Patton and Cormick, 1978).

MORE SOPHISTICATED RESPONSES OF WATER AGENCIES: RESTRUCTURING PLANNING PROCESSES

One of the things that became clear during the mid-1970's was that planning processes that worked well in the 1960's might not be very functional in dealing with the "planning environment" of the 1970's. During the 1960's, when the technical specialists within water agencies were able to plan effectively with little public involvement, a highly structured planning process could work reasonably well. Such a process, with the above-noted four planning tasks carried out in sequence, did not need to accommodate extensive public involvement. During the early 1970's, however, agencies like the Corps of Engineers found that extensive public involvement in planning was not accommodated by such a process, and that a more flexible planning process was required.

The importance of utilizing a planning process that accommodates continual public involvement can be illustrated by observing that publics and review agencies often have insufficient information to provide substantive feedback to planners early in a water resources study. As planning proceeds and information is provided to publics and review agencies, new concerns and problems may become evident; the reactions of publics and review agencies may call for abandonment of previously delineated alternatives, the examination of new alternatives, the assessment of impacts that had not been previously considered, etc. In a planning process where public involvement is infrequent and rigidly prescribed (e.g., a few public hearings conducted over the course of several years), the reactions and concerns of publics may be brought to the attention of planners only after substantial portions of their planning study budgets have been spent. Planners may thus find it difficult to respond to the publics' reactions, e.g., by giving serious consideration to newly suggested alternatives.

Recognizing the limitations of rigid, highly structured planning processes in accommodating public involvement, the Corps of Engineers supported research studies that examined how their field planning procedures could be modified to deal more effectively with the planning environment of the 1970's. One such study involved the conceptualization and field testing of what has been referred to as an "iterative, open planning process" (IOPP). The IOPP is "open" in the sense that it calls for extensive, two-way communication between water agency and staff members in other agencies. The IOPP is "iterative" in that it is based on the concurrent, as opposed to sequential performance of the four basic planning tasks: identification of concerns, formulation of alternatives, impact analysis and plan ranking (or evaluation).

Figure 1 serves to emphasize one of the fundamental characteristics of the IOPP, i.e. a sensitivity to the interdependencies among all four planning tasks. At any point in the process, information from each of the four planning tasks influences each of the other tasks. For example, the analysis of impacts may reveal new concerns of affected publics. Thus, the information from the impact analysis task "feeds back" to the identification of concerns task.

An important component of the information that links the four tasks together is the goals, concerns, constraints, etc. that various decision makers and affected publics consider important in ranking alternative actions. As a matter of convenience, the term "evaluative factors" is used to refer to these goals, concerns, constraints, etc.

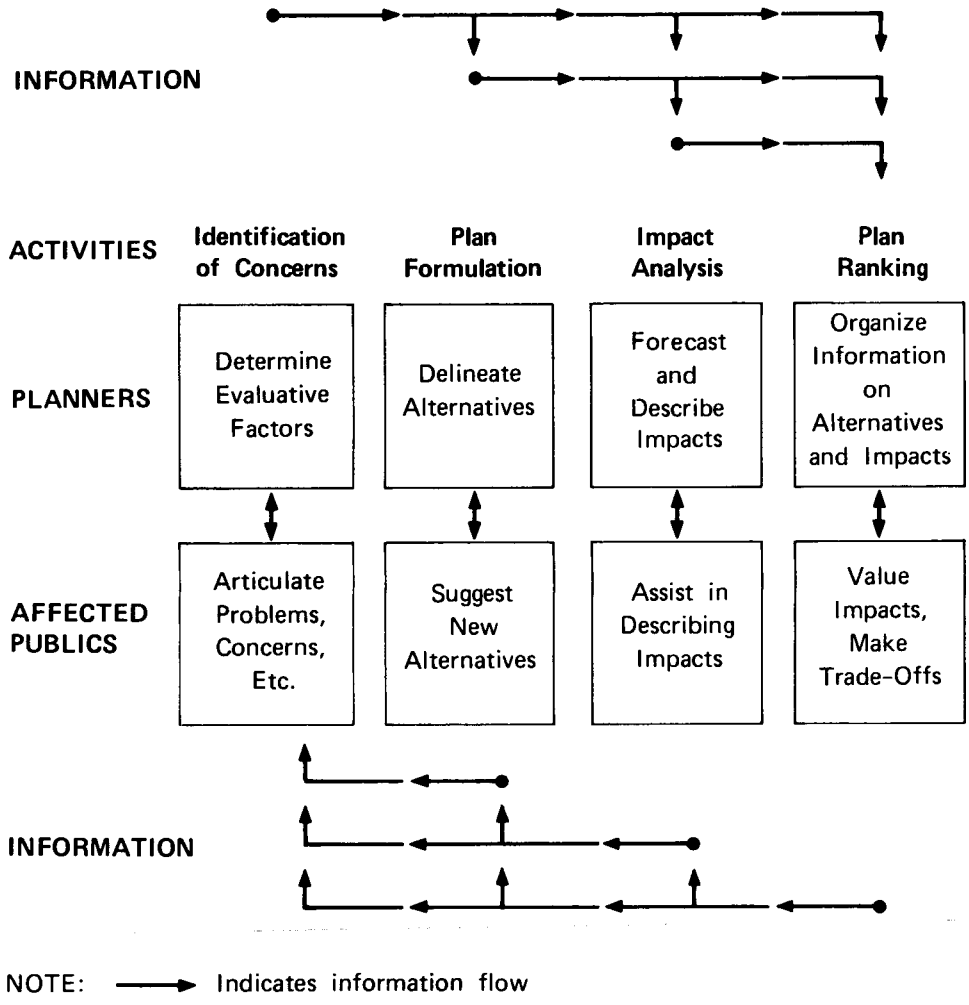


Figure 7-1. Information flow during any stage of IOPP.

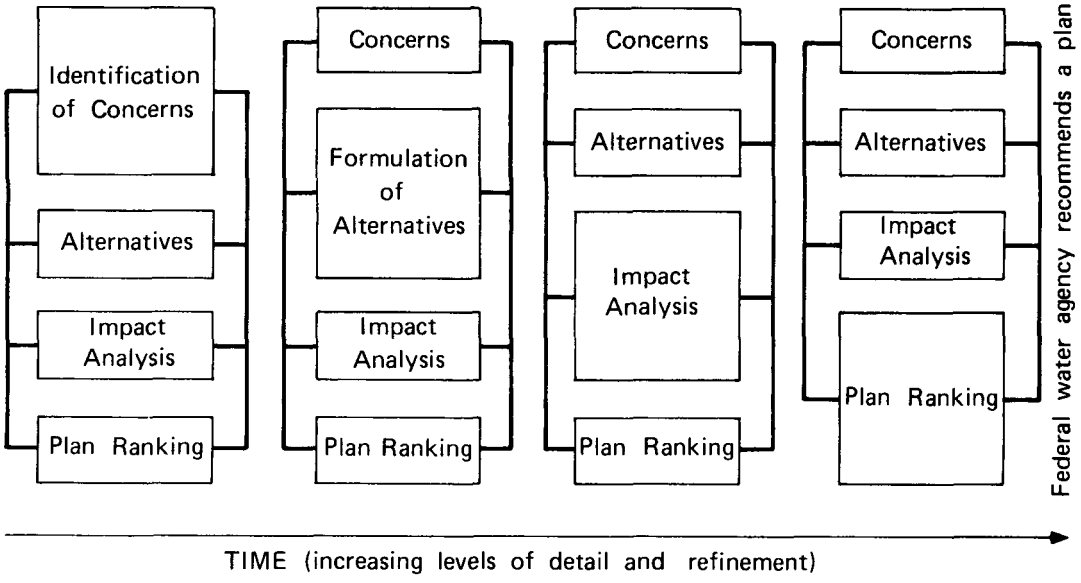
Figure 1 also represents the nature of the relationship between planners and publics. The IOPP calls for open and continual interaction with publics, wherein public "input" is used to guide other study activities, and publics are made aware of how their contributions to planning have been used. The IOPP recognizes public involvement as providing a key source of evaluative factors and an important part of the process of developing priorities among such factors.

Figure 2 represents another basic concept of the IOPP: each of the four planning tasks is conducted a number of times at increasing levels of detail as the study progresses over time. However, at any one time, one task may receive more emphasis than the others. Although the figure shows four stages of the four planning tasks, the distinction between stages is arbitrary. Thus, there is nothing sacred about four stages, nor is the number of stages necessarily "fixed" for all studies. The number of stages and iterations may vary depending upon the type of study, its geographical scope and location, etc.

It is worth emphasizing that the IOPP is, by definition, an iterative process. All four planning tasks are carried out concurrently and are repeated as the process unfolds. These iterations allow for the efficient use of planning resources and the continual clarification of study priorities. A more complete description of the IOPP has been given by Ortolano (1974).

Many of the detailed considerations required in implementing the IOPP were examined in the context of a "field-test" application on a real Corps of Engineers planning study for San Pedro Creek in Pacifica, California. The field-test clarified the problems involved in getting members of the local public to take an active role in all water resources planning activities from the beginning of a study. It also revealed that some of the key issues involved in implementing the IOPP relate to the way a water resources planning agency's field offices are organized and the way management controls are exercised. The field test results are described by Wagner and Ortolano (1976).

On the basis of the IOPP research study described above, as well as many other considerations, the Corps of Engineers has revised substantially the procedures utilized in carrying out its water resources planning studies. Its new planning process resembles the IOPP in many respects and places great emphasis on the relationships that exist bewteen public involvement activities, interagency coordination activities and environmental impact analysis activities (U.S. Army 1975).



NOTES: (a) The lines between boxes summarize information flows noted in Figure 1.

(b) The sizes of the various boxes suggest the emphasis placed on the four activities at any one point in the process.

(c) The figure does not show all possible variations in the way emphasis on activities may shift over time.

Figure 7-2. Representation of IOPP over Time.

A POSSIBLE RESEARCH AGENDA FOR ELECTRIC UTILITIES

Survey and Evaluation of Currently Used Techniques

One of the things that has been helpful to individuals concerned with public involvement in water planning has been the wide availability of information about public involvement techniques that have failed and succeeded in different contexts. The water resources planning literature contains results of studies in which field planners were asked to share their experiences regarding techniques that work effectively. For example, a number of such studies have revealed that, as far as establishing two-way flows of information is concerned, informal public workshops are far more effective than public hearings; such studies have also revealed information regarding how workshops can be effectively organized, the kind of training that is useful for the leaders of such workshops, etc. (see, e.g., Ortolano and Wagner, 1977).

One line of research that could prove useful to electric utility planners involves the synthesis of information from a number of electric utilities regarding the public involvement techniques they find effective in different contexts. One way to accomplish this involves the use of a mailed questionnaire survey that elicits information from a number of electric utilities regarding: when the public is involved, what techniques are used, how effective these techniques are at generating new information, etc. Experience in conducting such surveys suggests that the results will be more useful if the questions are asked in the context of a specific, recent planning study, e.g., the most recent hydroelectric power facility planned by the utility.

Recent conversations with staff members engaged in public involvement activities at Pacific Gas and Electric (PG&E) revealed some enthusiasm for obtaining the kinds of information that the aforementioned survey could yield. These conversations indicated that there exists a very wide variation in the types of public involvement programs utilized even within a single electric utility like PG&E. For example, planning studies concerning the location of a new electric power generating plant might involve only the public hearings called for by the State Energy Commission. In addition to wide variations in approaches to public involvement within a single utility, there will also be wide variations in approaches among different utilities. These sorts of variations would need to be reflected in the design of questionnaires used in any mail surveys. The existence of wide variations in approaches to public involvement suggest that there

may be a great deal of useful information that can be gathered by synthesizing the experiences of planners in different electric utilities.

Mail surveys have the advantage of providing broad coverage, i.e., the number of planning studies included in a survey can be large. However, with a mail survey, the amount of "in-depth" information that can be obtained regarding any single planning experience is relatively low. A way of getting a more detailed perspective regarding the use and effectiveness of techniques for involving the public in electric utility planning is to use ad-hoc evaluations of a few specific planning studies. This type of research could be carried out using interviews with both electric utility planners and representatives of different segments of the public who were involved in a particular recently completed planning study. These ad-hoc evaluations could, of course, be undertaken in conjunction with a more broadly based mail questionnaire survey.

The possible research efforts described above correspond, more or less, to the types of public involvement research carried out by water resources agencies in the early 1970's. The research possibilities noted below correspond more closely to the experiments involving modifications of entire planning processes carried out by the water resources agencies in the mid-1970's.

Public Involvement "Experiments" Involving Ongoing Studies

An alternative to ad-hoc evaluations regarding what has been done involves conducting an "experiment" to test the use of alternative approaches to public involvement in the context of an ongoing planning study. Such an experiment could be exclusively "technique oriented;" i.e. a utility might be perfectly content with its overall planning process, but it may wish to experiment with different methods of involving the public. Thus, for example, a utility might choose to depart from its usual reliance on informal public workshops and try some relatively new public involvement approaches like "gaming situations." The experiment would consist of designing and implementing the new public involvement approach, and then evaluating the results using follow-up interviews or questionnaires, or both.

A more elaborate type of experiment corresponds to the above noted IOPP research study on San Pedro Creek in California. In this instance, the electric utility involved in the experiment would have to perceive that its public involvement

activities did not integrate very well with its other planning activities. An example of this is when new information on alternatives is received from members of the public at a time in the utility's planning process that is after the utility has already invested (financially or intellectually) in a particular proposal. If a utility were to perceive that such a "problem" existed with its public involvement programs for a particular type of study (e.g., hydropower facilities), then it would be appropriate to examine carefully the utility's entire planning process used in studies of that type. Such an examination would serve to determine what types of information the planners expected publics to contribute and what preparation the public was given (e.g., citizen information bulletins) to meet these expectations. This sort of examination could be conducted productively in the context of a recently completed planning study in which the integration of public values and concerns into the planning process was acknowledged as a problem.

On the basis of the aforementioned examination, it would be possible to design and implement an experiment on one of the utility's ongoing planning studies. This type of research would involve:

1. The identification of different segments of the public and the articulation of the roles which various publics would be expected to play at different points in the planning process;
2. the design of techniques to establish two-way communication with various publics and otherwise be compatible with the roles that various publics were expected to play; and
3. the design of an overall planning process that accomodates the aforementioned expected roles and techniques in such a way that public involvement activities are carefully integrated with all other planning activities.

This is the type of research that was carried out by the U.S. Army Corps of Engineers during the mid-1970's. It served to assist the Corps in formulating a set of planning regulations that was well suited to carrying out its missions in the context of a planning environment that emphasizes public involvement and environmental and social issues.

A Concluding Observation on Staff Training

One thing that seems to have helped water resources agencies like the Corps of Engineers in dealing with public involvement is their emphasis on staff training. With few exceptions, there is little in the university level education of typical water resources (or electric utility) planners that prepares them for what is

involved in conducting effective public participation programs. Part of the information that is useful to such planners concerns different techniques and how particular techniques can be effective or ineffective depending on the particular objectives and context involved. This information can be transmitted to staff members using specially prepared training materials (see, e.g., Hanchey, 1975) or by means of "short courses."

One thing that it is difficult to accomplish without a course-type experience is the provision of training in relevant communication skills. Public involvement programs that are effective often benefit greatly from staff members who are good at managing group meetings and at interpersonal communications in general. The Corps of Engineers has run a large number of staff training sessions in which these sorts of communication skills are taught to the engineers and other that often are involved in managing Corps planning studies.

The various types of research activities described above can fit in quite well with the design of staff training materials for electric utility planners. Indeed, it may be convenient to use the results from such research projects as the basis for developing industry-wide instructional materials and short course training programs for staff members who are concerned with public involvement activities.

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Section 8

ECONOMIC ASPECTS OF THE USE OF WATER FOR ENERGY

Earl E. Gjelde*

President Lyndon Johnson in 1967 convened an international conference in Washington, D.C., on the theme of Water for Peace. Among the keynote speakers was the famous city planner Constantinos Doxiadis of Athens, Greece. Speaking on Water and Environment, Doxiadis estimated that around the middle of the 21st century the world population would stabilize at about 20 billion people of whom 17 billion would live in cities. Water use would have increased 15 times. He looked upon the intervening hundred years as a transition period of grace during which to get our water management under control and in order.

He proposed to solve the enormous water problems by what he called a plan for the universal city and the universal garden. In this plan water is used and reused in a virtually closed system which includes gardens as part of a natural filtration scheme. The cycle is much like the bloodstream of the human body and like the hydrologic cycle itself.

The broad, imaginative approach of Doxiadis can be a useful spur to our thinking. Instead of separating and isolating each of the many uses of water, he proposed to combine the multiple uses in what he calls a balanced, dynamic system.

We should bear in mind that what may appear economically infeasible or unattractive at one time, can become quite interesting and even practical at another time. Even if Doxiadis' "universal city" and "universal garden" approach seems fanciful and impractical now, many factors can combine over time to make it or alternative approaches the place where the "smart money" goes.

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*Assistant Power Manager, Bonneville Power Administration

First of all, technology can often come galloping to the rescue. Technology cannot be counted on invariably to fix every problem, but in predictably unpredictable ways it can often convert hopelessly impractical ideas into marvelously workable schemes.

Perhaps more important, as demand for water increases, and as supplies become more and more committed or overcommitted, the value which society attaches to water will be increasing. Hence, water should fetch a dearer and dearer price on the market. Our recent experience with energy indicates that technologies which were dismissed as wishful thinking and worse when crude oil was priced at $2 a barrel suddenly appear irresistible when that same oil commands a price of $30 a barrel.

There is no reason why water would respond differently as would be true, of course, for any resource that is limited in supply and confronted with increasing demand.

The Columbia River offers a fascinating case study. Even before Lewis and Clark's historic expedition to the Pacific, the Columbia had been a benefactor to mankind. Today, the River is well developed for multiple purposes and is a continuing source of envy, particularly from adjoining river basins which are less well endowed with rainfall and streamflow.

The people of the United States have invested more than $8 billion in 30 Federal multipurpose hydroelectric projects in the Columbia River basin including the irrigation works, the electric transmission system, and nonreimbursable, nonpower features for navigation, flood control, fish and wildlife, and recreation. All of the power facilities including those in joint power-nonpower facilities such as the dams themselves, plus a substantial portion of the irrigation investment must be repaid, with interest, to the U.S. Treasury out of power revenues. All in all, about 83 percent of the Federal multipurpose investment in the Columbia River basin is chargeable to power and must be repaid out of power revenues.

Notwithstanding the multipurpose character of the Federal dams in the Columbia basin, as a practical matter the generation of electricity and the large amount of revenue available from power sales made possible the building of most of the dams. Without electric revenues it is likely that very few dams would have been built. Electricity is the paying partner; it operates the cash register. In

this sense the other nonpower purposes of the Federal Columbia River Power System are extra dividends or features that were added as parts of these 30 multi-purpose projects although power production was often designated as a secondary rather than a primary purpose of many of the dams. The allocations of the Federal investment among the various project purposes is instructive and shows how much dependence is placed on the electric power "cash register." For example, the irrigation investment is subdivided whereby farmers repay about 29 percent of the irrigation investment while power users pay the other 71 percent as an irrigation subsidy. Cost allocations are one way of showing the interrelationships among the multiple uses of a water resources development program.

Without meaning to be disrespectful either to other regions or to anyone's religious sensibilities, in the Pacific Northwest there is an Eleventh Commandment: "Thou shalt not covet thy neighbor's water, particularly if thy neighbor is an adjoining river basin."

In 1968, after years of acrimony in which many schemes for diverting water from the Columbia River basin to the parched Southwest were surfaced and considered, the Congress established a 10-year moratorium against any Department of the Interior study of the diversion of the Columbia into the Colorado River basin. The moratorium was to have expired in September 1978.

A few days after the moratorium expired and just a few minutes before Congress was to adjourn, another 10-year moratorium was enacted. The Interior Department cannot study the matter until 1988.

Even without such a moratorium, there is not very much likelihood that large-scale interbasin water transfers between the Pacific Northwest and the Pacific Southwest would materialize. For example, in 1973, the blue-ribbon National Water Commission recommended that interbasin transfers pass at least three tests. First, an interbasin transfer proposal should be the least-cost way of securing a supply of water. Second, the value of the water in its proposed new use should be greater than the value of water in its old or alternative use plus the costs of the transfer. In other words, the benefits in the receiving basin should exceed the full costs of the transfer plus the foregone net benefits (hydroelectric generation for example) which that same water would have provided in the basin of origin. And third, the full costs of the interbasin transfer, including the

foregone opportunity costs in the region of origin, should be paid for by the direct beneficiaries in the receiving region; in other words, if the project is truly economically feasible, it should not be subsidized.

Economists have referred to these criteria as "super-rational" standards. And most observers have concluded that if all three standards are applied it is very unlikely that a single drop of water would ever be transferred between the Northwest and the Southwest, particularly if the value of the precluded or foregone hydroelectric generation in the Northwest is computed on the basis of the next lowest cost alternative -- namely, the very much higher cost power which has to be produced at nuclear or coal-fired thermal powerplants. Various estimates suggest that even without the inclusion of foregone net benefits in the region of origin as part of an interbasin water-transfer project's costs, it is very unlikely that the benefits of irrigation (or of municipal and industrial water) in the Pacific Southwest could ever equal the substantial costs involved in transporting water all the way south from the Columbia River or its tributaries.

Before taking up two cases of potential or actual competition for water use, I want to make clear that most uses of water are or can be compatible, complementary and indeed mutually supportive. We seldom hear about the harmonious and cooperative uses of water. The loud noise is when competition occurs. For example, in the Columbia River above The Dalles, Oregon, that is, east of the Cascade Mountains, the construction and operation of upstream storage projects has been primarily helpful for flood control and power but also for irrigation, and, under major flood conditions, in protecting the fish. Moreover, when the storage is at the headwaters, as in the Hungry Horse reservoir in western Montana, the released water produces additional power at some 20 downstream dams as well as at Hungry Horse Dam.

In contrast to the harmonious influence of the Hungry Horse upstream storage reservoir, two areas of tradeoff or competition with power are irrigation and fish. Both irrigation depletions and the struggle to re-establish the Columbia River salmon runs adversely affect hydroelectric power.

First of all, the potentially more serious of the two as far as power production is concerned is irrigation. Any added diversion of water from the Columbia River for irrigation will have an adverse impact on power in two ways. First, it will

reduce the water that is available for generation of hydroelectric power. Second, it will require more electricity for pumping the irrigation water to the fields for application by sprinklers.

The Columbia River average annual flow at The Dalles, Oregon, is about 134 million acre-feet. Irrigation diversion is not yet at the 10 percent level, but every bit is potentially costly. Diversion for irrigation has varying impacts. Columbia River storage reservoirs are filled by melting snow during the spring and summer and drawn down during the fall and winter. Irrigation diversions have a minor impact during high-water years and during the late spring runoff when some abundant streamflow may have to be spilled anyway. It can have a much more serious impact in a low-water year and when irrigation of fields is done in August and September. No matter from where the water is withdrawn -- from upstream storage, from free-flowing rivers, from ponds, or from wells -- if it is diverted upstream from one or more dams, it will reduce generating capabilities except when there are very abundant streamflows.

Another variable in determining the impact is whether the irrigation is done in an upstream area such as Idaho and Montana. Such diversion deprives more dams of water for generation. On the other hand, the impact is much less when occurring west of the Cascades. As an approximation and on the average, the added irrigation electric load for pumping is something on the order of twice the energy as is lost from reduced hydro capabilities that stem from irrigation depletions. The important thing is that there is a double impact. The range of both impacts in the Columbia River basin is from 500 to 3,300 kilowatthours per acre-foot of water diverted and consumed, and depends on how far upstream the diversion takes place and how high a lift is required to deliver the water under pressure to the cropland. Annual diversions average 3-1/2 acre-feet of water per acre of cropland (equivalent to 42 inches of rain annually). About one-third of the total water diverted returns to the river as return flow; the two-thirds remainder is "consumed" by evaporation or transpiration.

Before leaving the subject of irrigation depletion, let me emphasize that the Bonneville Power Administration historically has encouraged irrigation and an improved and stabilized agricultural economy. Irrigation also strengthens those counties which have, in years past, been subject to a net outmigration of people. Although there is a clearcut tradeoff between irrigation and power, both food and power are important. The value of crops produced by irrigation is immense. What

policymakers must bear in mind, however, is the cost of additional irrigation in terms of power and the costs of power in terms of irrigation. Placing proper price tags on those costs is a sensible way to gain perspective on the tradeoffs.

The second very important but potentially less serious conflict is the tradeoff between power production and fish. Anadromous fish travel twice a lifetime through the Columbia River and its tributaries -- once as juveniles traveling from the spawning beds or hatcheries to the sea, and again as adults migrating back upstream to spawn. The most serious problem is that of enabling fingerlings to get to the Pacific Ocean. Downstream mortality of fingerlings occurs in turbines and in spillways.

The tradeoff between power and fish becomes acute during low-water years, since the lower the flow, the more difficult the passage for juvenile fish and the more crucial the production of every last kilowatthour of electricity. The 1976-77 water year illustrates the point. After a considerable amount of discussion, the issue was brought before the Pacific Northwest Regional commission, which consists of the Governors of Idaho, Oregon and Washington. At a March 8, 1977 meeting the three governors plus a representative of the Governor of Montana, voted unanimously to support a plan called "Alternative B" which requested that some water be spilled and some power foregone to aid downstream fish migration. All parties voluntarily supported the plan.

In October of 1977 the Committee on Fishery Operations of the Columbia River Water Management Group published a report detailing the history and consequences of the implementation of "Alternative B" entitled "Special Drought Year Operation for Downstream Fish Migrants." Summarizing from that report, two fish passage operations were employed: "Fish Flow 1977" and "Fish Haul 1977." The "Fish Flow 1977" was a scheme to maintain a higher level of flow in the river than would otherwise be the case which would tend to flush the juvenile fish down the river; and spill water periodically to wash the juveniles over the spillways of the dams. The amount of water over and above what would have been released for power production was 1,400,000 acre-feet. Most of this additional release generated unneeded electricity which was then stored in other systems, primarily in British Columbia and in California, to be returned at a later date. Of the 1,400,000 acre-feet annually released from the upstream reservoirs, 230,000 acre-feet or 263,400 megowatthours of electricity was actually lost due to spill and transmission losses (transmitting power to be stored and then transmitting it back).

The value of this lost power, including energy storage and wheeling charges, was estimated to be $7.6 million using replacement cost pricing then in effect (24 mills per kilowatthour) and $2.2 million using the Bonneville Power Administration (BPA) nonfirm rate at that time (3.5 mills kilowatthour). It was estimated that between 332,000 and 367,000 additional adult salmon will return to the Columbia River system as a result of "Fish Flow 1977." This is an average cost per adult salmon of $21 to $22 using replacement cost pricing or a little more than $6 using the BPA usual nonfirm rate to evaluate foregone electricity.

"Fish Haul 1977" was an operation which transported fish downstream by truck, barge, and plane. It did not affect power production. As a result of the operation, an estimated 59,000 to 95,000 additional adult salmon will return to the Columbia River system. The cost of "Fish Haul 1977" was roughly $1 million or between $10.50 and $17.00 per additional adult return.

The fishery agencies argue that the 1977 operations just maintained the fish runs at a "survival level." They are now requesting that more water be set aside for downstream migration in low-water years. Until recently, they had been asking for a 20 percent spill around-the-clock at all the dams during the fish passage season. During the 1977 period, the fish biologists found by various techniques that they could effectively pass fish by using only a few hours of spill per day at appropriate times, but they continue to request more spill than the 230,000 acre-feet used in 1977. If significant additional spill yields incommensureately small increments of adult returns, the marginal cost of adult returns could become much higher than the costs of "Fish Flow 1977."

One interesting item concerning irrigation, fish and recreation is that between Banks Lake and the City of Ephrata, Washington, there is a string of small lakes that were very alkaline before the building of Grand Coulee Dam and pumping into Banks Lake. After the filling of Banks Lake, these lakes began receiving sweet water through groundwater flow to the point where they started becoming fresh enough to support fishing, swimming, and other recreational uses. These lakes began receiving more and more attention from a recreational standpoint. The lakes closest to Banks Lake were first in generating recreational interest. However, when Soap Lake, the last big lake in the string, began showing signs of losing its alkalinity, people there began protesting because the attraction of Soap Lake for years has been its medicinal qualities. Soap Lake water is bottled

and widely distributed. The protest became so great that the then Bureau of Reclamation (now Water and Power Resources Service) installed an interceptor pump which pumps intercepted groundwater into an irrigation canal, bypassing the lake.

Recreation is another economic problem which has become more significant in recent years. When Hungry Horse Dam was built on the South Fork of the Flathead River in western Montana, no one thought that it would have any other benefits than the power and flood control for which the project was built. Hungry Horse is near Flathead Lake, one of the largest, most beautiful inland freshwater lakes in the country. However, when water was needed for power one recent September, there was much complaining from early fall recreationists when the Hungry Horse reservoir was lowered.

One cold winter day after some large drafts of water were taken from Hungry Horse reservoir to meet power loads, an eager fisherman bored his hole in the ice in preparation for a day of ice fishing. When he peered through the hole and saw the water about 12 feet below him, he got off the ice about as fast as Eric Heiden skated the 500-meter race in the Olympics, and has not returned.

In this paper I have emphasized two tradeoffs in the use of Columbia River water--irrigation versus power and fish versus power. There are many other complex relationships, however. For example, the Treaty with Canada, the Pacific Northwest-Pacific Southwest Intertie contracts, and the Coordination Agreement each involves many other hydroelectric projects in the Pacific Northwest besides the 30 Federal projects, and each involves other imperatives which significantly complicate the decisionmaking process.

Clearly, the economic problems involved with the competing water uses of hydroelectric power, irrigation, and the anadromous fisheries industry are not yet solved. Some of the competing interests are less enthusiastic than others about the application of economic analyses to their solution. Obviously, where the opportunity costs of a sacrificed purpose carry high price tags and yield relatively modest gains in terms of the benefited purpose, it is difficult to make a persuasive case for the tradeoff. On the other hand, where modest sacrifices in terms of one resource yield large gains in terms of another, the tradeoff may become irresistible.

Operating agencies are working individually and collectively on these problems. The Pacific Northwest River Basins Commission is currently working with those involved in what is called the "Regional Tradeoffs Analyses Program."

Hydroelectricity is not the only use of water for electric energy. The use of water for cooling the condensers of thermal electric generating plants is, of course, another very important water use and involves many considerations. Many comparative studies exist.

In the United States a variety of condenser-cooling systems are used ranging from once-through cooling, especially for older powerplants, through spray ponds, cooling ponds, cooling canals, and wet cooling towers with or without forced draft, to dry-type cooling towers. At Gillette, Wyoming, where water is very scarce, the Pacific Power & Light Company and Black Hills Power & Light Company jointly own a 320,000 kW, coal-fired plant which depends on dry cooling. This plant uses very little water, merely makeup feedwater in effect, but it pays a substantial penalty in the form of reduced efficiency. Clearly, the scarcity of water at the site of this mine-mouth powerplant located in a very rich coal area translates into economic cost. Even so, the companies are planning a second unit.

Not unrelated to this subject of condenser cooling are the cogeneration plants which produce electricity by means of a high-pressure, turbine-driven generator. Steam is then bled from the turbine to a district heating system, pulp mill, or other industrial plant requiring process heat. Thus the factory or district heating system serves in lieu of the condenser.

Finally, in addition to hydroelectricity and condenser cooling, water is used to transport coal. The conventional system involves the use of the Nation's inland waterways to barge coal from mines to powerplants. But coal-slurry pipelines, of course, are now gaining increased attention. For example, Wyoming is involved in efforts to export coal by means of coal-slurry pipelines. Because of water scarcity, one scheme proposes to pump the slurry water back to Wyoming.

Let me turn now to Professor Linsley's mention of some topics he hoped might come up in my paper. I can see how he got to be a great teacher. He paves a pathway of great expectations for his students. Specifically, he mentions the stream of benefits from the building of an electric generating plant, and he would also like me to mention secondary benefits and employment benefits.

An important policy on benefits and costs was laid down by the Congress in the Flood Control Act of 1936 in these words:

> " . . . that the Federal Government should improve or participate in the improvement of navigable waters or their tributaries, including watershed thereof, for flood-control purposes if the benefits to whomsoever they may accrue are in excess of the estimated costs, and if the lives and social security of people are otherwise adversely affected.:
>
> Act of June 22, 1936

Beginning in 1946 and until 1965, the leadership on secondary and indirect benefits and methods of allocating project costs of those benefits resided in the Federal Interagency Committee for Water Resources, commonly known as Firewater. That Committee developed the well-known "Green Book" or "Proposed Practices for Economic Analysis on River Basin Projects" (1958). This was followed by Senate Document 97 in 1962.

The advent of the Federal Water Resources Council in 1965 has added to the debate. The real issue may come down to the respective roles of the Executive and Legislative branches of the Federal Government. The Congress, under the property clause of the Constitution, reserves to itself the final right and authority to decide on a proposed water resources project on the basis of a political economy decision. The Congress expects the Federal agencies to assemble the facts, but only as an aid to enable Congress to make the decision.

Before leaving the subject of secondary and indirect costs and benefits, I would venture a guess that new terminology and new methods may well arise without reference to the old rules of the water project evaluation reports. One such new term is cost effectiveness on a life-cycle basis. Cost effectiveness as a term appears increasingly in new laws relating to energy generally and specifically in connections with energy conservation and development of renewable energy resources.

In looking down the road I would suggest that energy may be a top-level national priority for at least the next two decades -- for the rest of this century. The reason it is likely to continue to occupy national attention is because of the real crushing economics that reside in the lack of energy. Perhaps as energy receives more and better organized attention, we will find a climate that will be more receptive to innovation.

As a research organization, the Electric Power Research Institute (EPRI) should have an opportunity to cash in on that improved climate for innovation and for looking into the future with an open mind. The economics of the use of water for electric energy production makes the siting and cooling of thermal plants difficult at present and perhaps more difficult in the future. And it illustrates one of the many challenges ahead for utilities.

Doxiadis suggested a total system approach to the use and reuse of water. He set aside traditional single-purpose methods. In doing so he made at least two contributions to the consideration of the economic aspects of the use of water for energy--one specific and one general. The specific contribution, of course, is a suggestion that the use and reuse of water be considered on the basis of a total system approach rather than on the basis of single purposes. The general contribution is an implied suggestion that innovative and large-scale approaches should be explored and cultivated in addition to traditional narrower approaches.

With respect to the specific contribution, the Columbia River system serves as an interesting example of a total system approach to the use and reuse of water. In many ways it is a pioneering effort where several water uses, some quite harmonious with one another, and others in competition with one another, are all programmed as part of the multipurpose development and operation of a large river basin system. It makes for a fascinating case study. And the final chapters are yet to be written. The ultimate tradeoffs among the multiple uses are still unsettled.

With respect to the general contribution, it strikes me that the Electric Power Research Institute is ideally suited to explore uncharted seas in ways which bring to bear creative and imaginative research. Now as perhaps never before, it is useful to look far and wide for solutions to energy problems in general and to water-related energy problems in particular. With so much underlying uncertainty about our energy future, and with so much at stake, visionary approaches should not be neglected. They need not always be substituted for more conventional problem-solving methods, but they should not be ignored.

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Section 9

SOCIAL EFFECTS ASSESSMENT FOR MULTIPLE USES OF WATER RESOURCES

Ruth L. Love*

WHOSE CUP DOES NOT RUNNETH OVER?

One objective of social effects assessments is to provide an accounting of which groups benefit and which groups bear the costs of a given undertaking. The development of such accountings depends upon an understanding of the biological, physical and social processes underlying chains of effects. In the Pacific Northwest, where once both anadromous fish and water were abundant, a variety of groups are now bearing the costs related to the depletion of salmon runs, a depletion to which the extensive system of hydropower dams in the Columbia Basin contributed. Now, considerable efforts are being invested in fine-tuning the operation of the dams in order to facilitate passage of the remaining fish runs. Had we known enough to undertake such mitigating efforts much earlier, the groups whose livelihood and cultural traditions depend upon the salmon would have borne fewer costs.

After social effects are identified, evaluation of them depends upon the values and perspectives of the person doing the evaluating. Very few social effects are clearly "good" or "bad" in and of themselves. Recreation facilities are often built at storage reservoirs designed for multiple uses, including the production of hydropower. In the west, reservoirs are often built in quiet, remote valleys with sparse populations. The influx of recreation visitors to such reservoirs elicit a diversity of reactions from the local residents. Some depreciate the increase in summer homes, noise, traffic, vandalism, trespassing and other activities that are concomitants of recreation developments. Others relish the sense of bustle and excitement that characterizes reservoir recreation developments. The elucidation of the meanings that effects have for different segments of a population is an important part of the social effects assessment process. One way of identifying these meanings is through public involvement programs (see Professor Ortolano's paper, Section 7).

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*Sociologist, Corps of Engineers, Portland, Oregon. This paper represents the views of the author; it should not be construed as representing the view of the U.S. Army Corps of Engineers.

In the case of water resources, the concept of water availability is itself subject to different meanings to different segments of the population. In the Pacific Northwest, farmers and others interested in irrigation development see water traveling down the Columbia River to the sea, and regard it as "wasted" if it is not withdrawn beforehand for beneficial use. The electric power industry, in contrast, worries about every drop of water that is withdrawn upstream of the various hydropower dams and so unavailable for power production. The agencies and groups concerned with fish resources view the river water as habitat, and one that has already reached critical limits such that the survival of fish runs are in doubt, especially if water flow and water temperatures are further altered by the operations of the hydropower dams and water withdrawals for irrigation. Thus, a resource that appears "wasted" to farmers is already in scarce supply from the perspective of others. A utility that does not take account of these differences in meanings of resource availability early in its planning process is all too likely to find itself in an adversary position when it applies for governmental permits to implement a power production plan.

Precisely because the same physical, biological and social effects have different meanings for different segments of the population, many planning decisions that are seemingly technical are also political because they bear on values and concerns held by different segments of the population. If these meanings and concerns are identified early in a planning process, through social effects assessment work and public involvement programs, plans can more readily be modified to reflect a variety of public concerns and to mitigate unavoidable effects that are regarded as adverse.

SOCIAL IMPACTS, SOCIAL EFFECTS AND SOCIAL CHANGE

The terms social impact and social effect tend to be used interchangeably. I prefer social effect because it provides scope for effects that are more subtle than dramatic. "Social impact" reminds me of bomb craters but very few social effects are of that nature.

Social effects are social changes that result from the introduction of a new action or phenomenon into a social system -- whether that system is as tiny as a family, middle-sized and more complex like a community or region, or very large like a whole society. (See Professor Trelease's paper, Section 10, for examples of social change in Wyoming due to coal mining.)

The occurence of social effects is based on the assumption that a change in one component of a social system is likely to effect changes in other components. I shall illustrate this with a social effects assessment that examined the effects of putting more land under irrigation in two Oregon counties bordering the Columbia River, west of McNary Dam (Figure 9-1). Historically, Morrow and Umatilla counties have been dryland wheat areas with just a small amount of irrigated agriculture on river bottom land. With the development of center-pivot irrigation technology in the 1960's, which allows large tracts of sandy soil to be irrigated very efficiently, irrigated agriculture mushroomed along the banks of the Columbia. In the two counties together, irrigated acreage increased from 93,000 acres in 1969 to about 153,000 acres in 1974, an increase of about 65 percent in 5 years. The water for irrigation was pumped both from the Columbia River and private wells. In Figure 9-2, the relatively rapid and large increase in irrigated acreage represents a development project input to the social system, in this case, Morrow and Umatilla counties.

The direct effects of this development were dramatic increases in employment and a reversal of the population decline that the area had been experiencing. Between 1970 and 1977, about 800 new agricultural jobs emerged, and about 1,300 jobs in new food processing plants, mainly potatoes for the fast and convenience food markets. The population of the two counties went from about 49,000 to about 60,000 in an 8-year period, with much of this growth being concentrated in several small towns. The town of Umatilla jumped from 700 to 3,000 inhabitants; Boardman from 200 to 1,300; Hermiston from 5,000 to 8,000; and so forth.

Having noted these direct effects of irrigation development, we are ready to move to the indirect effects which are less tangible, more difficult to measure and have different meanings for different people. In the interests of time, I shall talk mainly about the effects category of "social well-being." This is a global category that summarizes a person's satisfaction with both the monetary and non-monetary aspects of his life. Historically, there has been a tendency to assume that developments which induce more employment and population growth add to social well-being, but the matter is not quite that simple.

First, let us consider the jobs created through irrigation development. The bulk are semi-skilled and unskilled jobs that pay $3.00-$3.50 an hour in the food-processing plants and the new large corporate farms, or about $7,000 annually. These figures mean that a family needs two wage earners if it is going to have an

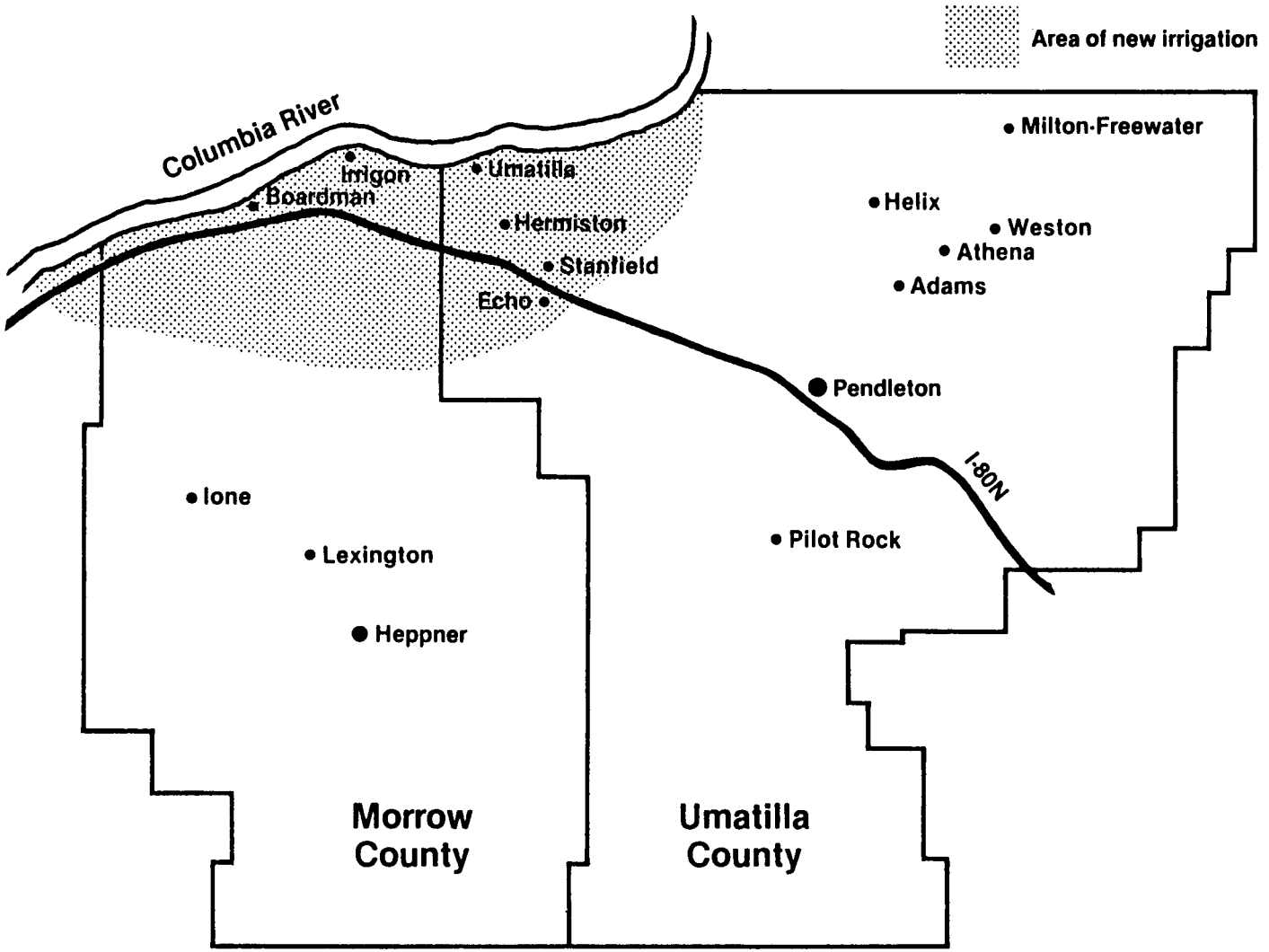

Figure 9-1. Umatilla and Morrow Counties, Oregon

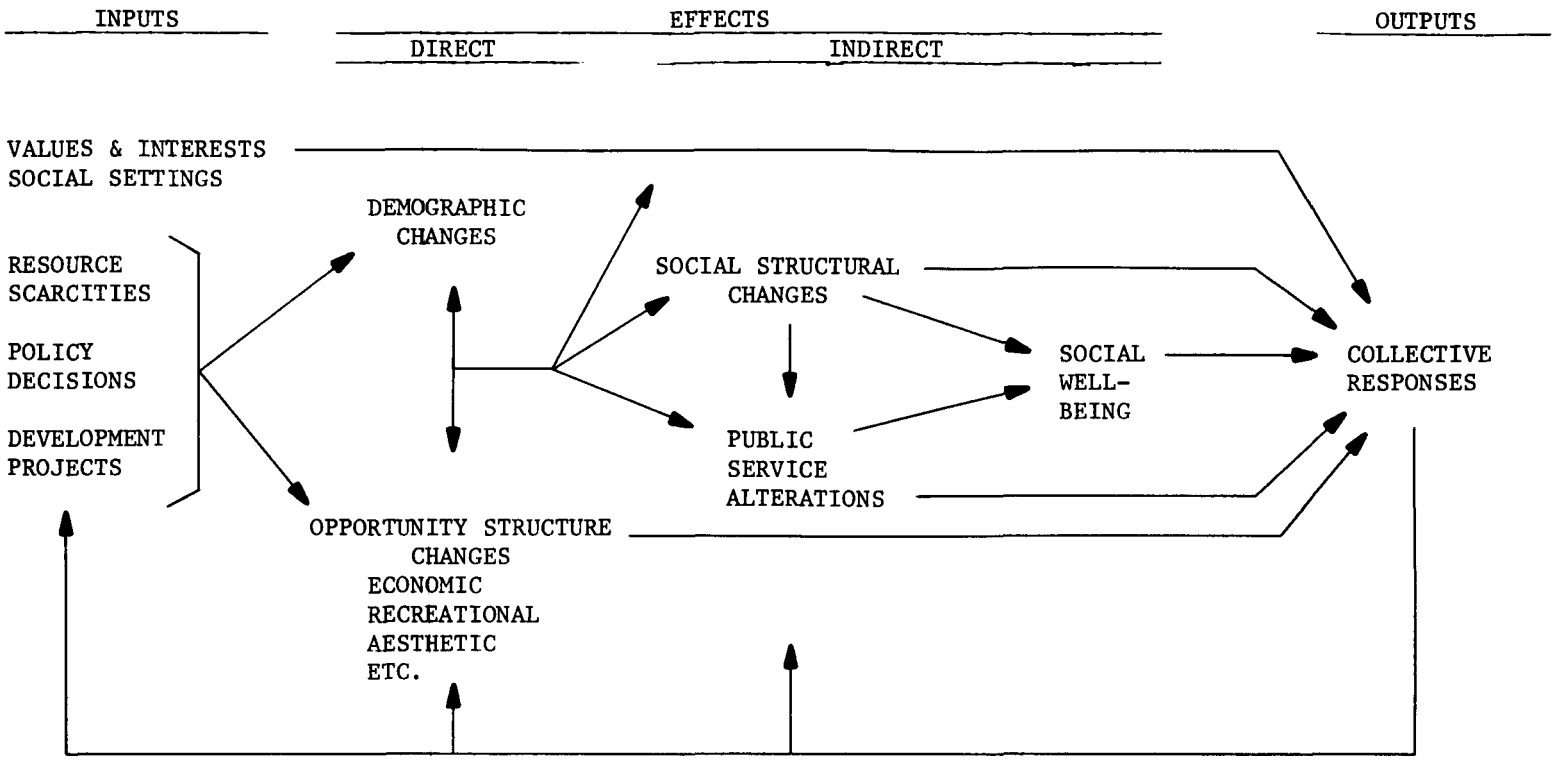

Figure 9-2. General Social Effects Model

Adapted from M.E. Olsen and D.J. Merwin, "Toward a Methodology for Conducting Social Impact Assessments. . ." in Methodology of Social Impact Assessment, ed. by K. Finsterbusch and C.P. Wolf, 1977.

income above poverty level. (In 1979, the poverty level was about $7,410 for a 4-person non-farm family.) Many food processing plant jobs are similar to assembly-line work. Turnover is high for several reasons, including the alienating aspects of the jobs. But for someone who has difficulty obtaining employment, a low skill, low paying and low prestige job may be preferable to unemployment. And for someone else, such a job may offer an opportunity to live in a small town instead of a larger city, the preference of over half of the American population. Thus the meaning of the jobs created by irrigation development, or any development for that matter, depends upon where the job holder is sitting in the social structure.

Population growth has similar multi-faceted implications for social well-being. When a town jumps from several hundred to several thousand in a short time, it not only has obvious implications for the provision of services and utilities, but also for how people relate to each other. A merchant may have to change his system of extending credit to accommodate more customers. A law enforcement officer may choose to book a youngster rather than talk with the parents because he doesn't know them. A principal may have less contact with parents and students as the school enlarges, adding to his administrative tasks, and so has to rely more on rules rather than informal contact to maintain order on the school premises. So it goes. Whether one regards the changes induced by population growth as good or bad depends upon one's own preferences and aspirations. A small school affords closer contact between parents, students and teachers but cannot offer the diversity of courses and activities that a larger school can. Likewise, a larger town offers more services than a smaller one even though the merchants and police may no longer know everyone.

In the case of the social changes attendant upon irrigation development in Morrow and Umatilla counties, a number of people commented on not knowing everyone anymore and on the new pattern of locking doors, but the general impression is that both long-time residents and newcomers are adapting to each other and to the changes, partly because there is a homogeniety of values among the two groups. Although there are a small number of Mexican-Americans among the newcomers, both groups tend to be white, protestant, and place high values on small town and agrarian ways of life. This is not to overlook the fact that among some newcomers, families may be undergoing stress as they find new jobs and new places to live and try to establish themselves.

Thus some of the factors underlying social well-being in the two counties have changed. The tantalizing question of whether there has been a net gain in social well-being would require a study over time. The even more tantalizing question of whether the use of water for irrigation development provides more net social well-being than the use of this resource for energy production would require a fairly extensive research plan.

Turning again to Figure 9-2, "collective responses" refers mainly to organized political responses to a situation. The citizens' group which supports or opposes the construction of a new powerplant is an example of a collective response. In the limited study that the Corps did of the Morrow-Umatilla area, we were able to identify only two collective responses associated to date with the effects of irrigation development. The first is that the local farmers disagree with the State of Oregon over whether the area should be declared a "critical groundwater area." Such a declaration would protect older wells from continued lowering of the groundwater table but would place restrictions on new wells. The second pertains to the county hospital, which is located 45 minutes away from the area of new irrigation, in the dryland wheat country. Historically, the dryland wheat farmers controlled politics in Morrow County, but the base of control is shifting to the new irrigated areas which now have the greater population. The hospital is in need of improvement, but twice, the voters from the irrigation areas have defeated county bond measures to improve the hospital. It is likely that Morrow County will have to create a hospital district that excludes the new irrigation area in order to have the bond measure pass. The hospital issue is an illustration of how an initial input, in this case irrigation development, can lead to a restructuring of constituencies, which, in turn, affect the outcome of collective responses (Figure 9-2).

Collective responses can take many forms, from voting down a bond issue to developing a systematic campaign for or against an action. Collective responses may arise out of an identifiable need or concern. For example, one Corps reservoir in western Oregon has become extremely popular for sailing and other water sports. This is a large shallow reservoir which does not fill in all years, and in some years, is drawn down to meet downstream minimum flow and irrigation requirements. As a result, several interest groups have arisen in a nearby city to watch the reservoir and correspond regularly with the Corps about maintaining an adequate water level in it for recreation. Collective responses can also arise from an accumulation of changes over which people feel they have little or no control,

but are seen as threatening their ways of life. When people vote down a new coal-fired plant, as has occurred in Idaho, they may be expressing broader concerns than fear of air pollution. They may be fearful of further development stimulated by the presence of a powerplant, which in turn, can change the social ambience with which they are familiar. (Professor Trelease has examples of this in his paper. Professor Ortolano discusses in his paper how early public involvement programs can help in these matters.)

SOCIAL EFFECTS ASSESSMENT AND THE PROJECT PLANNING, IMPLEMENTATION AND OPERATION CYCLE

Social effects differ in one very significant way from biological and physical effects. Biological and physical effects occur only if a project is implemented but not during a project's planning phase. In contrast, project-related social effects are continually ongoing, occurring during the entire cycle of planning, implementing and operating a project. For this reason, it is wise to consider them through the entire cycle. During the problem defining and planning phase of this cycle, social effects arise due to uncertainty about what is to happen or a given set of expectations about what is to happen. I shall draw on several examples from Corps projects to illustrate this point.

Dam building frequently involves the relocation of people and property on lands to be used for the project. Between the time a dam is first being considered and the time when the agency actually buys the property and removes people, much uncertainty is generated for the people in and near the damsite. They wonder about whether they should continue maintaining or remodeling their properties, what will happen to their businesses and homes, what compensation they will receive and how the proceedings will be handled. They wonder what their options for relocation are, when all this will occur, and whether it will actually occur. The uncertainties and unease generated by the possibility of impending dislocation tend to be compounded if the affected population has strong attachments to its community, if people have little experience making major residential moves, and if they do not readily perceive alternative areas to move to where they can follow their ways of life and retain their social ties.

One community in the Northwest lived with such uncertainties for over 20 years, due to the eventual construction of the Bonneville Dam second powerhouse. The townspeople were reluctant to do much maintenance and remodeling work, but at the same time, they developed a strong attachment to the area and to their own commun-

ity. As the time for dislocation drew nearer, the townspeople sought assistance for solving their problem and for developing a new town nearby. Assistance eventually came in the form of special Congressional legislation authorizing the construction of a new town, but in the meantime, relations between the Corps and the town had become extremely tense, for the townspeople felt the Corps was ignoring their concerns and needs. With an early public involvement program to assist the town with its uncertainties and needs, much heartache and expense might have been avoided.

Other people besides those facing the possibility of dislocation are affected during the planning phase of the project. About 40 years ago, when a dam was proposed for a popular fishing river, sportsmen, lodge owners and professional guides alike became concerned about what the project would do to the river's famed fish runs and water quality. In this instance, the affected parties were well organized. Also, the proposed dam was part of a reservoir system for which planning was being assisted and supported by a series of state and local committees, which set the tone for responsiveness to local concerns. As a result, the Corps changed its plans; instead of constructing a dam on the river's main stem, it constructed dams on two tributary streams. In this instance, the expectation that the fish runs would be adversely affected led to a modification of the plan.

During the planning phase of the project, people can develop "positive" expectations about it as well as "negative" ones. If the positive expectations are unrealistic, people are likely to be disappointed with the project when it is completed. Some research has been done on this social effect of project planning; it generally shows that people develop over-optimistic expectations about the economic effects of a project--that it will create more jobs and business for the community as a whole, for their friends and for themselves than turns out to be the case. One reason for over-optimistic expectations is that many of those jobs which are created by a project tend to be taken by newcomers to the area rather than by established residents. This is expecially the case with regard to the better paying, more highly skilled jobs. The long-term consequences of developing over-optimistic expectations during the project planning phase have not been studied, but I suspect that where this occurs, people are less likely to be supportive of future projects that generate social change but do not meet their expectations.

Other types of social effects can also be induced by the planning phase of a project. These include changes in property values and the local pattern of real estate transactions, changes in the rate of population growth or decline, and so forth. These planning phase effects compound the social changes that are induced as a project moves from planning to implementation and operation.

Another set of social effects emerges when a project moves to the implementation-construction phase. The social effects are most dramatic in isolated areas of small populations where a large work force is required for construction of a project; these effects are symbolized by the phrase "boomtown." During construction, the local population suddenly swells, and businesses and services are strained to meet the new demands placed on them. The situation is further complicated by the fact that construction workers sometimes bring with them different ways of life and values than those followed by the local community. Construction workers bringing children with them present problems for the schools; the children used to "nomadic" ways of life, do not make friends easily, and may be in a different learning phase than the local children.

Several years ago, the Corps discovered that small isolated towns which have had experience with construction boom-bust cycles are far from enthusiastic about new projects in their vicinity. As a result some efforts have been undertaken to develop social mitigation strategies but these are still very much in their infancy. To date, much more legislation and research has been devoted to fish and wildlife mitigation than to social mitigation.

After a project is constructed, its presence and operation generates social effects because it does, after all, constitute a new item in the social environment. The construction of reservoirs near logging communities in the foothills of the Oregon Cascades brought new opportunities and new headaches to them. Dealing with both requires greater coordination with other government agencies than that to which the townspeople were accustomed. With still-water recreation in their backyards, the townspeople have become interested in developing supervised municipal swimming beaches to serve local children in particular. But they have had difficulty in determining how to contact the Corps, and who to contact to help develop such a plan. The problem is that although the reservoir is highly visible the people who run it are not, being hidden away in a powerhouse below the dam. There is need for a liaison person, appointed by the agency or utility owning the project, to be visible and available to local residents, to help troubleshoot

problems, to identify opportunities for new undertakings as a result of the project's presence, etc. In effect, such a liaison person provides opportunities for maintaining an ongoing public involvement program after the project is in place. Fancy project visitor centers cannot fulfill this role unless the head of the visitor center is also given authority by the parent organization to assume this liaison function.

Where particular interest groups have been successful in establishing contact with the appropriate authorities responsible for a project, they have reaped some social benefits. For example, white-water canoeists have obtained increased flows downriver of dams on days of white-water races. I am not prepared to say whether such special operating releases detract from other project purposes, such as power production and fish and wildlife management. But what these releases point to is that through attention to alternative ways of operating as well as designing projects, it might be possible to serve more interests at least some of the time.

If social effects are to be given consideration through the entire planning, implementing and operating cycle of a project, then the organization owning the project must make appropriate internal institutional adjustments. These include having people trained in social effects assessment positioned not just in planning, but also in departments concerned with construction, operation and maintenance.

SOCIAL EFFECTS AND MULTIPLE USES OF WATER

The uses of water in this country are sweeping in their breadth and diversity. The uses range from the spiritual and aesthetic, as symbolized by photographs of sailboats and sunsets on sparkling waters to the disposal of all kinds of wastes. The Corps' litany of water resource development purposes include flood control, power production, navigation, municipal and industrial water supply, fish and wildlife management, recreation, and water quality control. Multi-purpose dams that the Corps builds are usually authorized to serve all these purposes.

There are two ironies, however, in building dams to serve all these purposes. First, some purposes are both weakened and strengthened by a project. For example, in the case of recreation, the damming of a stream can eliminate or modify the forms of recreation that were dependent on its free-flowing characteristics, while the reservoir behind the dam affords a new still-water recreation oppor-

tunity. In this way, the opportunity structure for water-related recreation has been altered, and one constituency has benefited while another bears the costs.

The second irony of multi-purpose water projects is that operating the project to realize one purpose can detract somewhat from the realization of another purpose. For example, to some extent, operating a dam in the interests of flood control can, in some years, reduce the amount of power produced there. In western Oregon, storage reservoirs are not filled to their maximum capacity during the spring filling season to retain flood control space for heavy, but rare summer storms. Thus there is simply not as much water stored as would be possible for power production and other purposes.

These ironies tell us that depending upon how water is used and water resources projects are managed, there are exchanges of social effects. A very systematic tracing of these exchanges may provide some clues for policies that would lead to the more optimal use of resources. Let us consider the use of water for power production, flood control and recreation. A major impetus for many dams has been flood protection for people living and working in flood plains. These dams have, in some parts of the country, also provided summer flow augmentation to rivers, making them more attractive for recreation. But flood plain development, which has increased greatly due to the protection from the dams, has reduced access to rivers for recreation. Recently, the Corps has been studying non-structural alternatives for achieving flood protection, including the removal of people and damageable property from the flood plain. Such removal reduces the amount of damage a flood can inflict, and makes flood plain land available for uses not vulnerable to flooding. In areas where dams are already in place, like in western Oregon, the removal of structures which could be damaged during summer flooding would permit the "exchange of social effects." If these properties were removed, some of the operating constraints on the dams would also be removed, allowing for more summer filling and more fall power production. The removal of private properties would make riverfront land available for a variety of low-cost uses including wildlife habitat and recreation. The removal of people and properties from flood plains of course has its own social effects which would need to be considered.

The technique of tracing the exchanges of social effects under alternative approaches to water resource utilization has several uses. First, it should permit identification of the social effects that are not exchangeable. The

opportunity to recreate on fast, free-flowing streams may simply not be exchangeable anymore because there are relatively few such streams left. Second, it may permit a more realistic assessment of what can be expected from utilizing resources in a certain manner. I suspect that one of the strong impetuses for promoting more irrigation development in the Northwest is to provide more opportunity for farming. But our research on social effects of irrigation shows that the new high technology irrigation is producing corporate style farms, whether or not they are family-owned, and many low-paying jobs. If more farming opportunities for many families are the social goal, we may be better served by conserving farmland in the humid portions of the country than by adding more water to the desert.

Tracing the exchanges of social effects under alternative uses of water resources requires considerably more data on social effects of projects than is now available. In particular, we need to consider the social effects of water resource projects over time. For example, what will be the social characteristics and level of social well-being in Morrow and Umatilla Counties in a few years, once the boom effects of irrigation development have passed and the long-time residents and newcomers have had time to adapt to the changes? Will turnover in the food processing plants continue to be high? What happened to the employees who left these plants? Did employment there give them a toe-hold in the economy and lead to more rewarding jobs? And how do all these effects compare with the social effects that result when water is used for energy to produce a given mix of goods and services?

SOCIAL EFFECTS ASSESSMENT AND PROJECT FATE

Many utilities are finding themselves cast in the role of adversary, having to defend their project plans for meeting anticipated future power demands before a variety of government bodies. In part this situation has emerged because in the past utilities (like so many others) did not take into account the environmental and social effects that their projects would have which would be regarded as undesirable by some segments of the public. Projects were built on faith that they would benefit society. This faith began to be shaken when projects produced undesirable side effects that had not been anticipated beforehand. The "cross examination" of plans for future power projects constitutes an adaptive response to what happened in the past. The "cross examination" process, although placing utilities in an adversary position, had already led to plan modifications that

mitigate some undesirable effects. For example, in the case of one nuclear plant, the utility changed its plans for disposing of "cooling water" in order to reduce the effect disposal would have on river temperatures.

In essence, assessment of biological, physical and social effects of plans for producing future power allow the utilities to conduct their own "cross examinations" prior to the requests for permits. The effects assessment process is intended to lead to wiser plans, and proposals for mitigating undesirable but unavoidable effects.

Effects assessment work cannot guarantee that a utility will have an easier time having its proposals approved, but it will show that it has done its homework, and understands the various public concerns in regard to future power projects. Public involvement programs that accompany planning and effects assessments serve as the record for showing how a utility has become aware of public concerns and taken them into account. This can help move a utility out of the adversary role, and into a new partnership role with the population whose power needs it is responsible for meeting. That EPRI is interested in undertaking programs in the area of social effects, institutional constraints and public involvement represents an important step toward this new partnership.

PROGRAM DIRECTIONS FOR EPRI TO CONSIDER

The quest for knowledge involves more than the finding of answers to questions. The answers must be synthesized and disseminated to potential users of knowledge. Many research programs have languished on dusty shelves because after the findings were published in the scientific literature, little thought was given to wider dissemination. In regard to some social effects, enough is known now that more attention needs to be given to dissemination than to original research.

Research programs where attention has been given to disseminating findings to potential users have languished for another reason. Potential users are typically involved with practical day-to-day concerns and are looking for "quick and ready" answers to their questions. They want the "magic recipe" that will solve their problems. But research findings do not lend themselves to magic answers. They have to be contemplated in regard to the problem at hand, with the user distilling and adapting the findings to suit his particular situation. Thus a general knowledge and understanding of social effects can guide a utility in identifying

possible social effects of a proposed undertaking in its district. But the general knowledge cannot tell him specifically what the social effects will be. Social effects are specific to a region at given point in time. Social effects studies can only function as a guide to the possible range of effects that might be expected under given conditions.

The two foregoing points apply to the following proposals for program directions that EPRI might consider.

Literature Review, Consolidation and Analysis of Past Social Effects Studies

Since the mid-1960's, Congress had funded considerable research pertaining to the uses of water and the effects of water resource development projects. Since the passage of the National Environmental Policy Act of 1969, a fair amount of research has been undertaken in regard to the construction-related effects of water and energy projects. Also, since the mid-1950's, the Department of Agriculture and other agencies have funded research on the effects of economic development in rural areas. Consequently, there are several social effects areas where there is now a sufficient literature (scattered in agency reports, university institutes and the academic journal literature) to permit consolidation of findings and specification of conditions under which certain social effects are likely to occur. Two areas, in particular, for which such consolidation and analysis is needed are boom town construction effects and the social effects of more intensive development in small towns and rural areas. Social effects pertaining to water-related recreation and to fisheries have also received a fair amount of study so that literature review, synthesis and analysis would be feasible. Analysis of the existing literature on these topics may supply more data and ideas for tracing the exchange of social effects for different uses of water. Also, such analysis would better define areas where original research is needed.

Long-Term Monitoring of Effects

Under the heading of original research studies, to my knowledge, there are few studies which have monitored the social effects of water projects and water uses over time. With the exception of the Nuclear Regulatory Commission, no agency, as far as I know, is following up its social effects assessments with studies to see whether the anticipated effects are indeed occurring. Such monitoring studies need to cover a sufficiently long timespan to identify what happens after an area goes through the initial turmoil and change associated with a water-using project, and has had opportunity to adapt to new circumstances.

Social Mitigation Studies

Also, under the heading of original research, social effects mitigation studies are needed. Very little is known about social mitigation strategies that would benefit those groups bearing the social costs of a project. Certain types of effects pertaining to fiscal matters, community functioning and the relocation of people could be mitigated through better prior planning and provision for expected effects.

Case Studies of Planning Successes and Failures

A planning success occurs when a utility is able to receive the permits it needs, with a minimum of delay, to proceed with construction of a project. A planning failure occurs when a utility undergoes considerable delays and difficulties in obtaining its permits, or is denied its permits. Two or three studies of each type of event may help identify how social effects assessment, public involvement programs and social mitigation strategies can be used to facilitate planning processes.

"Thinking About Alternatives" Research

Can we invent new ways of thinking about alternatives for using water in energy production? Professor Trelease's paper I found highly informative because I did not realize that large-scale coal mining in the Great Plains also led to water "mining." Given the high value of water in the arid west, one wonders about such alternatives as transporting Great Plains coal to areas of more abundant water before converting it to energy. This is an example of what I mean about "alternatives thinking."

In general, some conceptual work needs to be done on how to think about alternatives, and different levels of alternatives, given that some effects are probably not exchangeable. One conceptual level is the water supply itself. Can something else be substituted for water, for a given purpose? In the case of irrigated agriculture, studies and experiments are underway to use certain types of waste water as both a source of fertilizer and irrigation water for irrigated pasture and other suitable crops. A second conceptual level is developing alternative approaches to project design in order not to disrupt some aspects of water supply. For example, Idaho Power is considering underground tunnels on the North Fork of the Payette River to provide the head needed for power production, to avoid damming the river. This proposal will have fewer adverse effects on fish although it still would detract from white-water boating on the river. Clearly, different

alternatives will have different costs and effects but first we need to increase our ability to think imaginatively of alternatives before we can compare their costs and effects to more traditional plans for using water. This suggested program direction overlaps with the social mitigation program direction. In essence, the expansion of alternatives makes it more feasible to develop some that mitigate the effects of other alternatives.

Coordination of Research

The final point I want to make bears on the coordination of research rather than research itself. The Federal Government funds a broad array of research activities; also private foundations fund a broad array. EPRI might consider establishing a research coordination office which would be responsible both for tracking these activities and possibly influencing the direction of the research so that the resulting studies can be of some use to EPRI. Some research activities that could be followed in this manner include research sponsored by the Sociology Office of the National Science Foundation, the Water Resources Research Institutes attached to state universities (usually the land grant universities), and the Institute of Water Resources of the Corps of Engineers. It does not seem entirely appropriate for EPRI to sponsor original research on some of the broad questions I outlined earlier, like what is the net social well-being associated with using water for agriculture in comparison to using it for energy production and the end uses thereof. But it would be appropriate for EPRI to inform other research entities that it is interested in these types of questions.

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Section 10

LEGAL PROBLEMS IN THE ALLOCATION AND TRANSFER OF WATER TO ELECTRIC UTILITIES

Frank J. Trelease*

INTRODUCTION

The expansion of electric energy production in the western United States will increase the industry's demands for water in three areas: for hydroelectric power, for cooling, and for coal slurry pipelines. Insofar as these needs are met by the utilization of new water supplies only the allocation of water to slurry pipeline produces a significant legal problem. On the other hand, where it becomes necessary to take water presently put to other uses and shift it to energy production, the laws governing the transfer of water rights may present some problems.

ALLOCATION OF NEW SUPPLIES

The law of prior appropriation had crude beginnings in the California gold rush. Thousands of forty-niners crowded the diggings at the mouths of the Sierra canyons and staked "placer claims" on the alluvial benches and fans. They staked similar claims to the water needed to wash the gold from the gravel. Since there was neither gold nor water enough for everyone, both were put on a "first come, first served" basis. Claim jumping was discouraged by Colt and Winchester. When the Great American Desert was found to be habitable, the first settler in a valley took first choice of the land and enough water to irrigate it, the second comer had to make do out of what was left. These self-made laws were recognized by courts and formalized by legislatures, and today prior appropriation is a quite civilized system of state grants of property rights, enforced and regulated by administrative agencies with substantial offices, rooms full of records and squads of men in the field.

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*Professor of Law, McGeorge School of Law, University of the Pacific, Sacramento, California.

One of the most important features of modern appropriation law is the permit system. Any person desiring to start a new water use must get a permit from the state. The permit may be denied if there is no unappropriated water in the source and if the new right, if granted, would conflict with existing rights. The permit may also be denied if the proposed use would not be "in the public interest." Using this power, water officials have chosen the better of two competing projects: they have denied permits for projects that do not comport with state water plans, and they have placed conditions and limits on permits in order to prevent serious environmental harm.

An appropriation is a definite and identifiable piece of property. Its boundaries are marked by the quantity that may be diverted from the source, the place the diversion may be made, the use that may be made, and the date that tells when the right may be used. The quantity of water is expressed in terms of cubic feet per second, the rate at which water may be diverted from the sources (1), unless the appropriation is one for storage, in which case the water allowed is expressed in total quantity in acre-feet (2). An appropriation need not be used on riparian land or even in the valley where the water originates (3). Most are for irrigation, but every type of beneficial use of water may have an appropriation to serve it: municipal use, manufacturing, production of hydroelectric or steam power, mining, or processing, recreation -- beneficial use is not a closed category (4).

When the "coal rush" to the northern high plains started a few years ago the people seemed to lose faith in these long-used mechanisms for allocating water and initiating water rights. Slurry pipelines attracted particularly vigorous opposition. Some water was apparently available for them. Water for the iron horses of the first transcontinental railways had been one of the earliest uses in these states, so the transportation of coal sounded very much like a beneficial use. Cost-benefit ratios and net benefit comparisons seemed undoubtedly favorable to the pipelines. But the public reaction to slurry lines was very negative. They would take some of the last unappropriated water out of the state, and this ran counter to local claims that even unappropriated water was "our water," not to be taken away by strangers. This feeling had long ago resulted in some states placing restrictions on the appropriation of water within the state for use outside it (5). There were also some fears that the exporting states would be stripped of their coal resources without the production of much local wealth. In addition, these rural states had long had one strongly

unionized industry, the railroads, and their present and future prosperity could be affected if coal were transported in pipelines instead of in railroad cars.

The matter was first brought to a head in Wyoming by a coal company's applications for a large number of wells into the state's largest untapped groundwater aquifer. The ultimate use was for coal development, but was otherwise unspecified; steam power, synthetic fuel plants or slurry lines were possibilities. People in the small town of Buffalo, Wyoming saw their way of life threatened by overwhelming numbers of miners and construction workers; surrounding ranchers saw the last unappropriated water gobbled up for a new development that also threatened parts of their range land. Their representative in the legislature was successful in securing passage of a bill that slapped a one-year moratorium on the approval of applications to use more than 6,000 acre-feet per year of groundwater for industrial purposes and called for a study of underground water use (6). This got combined with another bill that extended to groundwater the longstanding prohibition against the appropriation, storage or diversion of stream water for use outside the state without prior approval of the legislature (7) and another section that specifically prohibited the use of surface or groundwater as a medium of transportation of mineral, chemical or other products to another state (8). In the same statute, however, the legislature gave its approval in advance to the appropriation by Energy Transportation Systems Incorporated of 20,000 acre-feet of groundwater for use in a slurry pipeline to transport coal to a large steam electric plant in Little Rock, Arkansas (9).

In the following year Montana was faced with the same problem. Knowing that prohibitions on export might run into constitutional challenge as invalid restraints on interstate commerce (10), the Montana legislature tried another tack, adding the following language to their statutory definition of "beneficial use:" "A use of water for slurry to export coal from Montana is not a beneficial use. Slurry is a mixture of water and insoluble matter (11)." Since water can only be appropriated for beneficial use, this blunt instrument approach means that in Montana no appropriation for slurry for export can be made.

South Dakota was more subtle. Her legislature required the Water Rights Commission to submit all applications to appropriate more than 10,000 acre-feet per year to the legislature for approval, and denied powers of eminent domain to any common carrier which had not obtained such prior approval (12).

TRANSFER OF WATER

As each pioneer appropriator was awarded a water right, the supply soon dwindled and newcomers found no water available for them, at least no inexpensive, easily obtainable water. Obviously the best uses of water did not always arise first and get the earliest rights, so it became necessary to reallocate the water. Since farming had taken the largest share this meant that the use and place of use had to be changed from irrigation, often of low value crops, to industrial and municipal uses that would produce greater wealth or command greater income.

The institutions evolved for reallocating water were the transferable property right and the market. The decision-makers were the parties to the transaction. In theory, the process was much like the reallocation of rights in land. A farmer has a fee simple title to his land, running "to him and his heirs forever," but when an encroaching city makes the land more valuable for residences than for crops, a subdivider who will get greater value from the land than the farmer will offer the farmer a price which will compensate him for his lost farm income and give him enough profit to induce him to sell. Although the "land right" lasts forever, the land use is flexible and can meet new and changing demands.

The process is much the same for water. A permanent, stable water right guarantees the farmer irrigation water, but if the water would be more productive in a slurry pipeline or steam power plant, a transfer of the water to the new use can be made by a sale of the right (13). Some think that flexibility requires intervention of the state, but it can be achieved without sacrificing security. The property right insures that the gainers pay the losers; it does not prevent the reallocation of the resource (14).

Superimposing a large scale energy production industry on the sparsely populated grazing and agricultural lands of the West will require large quantities of water, historically applied to hay- and crop-lands, to be reallocated to mining operations, steam power plants, coal slurry pipelines, and mined land reclamation, as well as to municipal use in the towns that house the workers in the new industries. The use of water in the energy industry is on the whole a more efficient, more productive use than the growing of hay, fodder and feed for the meat and dairy industry. According to economic theory, this should create a pressure for change in water use. The economic mechanism for shifting the

resource from a lower to a higher productive use is the market, where water can be bought for a higher productive value at a price which will compensate the displaced user and give him enough profit to induce him to sell.

The legal arrangements for water use should parallel the economic structure and enable and facilitate changes in the market. Unfortunately, it appears that the market in water rights works very poorly. An economist studied conditions in a California valley and concluded that water law was to blame for blocking transfers of water from low- to high-value crops (15). One attorney cited additional problems: defects in titles, poor descriptions, differences between different kinds of water, abandonment, forfeiture, conveyancing, and limitations on use (16). Another expanded this list to reveal the uncertainties, unknowns and impossibilities met when assembling water rights for new uses (17).

One set of differences seems to stem from history: western water rights were set up primarily to create a stable agriculture. While mobility was recognized as a possibility, the system did not really foster it. The result was awkward procedures, poor records and uncertainties that bothered no one until uncovered by proposed changes. Furthermore, in some places, agricultural stability was thought to require express, institutionalized restrictions and prohibitions against change. Several were the "burn down the barn to get rid of the rats" type. In practice, abuses arose; so to prevent the abuses, the practice was prohibited (18). Outright prohibitions seem to be vanishing (19), however, and reform of the technical and mechanical impediments has been advocated by the National Water Commission (20), and some progress has been made. Meyers and Posner, in their study for the Commission, attacked the problem on a wider basis. They looked to organizational improvements to facilitate transfers and transfer proceedings within and by the large water projects that supply so much of the West's water (21).

Even if these restrictions are eliminated, several fundamental problems seem to remain. When A wants to buy B's water, B may be quite willing to sell, but they both may find that C raises objections to block the sale. Perhaps if we find out who C is and what makes him tick, we can come closer to solving the problem.

C may have substantial ground to complain. He may be quite directly affected by the transfer; he may suffer some serious disadvantages from it; but he is not at the bargaining table and he receives no money from A. In other words, the transfer may impose an "externality" upon him. (Some economists call these "spillovers," especially appropriate in the water field.) We used to laugh at the economists who urged us to "internalize the externalities" but this has now become a cliche. We must bring C to the bargaining table and require A and B to deal with him.

Externalities arise because of the imperfect definitions of property rights. Western courts have prevented one type of externality. The rule allowing one appropriator to sell his water has always been subject to the limitation that the transfer must not injure other appropriators. Most irrigation is quite inefficient in the engineering sense. Only a portion of the water diverted and applied to adjacent fields evaporates or is consumed by plants; the remainder seeps back into the stream where it becomes available downstream. Since water can be used and reused, many irrigators may have rights to the same molecules of water. The water right of an irrigator may be phrased in terms of a right to divert a specific quantity of water. If he sells that right to a coal developer for use outside the watershed, he will have sold some molecules of water that belong to others. To avoid this type of injury, the rule was early developed that the transferee can take only the amount consumed by the original use, not the amount diverted from the stream. Put differently, the downstream appropriator has "no right" to sell that part of the water.

Many transfers of this type are hotly contested by downstream appropriators who fear a loss of their water. The factual questions are not susceptible of easy proof. The best way for a downstream irrigator to insure that he is not injured is to block the transfer. A recent Wyoming example arose in which a right to a substantial quantity of water, approximately 32 cubic feet per second, was to be transferred from agricultural land on the North Platte and a reduced quantity pumped out of the basin to coal development operations far away. The diversion point for the pipeline was to be 100 miles upstream from the irrigation ditch. The purchasing company made every effort to show it would install a system of oepration to prevent injury to other appropriators, and pay all costs for installation, maintenance and operation of necessary measuring devices and for administering the proposed change.

The Wyoming State Board of Control, which had to approve the change, believed that other appropriators could not be protected from injury with any reasonable certainty. Two categories of other users were affected: those between the present and proposed diversion points, and those below the old point. The distance and time lag involved, combined with the problems of administration and accounting for water in transit, were considered insuperable. The Board therefore denied the petition (22).

This type of difficulty is probably going to continue. Help might come from another discipline: hydrology. If engineers can find improved measurement and control devices, the law can also provide relief. In some states experimental and conditional changes are allowed (23), but the possibilities of failure may be too expensive.

It is possible that the intervenor is really not concerned directly with the water transfer but has an ulterior motive. Full development of coal will bring intangible changes to the West, as well as physical changes to the landscape. Yet it may be harder to break tradition, habits and patterns of thought than to move the rock and shatter the coal. The future coal country has always been wide open spaces, cow country: A land of irrigated farms and rural county seats. Those who live and love this lifestyle see themselves soon to be overwhelmed by changes brought about by alien forces. In much of the rural West, water is held almost in reverence. Water rights are heirlooms to be treasured beyond their intrinsic value. There is a real resistance to the notion that water is an article of commerce, a subject for trading in the marketplace. The notion persists that water for cattle, for hay, for fodder, for feed grain, for cash crops is the highest and best use of the resource. This has been the predominant use in the past; it fostered the development of the land and the state.

Why is it not the best use for the future? Is it right to take the water now used on the land and gunk it up in mining operations, burn it up in steam plants, convert it into gas, or pump it out of the state in a slurry pipeline? These attitudes may not be logical; they may be subliminal and unrecognized; but they can be very real.

Sometimes the water and its use are really not the prime concern. The real objections may be to smoky industries that will dim the bright mountains, and to hordes of construction workers who will overwhelm the crossroads town, compete

for the trout and the antelope, and bring about changes that will forever destroy the land use of the area and the lifestyle of the oldtimers. In the face of these threats there have been attempts to seize upon water law to hold back development and to throw up roadblocks to delay the transition.

Such motivations have caused South Dakota and Wyoming to pass laws designed to curb and control water appropriation by the coal industry (24). However, Montana's response is the most pertinent to this study. Her legislature flatly forbade the change to industrial use of any agricultural appropriation of more than 15 cubic feet per second (25). In addition, Montanans have redefined the basic water right by declaring that the use of water to export coal from the state is not a beneficial use. If this holds up, an energy company cannot appropriate or buy water for slurry, for the requirement that water be put to beneficial use applies not only to the original appropriation but also to appropriations changed to new uses.

LARGER SPILLOVERS

The externalities so far discussed have been spillovers on particular water users who will be quite directly and seriously affected by loss of water. Some spillovers, however, fall on many people; their effects may be quite intangible, and the impact on each individual may be slight. For the most part the law has not recognized them. Only in rare instances have the courts protected injured persons other than appropriators or required compensation for types of injury other than loss of water.

In Colorado, irrigators who receive water from a distributing agency such as a mutual ditch company are regarded as the appropriators. The company that actually diverts the water from the stream is a carrier of the farmer's water, and is not itself an appropriator. When one farmer sold his water right to a city which did not use the ditch, there was one less person to share the costs of operation and maintenance. The Colorado court required the city to continue to pay to the company the displaced farmer's share of the costs (26). A California court prohibited a change of recipients from a mutual water company, when the water would have been taken through another ditch and the company forced to give service outside its chosen service area (27).

But most social costs seem to have been ignored. When an Idaho farmer sold his water right, his neighbors complained that since the taxes on his land were reduced their's had to be increased to pay for schools and roads. The court found that this external effect of the sale was not a valid objection to the change (28).

Recently, however, these social costs have received recognition and protection in two of the important western energy states. In Wyoming, not only do people in the importing valley feel abused because their lifestyle is threatened by coal development, but the people in the exporting valleys also feel abused. This is not a new phenomenon. The most famous (and extreme) example of this side effect arose early in this century in California, when Los Angeles purchased so much water from the Owens River that the prosperous valley was "laid waste." There and then the reaction was an actual resort to violence -- sundown sniper fire and midnight dynamitings. The new examples are less extreme, but just as real.

In 1975 a significant addition was made to the Wyoming change-of-use statute as it was originally enacted in 1973. The spur for legislative action was a proposal by a mineral developer to take water from agricultural land in the North Platte valley near Torrington, Wyoming, and pipe it to the coal fields near Gillette, nearly 200 miles away. This proposal involved taking several sections of rich crop-land out of production. The company purchased both land and water and intended to change the type and place of use to its mine and resell the land. Residents of Torrington and the surrounding area feared that if a substantial amount of farm land were returned to grazing, tax revenues to the county would diminish, fewer people would live in the area, schools, hospitals, roads and other public services would have reduced budgets, the economic base of the county seat would suffer and businessmen would lose customers.

The Wyoming statute, as it then stood, permitted the change (of historic consumption) if other existing lawful appropriators were not injured. There was no precedent for consideration of these other social costs except the Idaho case to the contrary. Recognizing that the rule could not be changed for the instant case, the people affected secured from the legislature a rule for future cases:

> The Board of Control shall consider all facts it believes pertinent to the transfer, which may include the following:
> (i) The economic loss to the community and the state if the use from which the right is transferred is discontinued;

(ii) The extent to which such economic loss will be offset by the new use;
(iii) Whether other sources of water are available for the new use (29).

This amendment has its own ambiguities and need of interpretation (30), but it recognizes that the social costs of a transfer, though they consist of small amounts spread over a wide area, should be taken into account in determining whether to allow a change.

A case in Colorado involved condemnation by municipalities (not purchase by energy companies), but the problem and the attempted solution were similar to Wyoming's. Since Denver is an attractive living area, people and industries have swarmed to it, causing a rapid urbanization of the surrounding rural area. A few years ago the nearby suburb of Thornton was founded, a "bedroom city" whose wage earners commute to Denver. It has now grown to 27,000 and still it grows. But there is now no unused water to sustain that growth. All of the water east of the Rocky Mountains was long ago used for agriculture; streams on the other side of the Continental Divide have been claimed by the City of Denver. If Thornton is to get more water, it must displace some existing users. It filed a condemnation suit in which it sought to take the water supply and works of a mutual irrigation company that served hundreds of farms. The people of the area felt that mere compensation to displaced farmers was not enough. They, too, turned to their legislators. If the land were returned to dry farming, it could produce only 20 percent of the present crops, and if grain production were so decreased, grain-dependent industries such as elevators, feed mills, beef cattle feed lots and breweries would suffer. Farm labor jobs, farm machinery sales and fertilizer sales would also decrease. Existing farm units would be too small for dry farming, many would have to be consolidated and some land would have to be abandoned. The size of farms would have to be increased considerably to maintain feasible income-producing units for the farm families that remain (31). Like the Wyoming legislature, the Colorado legislature responded to Thornton's problem. Colorado's law dealt only with eminent domain. It provided that when a city starts proceedings to condemn a water right, a commissioner appointed by the court will consider a "growth plan" for the city and an "impact statement" showing the economic, social and environmental effects of the change on the county and the state, the unavoidable adverse and irreversible effects of the taking, and sources and costs of alternative water supplies. The commission may

recommend to the court that condemnation is not necessary, is not in the public interest, or is premature; and it may recommend that an alternative source be used (32).

Neither of these laws affords a complete solution for all problems. The Wyoming law is limited to economic losses and seems to preclude consideration of social and environmental factors. The Colorado statute brings into play a much broader range of considerations but in a narrower group of cases, since it applies only to cities which seek a forced transfer by eminent domain. If the city and the irrigator could agree to a negotiated transfer, no social costs or alternatives need be considered.

Furthermore, Thornton challenged the statute and it has now been severely limited in its operation. The court ruled that Colorado's constitutional grant of eminent domain powers to home rule cities may not be restricted by the legislature. So the Act has no application to the water acquisitions of most of Colorado's important municipalities (33).

NEEDS FOR RESEARCH

Water law rules for the initial allocation of available supplies to new beneficial uses are in general clear and straightforward. The fact that the beneficial use to be fulfilled is the production of electric power does not raise unique issues. The public interest in obtaining the most efficient use of the resource and choosing the best of competing projects is much the same for all types of uses and kinds of projects. The rules for protecting the environment, minimizing recreational losses and avoiding ecological damage apply across the board. The possible assertion by the federal government of rights for Indian reservations and other types of federal reserved rights threaten the stability of all types of rights initiated under and protected by state law. Appropriations of water for in-stream uses could block or limit future diversion or storage projects. All of these concepts have been and still are the topics of many studies and much research. But none of them are "energy specific" and there is little reason for the electric power industry to take responsibility for them. I see no need for industry-oriented studies on these general laws, no special reason why an electric energy approach would produce any different insights or conclusions. A plan to construct a dam and reservoir for a hydropower project or to provide cooling water to a steam plant might run into "site-specific" public interest problems, environmental opposition, federal claims and in-stream

demands. But again, I see no need for studies designed to solve such future problems of the power industry, as a matter of fact, they would perhaps be less helpful than broader-based studies. The factual setting of each project will provide directions for specific research that cannot be known in advance of the project. The issues may be unique and call for analogy to other fields rather than to electrical precedents.

I do see two areas of appropriation law that could be studied. One is a rather old item, probably not of great modern concern. Several western states have preference statutes that subordinate hydroelectric power production to irrigation and municipal purposes (34). "Preference" can refer to one of several quite different things: (1) in time of shortage, the water is devoted to the preferred use instead of to a non-preferred purpose although the latter has the prior right; (2) where applicants compete for permits to appropriate a supply of unappropriated water insufficient for all proposed uses, the preferred user gets the water right, regardless of the relative priority of filing the applications; and (3) where a change is needed in the use of appropriated water, the preferred user may condemn and pay for a prior right for a non-preferred use. These statutory lists of purposes in order of preference reflect the economic thinking of another age and could result in desirable hydropower projects being foregone for irrigation projects of little value or use of a promising power dam site for municipal water that the city could obtain from an alternate source. Perhaps an empirical study of whether this is really a major problem and where it exists should precede an economic study showing the undesirability of such laws and a legal study of precedence for repeal.

The slurry pipeline presents the other topic for study. The matter could be settled by the federal courts, since there is authority for the proposition that attempts by the states to restrict the export of water may be an unconstitutional restraint on interstate commerce (35). There are indications, however, that Congress intends to throw the matter back to state law. Bills now pending before Congress authorize slurry pipelines to acquire rights-of-way over private and federal land contain promises that state water law, not federal powers, will govern the rights of the coal transporters (36).

The shape of the pipeline problem also seems to call for public opinion and motivation research that would precede a move toward legal change. I think that research of this type is needed to determine the attitude of legislators,

officials and members of the public and the public relations programs and educational efforts that might produce a more favorable climate for repeal of the discriminatory laws. Perhaps the problem can be attacked indirectly and legal studies on the environmental and land use planning needs can show the way to direct solutions of the subliminal problems that seem to underline the present unfavorable attitudes toward the pipelines.

The coal slurry pipeline may also run into opposition to the transfer of irrigation water rights from agriculture to industry, but this problem is also faced by those steam plants that will need cooling water to generate power at the mine-mouth. Perhaps the secondary effects of departure from irrigated agriculture are no more than the inevitable effective progress and growth. There are losses to employed workers skilled in the lost activity, to homeowners when property values drop and mobility is lost, to businessmen whose trade diminishes. These effects have been suffered in every town that has had a major local industry go out of business or move elsewhere. Nevertheless these social costs are real, they do impose impediments on desirable shifts of water, and the problem presents a subject for study.

Some precedents for compensating this type of harm can be found. When the United States made substantial additions to Redwood National Park it dealt a severe blow to the logging industry and several cities in northern California. Congress not only bought the land on which the trees stood, it inaugurated a substantial program of actions regarded as necessary or desirable to mitigate adverse impacts on the public and private segments of the local economy, identifying employment programs, employment preferences, retraining, and subsidies to employers of displaced workers (37).

Government intervention and subsidy offer one possibility, but perhaps the market and self-determination could offer another, if better institutional arrangements could be found. Water rights can not only be held by private firms but also by large districts that represent and suppply water to wide segments of the population. Political scientists and lawyers might seek precedents and powers for an organization that could represent the people of the area in an accounting of social costs. For example, had Torrington, Wyoming, been the center of something called the Goshen County Conservancy District, the district might have represented the community in negotiating and collecting not only the costs of reimbursing displaced holders of agricultural water but also some recompense for losses

to the community that might follow a large-scale loss of water from irrigation to electric power production.

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4. Empire Water & Power Co. v. Cascade Town Co., 205 F. 123 (C.A. 8th 1913).
5. W. Hutchins, Water Rights Law in the Nineteen Western States, U.S. Dept. Agr. Misc. Pub. 1206, 1971, pp. 389-396.
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13. See (5), p. 633.
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17. R. L. Dewsnup, Assembling Water Rights for a New Use: Needed Reforms in the Law, Rocky Mtn. Min. L. Inst. 613 1971, p. 613
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22. W. Kriven, Application for New Surface Water Appropriation and Acquisition of Existing Surface Water Appropriation, Water Acquisition for Mineral Development Institute, Paper 4, Rocky Mountain Mineral Law Foundation, 1978.
23. Colorado Springs v. Yust, 126 Colo. 289, 249 P.2d 151 (1952); East Bench Irrigation Co. v. Deseret Irrigation Co., 2 Utah 2d 170, 271 P.2d 449 (1954).

24. South Dakota Compiled Laws Ann. §46-5-29 (1967); 1974 Who. Sess. Laws ch. 25, §3.

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33. Thornton v. Farmers Reservoir and Irrigation Co., 575 P. 2d 328 (Colo. 1978).

34. See No. Dak. Cent. Code 61-06-06.0; Utah Code Ann. 73-3-21; Cal. Water Code §106; Ariz. Rev. Stat. §45-141C; Tex. Water Code §5.024.

35. Altus v. Carr, 255 F. Supp. 828 (W.D. Tex. 1966), Aff'd., 385 U.S. 35 (1966) and see fn. 10, supra.

36. H. R. 4370, 96th Cong. 1st Sess. (1979) sec. 302.

37. 16 U.S. Code Ann. §§79k, 791 (1978).

Appendix A

AGENDA

Wednesday, March 19, 1980

8:00 am	Registration . . . . . Patrician I Lobby
9:00 am	Welcome . . . . . Patrician I Room René Malès, Director of Energy Analysis & Environment Division, EPRI
9:15 am	Objectives of the Workshop Ed Altouney - Project Manager, Supply Program, EPRI
9:30 am	Ecological Effects Program Research on Aquatic Ecology Ishwar P. Murarka - Project Manager, Ecological Effects Program, EPRI
10:30 am	Refreshment Break
10:45 am	Water Quality Control and Heat Rejection Research Program John Maulbetsch - Program Manager, Water Quality Control and Heat Rejection, EPRI
11:45 am	Luncheon . . . . . Cardinal Room
1:00 pm	Systems Program Research on Inclusion of Water Constraints in Energy Models Dom Geraghty - Project Manager, Energy Storage, EPRI
2:00 pm	Energy Storage Program Research on Hydroelectric Power Tony Ferreira - Project Manager, Energy Storage, EPRI
3:00 pm	Water Aspects of the Integrated Assessment Program Ron Wyzga - Program Manager, Integrated Assessment, EPRI
3:30 pm	Refreshment Break
3:45 pm	Supply Program Research in Water Supply Ed Altouney
	Water Supply Computerized Information Directory Dave Pingry - Associate Professor, University of Arizona
4:45 pm	Adjourn
5:30 pm	No Host Social Hour. . . . . Bon Vivant Room

Thursday, March 20, 1980

8:30 am	Opening Remarks . . . . . Patrician I Room
8:45 am	"Water Availability for Energy" Ray Linsley - Professor Emeritus, Stanford University
9:15 am	"Public Involvement in Water Use Planning by Electric Utilities" Len Ortolano - Associate Professor, Stanford University
10:15 am	Refreshment Break

10:30 am	"Economic Aspects of the Use of Water for Energy" Earl Gjelde - Assistant Power Manager, Bonneville Power Administration (presented by Clifford H. Watkins)
11:45 am	Luncheon . . . . . Cardinal Room
1:00 pm	"Regional and Community Level Social Effects Analysis of Water Use for Energy" Ruth Love - Sociologist, Portland District, U.S. Army Corps of Engineers
2:00 pm	"Legal Problems and Transfer of Water Rights to Electric Utilities" Frank Trelease - Professor of Law, McGeorge School of Law, University of the Pacific (presented by Ray Linsley)
3:00 pm	Refreshment Break
3:15 pm	Workshop Task Groups Meetings (Timing of sessions and adjournment left up to Task Group Chairpersons)

Friday, March 21, 1980

8:45 am	Plenary Session . . . . . Patrician I Room Task Group Chairpersons Reports
10:00 am	Refreshment Break
10:15 am	Plenary Session Discussions
11:15 am	Workshop Summary Ray Linsley
12:00 noon	Adjourn

Appendix B

LIST OF PARTICIPANTS

David Abbey
Staff Member
Los Alamos Scientific Laboratory
MS/603/LASL
Los Alamos, NM 87545
505-667-3461

Edward G. Altouney
Project Manager
Electric Power Research Institute
P. O. Box 10412
Palo Alto, CA 94303
415-855-2626

John A Bartz
Project Manager
Electric Power Research Institute
P. O. Box 10412
Palo Alto, CA 94303
415-855-2851

W. B. Betchart
Intasa, Inc.
1030 Curtis Street
Menlo Park, CA 94025
415-323-9011

Robert Black
Technical Assistant
Electric Power Research Institute
P. O. Box 10412
Palo Alto, CA 94303
415-855-2735

Zene Bohrer, Jr.
Hydrologist
California Energy Commission
1111 Howe Avenue MS 29
Sacramento, CA 95825
916-920-6885

Thomas E. Browne
Assistant Program Manager
Electric Power Research Institute
P. O. Box 10412
Palo Alto, CA 94303
415-855-2607

Nathan Buras
Visiting Professor
Department of Operations Research
Stanford University
Stanford, CA 94305
415-497-1252

John M. Burns
Manager, Licensing & Environmental
San Diego Gas & Electric Company
P. O. Box 1831
San Diego, CA 92112
714-235-7765

William S. Butcher
Special Assistant to Assistant Director
National Science Foundation
Washington, DC 20550
202-632-7344

J. W. Carroll
Senior Engineer
San Diego Gas & Electric Company
P. O. Box 1831
San Diego, CA 92112
714-235-7732

Winston Chow
Project Manager
Electric Power Research Institute
P. O. Box 10412
Palo Alto, CA 94303
415-855-2868

Marvin Cohn
Staff Engineer
Science Applications, Inc.
5 Palo Alto Square
Palo Alto, CA 94304
415-943-4326

Norman H. Crawford
Chairman
Hydrocomp, Inc.
201 San Antonio Circle #280
Mountain View, CA 94040
415-948-3919

Wayne Everett
Project Manager
Manitoba Hydro
820 Taylor Avenue
Winnipeg, Manitoba R3C 2P4
Canada

Brian Farrell
Associate Environmental Scientist
Edison Electric Institute
1111 19th Street N.W.
Washington, DC 20036
202-828-7627

J. Guy Farthing
Manager, Member Service
Electric Power Research Institute
P. O. Box 10412
Palo Alto, CA 94303
415-855-2392

Sherman Feher
Planning Analyst
Electric Power Research Institute
P. O. Box 10412
Palo Alto, CA 94303
415-855-2838

Edward A. Feith
Supervisor, Water Resources Group
Houston Lighting & Power Company
P. O. Box 1700, 7th Floor
Houston, TX 77001
713-228-9211x2756

Antonio Ferreira
Project Manager
Electric Power Research Institute
c/o Neplan
174 Brush Hill Avenue
West Springfield, MA 01040
413-736-3343

Thomas W. Forsgren
Attorney
Utah Power & Light Company
1407 W. North Temple
Salt Lake City, UT 84116
801-535-4261

Myra Fraser
Technical Assistant
Electric Power Research Institute
P. O. Box 10412
Palo Alto, CA 94303
415-855-2739

Dom Geraghty
Project Manager
Electric Power Research Institute
P. O. Box 10412
Palo Alto, CA 94303
415-855-2601

Oliver Gildersleeve
Project Manager
Electric Power Research Institute
P. O. Box 10412
Palo Alto, CA 94303
415-855-2507

M. Dianne Guinee
Electric Power Research Institute
P. O. Box 10412
Palo Alto, CA 94303
415-855-2721

Charles Hakkarinen
Project Manager
Electric Power Research Institute
P. O. Box 10412
Palo Alto, CA 94303
415-855-2592

Robert Haussier
Water Quality Biologist
California Energy Commission
1111 Howe Avenue
Sacramento, CA 95825
916-920-7520

Christopher F. Hughes
Environmental Projects Manager
Edison Electric Institute
1111 19th St. N.W.
Washington, DC 20036
202-828-7623

Terry D. Hudgins
Senior Water Resources Analyst
Arizona Public Service Company
P. O. Box 21666
Phoenix, AZ 85036
602-271-2012

James F. Jenks
Vice President
Leeds, Hill & Jewett, Inc.
1275 Market Street
San Francisco, CA 94103
415-626-2070

David Landes
Senior Civil Engineer
Pacific Gas & Electric Company
77 Beale Street, Room 2394
San Francisco, CA 94106
415-781-4211 x 3684

Ray K. Linsley
Consultant
Linsley, Kraeger Associates
527 Bayview Drive
Aptos, CA 95003
408-688-7092

Ruth L. Love
Sociologist
U.S. Army Corps of Engineers
P. O. Box 2946
Portland, OR 97208
503-221-4974

Robert M. Lundberg
Staff Engineer
Electric Power Research Institute
P. O. Box 10412
Palo Alto, 94303
415-855-2341

René Malès
Department Director
Electric Power Research Institute
P. O. Box 10412
Palo Alto, CA 94303
415-855-2341

John Maulbetsch
Program Manager
Electric Power Research Institute
P. O. Box 10412
Palo Alto, CA 94303
415-855-2438

Ishwar Murarka
Project Manager
Electric Power Research Institute
P. O. Box 10412
Palo Alto, CA 94303
415-855-2150

C. Burton Nelson
Director, Regulatory Relations
Electric Power Research Institute
P. O. Box 10412
Palo Alto, CA 94303
415-855-2330

Leonard Ortolano
Associate Professor
Department of Civil Engineering
Stanford University
Stanford, CA 94305
415-497-2937

David E. Pingry
Associate Professor of Economics
Department of Economics, Bldg. #23
The University of Arizona
Tucson, AZ 85721
502-626-2155

James L. Plummer
Director, Energy Analysis Department
Electric Power Research Institute
P. O. Box 10412
Palo Alto, CA 94303
415-855-2139

John Z. Reynolds
Director, Dept. of Environmental Serv.
Consumers Power Company
1945 Parnall Road
Jackson, MI 49201
517-788-1403

John H. Ryther
Senior Scientist
Florida Power & Light Company
P. O. Box 529100
Miami, FL 33152
305-552-3579

Frank Salas
Civil Engineer
Los Angeles Department of Water & Power
111 N. Hope Street
Los Angeles, CA 90012
213-481-6045

Alton Schick
Stanford University
Palo Alto, CA 94304

Tom Schneider
Program Manager
Electric Power Research Institute
P. O. Box 10412
Palo Alto, CA 94303
415-855-2549

James E. Schumann
Supervising Civil Engineer
Pacific Gas & Electric Company
77 Beale Street
San Francisco, CA 94106
415-781-4211 x 1685

Milton Searl
Electric Power Research Institute
P. O. Box 10412
Palo Alto, CA 94303
415-855-2120

Douglas M. Short
Water Resources Supervisor
Tri-State G & T Association
12076 Grant Street
Thornton, CO 80241
303-452-6111

Timothy F. Such
Investigator
Morrison & Foerster
1 Market Plaza
San Francisco, CA 94105
415-777-8015

Dan Swett
Development Research Manager
Florida Power & Light Company
P. O. Box 529100
Miami, FL 33152
305-552-3579

Richard C. Tucker
Principal
Dames & Moore
7101 Wisconsin Avenue
Washington, D.C. 20014
301-652-2215

Dan Van Atta
News Bureau Supervisor
Electric Power Research Institute
P. O. Box 10412
Palo Alto, CA 94303
415-855-2262

Clifford H. Watkins
Chief, Branch of Power Resources
Bonneville Power Administration
P. O. Box 3621
Portland, OR 97208
503-234-3361 x 4451

Lyna L. Wiggins
Partner
Wiggins & Wormhoudt
2039 Shattuck Avenue, Suite 200
Berkeley, CA 94701
415-843-1131

J. Ross Wilcox
Ecologist
Florida Power & Light Company
P. O. Box 529100
Miami, FL 33152
305-552-3579

Kenneth R. Wise
Supervisor, Environmental Engineering
Washington Public Power Supply System
P. O. Box 968
Richland, WA 99352
509-375-5371

Daniel T. Wormhouldt
Partner
Wiggins & Wormhoudt
2039 Shattuck Avenue, Suite 200
Berkeley, CA 94701
415-843-1131

Ron Wyzga
Program Manager
Electric Power Research Institute
P. O. Box 10412
Palo Alto, CA 94303
415-855-2577

Monta W. Zengerle
Technical Assistant to Depart. Direct.
Electric Power Research Institute
P. O. Box 10412
Palo Alto, CA 94303
415-855-2736

Appendix C

TASK GROUP MEMBERS

GROUP 1

W. S. Butcher, Chairman
W. B. Betchart
N. H. Crawford
Brian Farrell
James Jenks
Ruth Love
D. M. Short
R. C. Tucker

GROUP 2

John Z. Reynolds, Chairman
David Abbey
J. W. Carroll
Nathan Buras
Wayne Everett
Bob Haussier
Frank Salas
Dan Swett
L. L. Wiggins

GROUP 3

Christopher Hughes, Chairman
Zene D. Bohrer
Edward A Feith
Sherman Feher
David Landes
David Pingry
Clifford H. Watkins
Kenneth R. Wise

Appendix D

BIOGRAPHIES OF SPEAKERS

EDWARD G. ALTOUNEY

Edward G. Altouney is Project Manager, Supply Program, Energy Analysis & Environment Division, Electric Power Research Institute. Before joining EPRI in 1979, Altouney served as Director, Water Resources Management Program for SRI International. Earlier positions included Deputy Director, Marine Ecosystems Analysis Program, U.S. Department of Commerce; Senior Specialist in Engineering and Public Works, Congressional Research Service, Library of Congress; Water Research Scientist, Office of Water Resources Research, U.S. Department of Interior; and Program Manager, Department of Water Resources, State of California. He received Civil Engineering and M.S. in Physics degrees from the University of Lyons and an M.S. degree in Management and Ph.D. degree in Civil Engineering from Stanford University.

ANTONIO FERREIRA

Antonio Ferreira is Project Manager, Energy Storage and Hydraulic Engineering, Advance Power Systems Division, Electric Power Research Institute. Prior to joining EPRI, Ferreira served as Hydroelectric Consultant for Northeastern Utilities with whom he had been associated since 1951. Before that he was Resident Engineer for the Massachusetts Department of Public Works. Ferreira is a Registered Professional Engineer. He received his B.S. degree in Civil Engineering from the University of Massachusetts.

DOMINIC M. GERAGHTY

Dominic M. Geraghty is Project Manager, Systems Program, Energy Analysis & Environment Division, Electric Power Research Institute. Prior to joining EPRI, Geraghty served as Energy Systems Analyst with the Irish Government and was National Representative in an energy systems analysis project of the International Energy Agency at Brookhaven National Laboratory. Geraghty received his B.E. and Ph.D. degrees in Chemical Engineering from University College in Dublin, Ireland.

EARL E. GJELDE

Earl. E. Gjelde is Assistant Power Manager, Division of Power Management, Bonneville Power Administration. Gjelde joined Bonneville Power Administration in 1963 as an engineering student trainee. In February of 1975 he was advanced to head up the Power Scheduling Section within the Division of Power Management, and in September of 1975 he was named Assistant Power Manager for Bonneville Power Administration. Gjelde received his B.S. degree in Civil Engineering from Oregon State University.

RAY K. LINSLEY

Ray K. Linsley is Professor of Hydraulic Engineering (Emeritus), Stanford University, and partner in the consulting firm of Linsley, Kraeger Associates. Mr. Linsley first joined Stanford University in 1950 and held the position of Professor of Hydraulic Engineering from 1955 to 1975. Prior to that he was Senior and Head Hydrologic Engineer, U.S. Weather Bureau, and taught hydrology and graduate courses both at the University of California War Training School and the U.S. Department of Agriculture Graduate School. While at Stanford, he served as Director, Program in Engineering-Economic Planning and Executive Head, Department of Civil Engineering. He received a B.S. degree from Worcester Polytechnic Institute and did graduate work at the University of Tennessee and the U.S. Department of Agriculture Graduate School.

RUTH L. LOVE

Ruth L. Love is a Sociologist in the Economics Section of Planning Branch, Portland District, U.S. Army Corps of Engineers, a position she has held since 1975. Prior to joining the Corps of Engineers, she served as member of Mt. Hood Planning Unit Citizen Advisory Committee, taught sociology at both Lewis and Clark and Reed Colleges; and was a self-employed consultant in the area of land use planning. Ms. Love received her B.A. degree from Reed College, and M.A. and Ph.D. degrees from Columbia University.

RENÉ MALÈS

René Malès is Director of the Energy Analysis and Environment Division of Electric Power Research Institute (EPRI), a position he has held since 1976. Prior to joining EPRI, he held various positions with Commonwealth Edison including Director of Economic Research, Assistant to the Vice President, and Manager of General

Service. Malès has chaired the Advisory Committees of Oak Ridge National Laboratory's Energy Division and the Brookhaven National Laboratory's Center for Analysis, and has served on the Advisory Committee of the Energy Analysis Division of the Edison Electric Institute. Malès received an M.B.A. degree from Northwestern University.

JOHN S. MAULBETSCH

John S. Maulbetsch is Manager of the Water Quality Control and Heat Rejection Program in the Coal Combustion Systems Division of Electric Power Research Institute in charge of defining research needs and developing technology for power plant cooling water treatment, and the disposal of solid wastes. Before joining EPRI in 1975, Maulbetsch was Director of the Energy Technology Center at Dynatech R/D Company and an Assistant Professor of Mechanical Engineering at the Massachusetts Institute of Technology. Maulbetsch received B.S., M.S. and Ph.D. degrees in mechanical engineering from the Massachusetts Institute of Technology.

ISHWAR P. MURARKA

Ishwar P. Murarka is Project Manager, Energy Analysis and Environment Division of Electric Power Research Institute, a position he has held since October, 1979. Before joining EPRI Murarka was a scientist with the Environmental Impact Studies Division of Argonne National Laboratory from 1974 to 1979. Prior positions included Adjunct Assistant Professor at Northern Illinois University and Statistician, Ecological Services Group, Texas Instruments, Inc. Murarka received B.A. and M.A. degrees from the University of Calcutta, M.S. and Ph.D. degrees from Oregon State University and an M.B.A. from the University of Chicago.

LEONARD ORTOLANO

Leonard Ortolano is Associate Professor, Department of Civil Engineering, Stanford University, a position he has held since 1970. He is Principal Investigator on research contracts and grants from the U.S. Army Corps of Engineers Institute for Water Resources and the Office of Water Research and Technology. Prior to joining Stanford, Ortolano was Research Scientist, Land and Water Management Group, Center for the Environment and Man at Hartford, Connecticut. Ortolano received a B.S. in Civil Engineering from the Polytechnic Institute of Brooklyn, and M.S. and Ph.D. degrees in Engineering from Harvard University.

FRANK J. TRELEASE

Frank J. Trelease is Dean and Professor of Law, University of the Pacific, McGeorge School of Law. Trelease was associated with the University of Wyoming from 1942 to 1977; Dean of the College of Law from 1960 to 1971; Visiting Professor at the Universities of Arizona, Colorado, New Mexico, North Carolina, Washington, Texas, Chicago, and Louisiana State University. Trelease has acted as consultant to the States of Alaska, Nebraska, and Wyoming on reform and revision of water laws, and as general consultant to a number of cities, industries and companies on water law and litigation. He received his Bachelor of Laws degree from the University of Colorado and his Doctor of Science of Jurisrudence degree from the University of Wisconsin.

RONALD E. WYZGA

Ronald E. Wygza is Program Manager, Integrated Assessment Program, Energy Analysis and Environment Division of Electric Power Research Institute, a position he has held since 1978. Prior to joining EPRI Wyzga served as statistical consultant to International Wildlife Sampling Program, OECD, and from 1971 to 1974 was associated with the Organization for Economic Cooperation and Development in Paris, France. He served as Professor of Statistics at the American College in Paris and as instructor in biostatistics and computer programming for the Department of Biostatistics, Harvard School of Public Health. Wygza received an A.B. degree in Mathematics and an Sc.D. degree in Biostatistics from Harvard University and an M.S. in Statistics from Florida State University.

CLIFFORD H. WATKINS

Clifford H. Watkins is Chief, Branch of Power Resources, Bonneville Power Administration. Before joining Bonneville Power Administration, he was employed by the U.S. Weather Bureau and the Oregon State Forestry Department. Before his present assignment, he served as Head of BPA's Hydrometeorology Section concerned with forecasting and river operations. He has served as Chairman of Columbia River Water Management Group and various committeesof the Pacific Northwest River Basin Commission. He studied meteorology at Oregon State University where he earned his M.S. degree and for a time served as instructor in the Meteorology Department.