TRANSFER OF WATER
RESOURCES KNOWLEDGE

AN ASSESSMENT

By Neil S. Grigg, Director
Water Resources Research Institute
The University of North Carolina

July 1, 1978

Final Summary Report of Project T-0012
"Development of Mechanisms for Technology Transfer Through Water Resources Research Programs"

Project conducted jointly between
Colorado State University
and
The University of North Carolina Water Resources Research Institute

The work upon which this publication is based was supported in part by funds provided by the Office of Water Research and Technology, Department of the Interior, through the Environmental Resources Center of Colorado State University under the Water Resources Research Act of 1964, as amended.
ABSTRACT

Water resources knowledge transfer seeks to make best use of scientific and technical information in water management. It is an important process in water research management because its outcome determines the effectiveness of entire programs. The report contains an analysis of the problem in the water sector, a general overview of the "technology transfer" question, presentation of conceptual models for transfer, and recommendations for policy changes. The genesis of the report lies in the planning and organization of the Second International Conference on Transfer of Water Resources Knowledge. The Conference was held in summer, 1977, at Fort Collins, Colorado. Conference Proceedings are issued separately containing 98 specific papers on knowledge transfer.

ACKNOWLEDGMENTS

Financial support from the U.S. Office of Water Research and Technology helped support the Second International Conference on Transfer of Water Resources Knowledge and the preparation of this report. The assistance of Mr. Jack Jorgensen of OWRT is gratefully acknowledged. The help of Professors Warren Hall, Norman Wangert, and Evan Vlachos in planning and conducting the Conference is also appreciated. Professor Vlachos, in particular, stimulated several ideas with his valuable suggestions. Dr. Vujica Yevjevich deserves credit for initiating the series of conferences in the first place. Mr. Janakiram Subramaniam was also very helpful and supportful in the conduct of the Conference. Appreciation is extended to Dr. Doug James and Mr. Murray B. McPherson for good reviews of the manuscript. Mrs. Kris Schneider deserves credit for steady and professional management of the Conference and Proceedings from the very beginning.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUMMARY AND CONCLUSIONS</td>
<td>vii</td>
</tr>
<tr>
<td>INTRODUCTION AND BACKGROUND</td>
<td>1</td>
</tr>
<tr>
<td>DEFINITION OF THE PROBLEM</td>
<td>1</td>
</tr>
<tr>
<td>TECHNOLOGY TRANSFER: AN OVERVIEW</td>
<td>2</td>
</tr>
<tr>
<td>TECHNOLOGY TRANSFER IN THE WATER RESOURCES SECTOR</td>
<td>5</td>
</tr>
<tr>
<td>CONFERENCE BACKGROUND AND RESULTS</td>
<td>8</td>
</tr>
<tr>
<td>Research Management</td>
<td>8</td>
</tr>
<tr>
<td>Scientific Information Systems (SIS)</td>
<td>9</td>
</tr>
<tr>
<td>Rural Development</td>
<td>10</td>
</tr>
<tr>
<td>POLICY ANALYSIS AND RECOMMENDATIONS</td>
<td>12</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>19</td>
</tr>
<tr>
<td>APPENDICES</td>
<td>21</td>
</tr>
<tr>
<td>A. Recommendations from Banks and Wolfe (1969)</td>
<td>A-1</td>
</tr>
<tr>
<td>B. List of papers presented at Second International Conference</td>
<td>B-1</td>
</tr>
<tr>
<td>C. Paper - Role of Non-governmental Organizations in Water Knowledge Transfer, by Eric F. Johnson</td>
<td>C-1</td>
</tr>
<tr>
<td>D. Paper - The Transfer of Technology Through Centers of Competence, by Leo R. Beard</td>
<td>D-1</td>
</tr>
</tbody>
</table>
SUMMARY AND CONCLUSIONS

The report presents an assessment of the status of water resources knowledge transfer systems. It is based on background research and papers presented at the Second International Conference on Transfer of Water Resources Knowledge as well as analysis of previous recommendations and gaps which need to be filled. Policy recommendations are made, and conference conclusions are presented in the three categories of research management, scientific information systems, and rural development.

The report is addressed to an international audience but concentrates on the U.S. arrangements for knowledge transfer. Although it has international implications, it does not specifically address the problems of developing countries. This subject was of concern at the Conference, however, and is addressed in the Conference Proceedings.

Major conclusions and recommendations included in this report are as follows:

1. The need for more effective technology transfer programs should be recognized as co-equal in importance with additional water research. Greater use of completed research results will improve the entire research process, from identification of needs to application of results.

2. The U.S. has a good water resources knowledge production system, but more federal research funds are needed, particularly to serve the needs of state and local governments.

3. OWRT should provide funding for studies on improving research management and technology transfer, and for monitoring the effectiveness of past efforts.

4. An international organization such as UNESCO should organize an international working group to share methods for transfer of water resources knowledge and to facilitate multilateral cooperation.

5. Although increased attention has been given to extension and technology transfer, academic units and other research organizations need to better assess exactly who their customers are and direct more attention to meeting their needs.

6. The U.S. national model presented by Banks (1969) needs to be reexamined and reconsidered for full funding and implementation.

7. As water resources management responsibilities are increasingly passing to state and local government, more attention needs to be given to their needs for transfer of knowledge.

8. The role of professional associations has not been fully appreciated. Suggestions are made for involving them to a greater extent in the transfer of water resources knowledge.

9. A great deal of attention must be given to getting water "know-how" into national STI systems. This is an obvious opportunity for cooperation between professional or trade associations and the Federal Government. Much of this is generated and applied by local governments.

10. National centers are needed for augmented activities in the dissemination of scientific information and the development of transfer programs for computer models and other technology. Arguments are made for the establishment of an "HEC-East," which is needed on the East Coast.

11. State water resources institutes and other research units should pay careful attention to the UCOWR Technology Transfer "Guide" to improve their programs.

12. As part of the report, conclusions from the Second International Conference on Transfer of Water Resources Knowledge are presented. These include a number of principles and recommendations which should be carefully studied by water resources research administrators.

13. Innovative national approaches for knowledge transfer such as that operated by the ASCE Urban Water Resources Research Program should be considered. The "technological gatekeeper" principle should be recognized for its importance.
14. State water resources institutes can play a key role in the transfer of knowledge with a geographical focus. Professional associations should be designated to provide the functional or disciplinary focus.

15. The use of the term "technology transfer" in the water sector is adequately understood to include both diffusion of technologies and information dissemination. In other applications, however, it refers to the application of technology to a different use than originally intended, a sort of cross-industry transfer. This contributes to the confusion with the use of the term. Introduction of a new term such as "knowledge transfer" probably would not help the situation.

16. There are a number of further studies needed. High on the list of priorities should be: a) a U.S. study of total water industry expenditures and total R&D or "knowledge generating" activities, and b) a further study of how to involve professional associations better in the process of improving the flow of water resources knowledge.

Other specific conclusions from the Second International Conference on Transfer of Water Resources Knowledge are included in the text. Full Conference Proceedings with 98 papers are to be issued.
INTRODUCTION AND BACKGROUND

The knowledge explosion and advent of the "information economy" are being felt all over the world. In spite of this, some of mankind's most serious problems are due to ignorance, lack of education and training, lack of "know-how," and conflict caused by faulty communications. In developing countries, and in pockets of rich countries, the poor seek the "quality of life" (QOL) of the more affluent.

A most fundamental contribution to QOL is provided by high-quality water resources which are necessary for drinking, raising food and fiber, energy, and for meeting other needs. Improving water management is a matter of extreme urgency in improving QOL. The knowledge and "know-how" are mostly in existence. How can they be transferred effectively to the point of need? This is a problem which transcends the rich-poor question and extends to the improvement of productivity and QOL at all levels.

The substantive support for this document comes from papers contributed to the Second International Conference on Transfer of Water Resources Knowledge, held at Colorado State University, Fort Collins, Colorado, June 29-July 2, 1977, and from background research. The specific objectives of this Assessment Report are to summarize the points made at the Conference in the framework of suggestions for policy in improving the transfer of knowledge in the water sector. These suggestions are intended to be useful to U.S. and international agencies responsible for water resources research, but are aimed primarily at U.S. policy. Full proceedings of the Conference, containing some 100 papers, are also to be available (Grigg, et al., 1978).

The focus of this report is on models for knowledge transfer and on national program needs. A recent report by the Technology Transfer Committee of the Universities Council on Water Resources (UCOWR) describes the techniques for application at the organizational level (UCOWR, 1977), such as at the water resources research institutes.

DEFINITION OF THE PROBLEM

The fundamental problem that we are addressing is the need to translate knowledge as it is developed into programs to manage water to improve living conditions. Management encompasses all activities used to develop, process, deliver, conserve, and dispose of the water resource. It includes the maintenance of desirable levels of water quality, coping with unusual events such as floods and droughts, and all the indirect activities either causing or affecting the direct management activities.

Water management must be defined broadly. It can consist of different frameworks and different perspectives. It is usually taken to mean management activities undertaken to effectively utilize the multi-dimensional benefits of water for the good of mankind.

The problem may also be classified by the perspective of the individual making action choices into: public or private sector; level of government; developer or conservationist, etc. Another type of classification is concerned with timing; whether a problem is in the perceived, planning, design, implementation, or operational stage. Another classification is concerned with the water use or problem. Examples are water supply, agriculture, and flood control. Yet an additional classification might be one such as that used by the Office of Water Research and Technology (OWRT) to describe problem-oriented research. It includes the following cross classification:

<table>
<thead>
<tr>
<th>Problem Areas</th>
<th>Management Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Water Quantity</td>
<td>1. Hydrological Systems and Processes</td>
</tr>
<tr>
<td>2. Water Quality</td>
<td>2. Biological Systems and Processes</td>
</tr>
<tr>
<td>5. Engineering Works</td>
<td>5. Engineering Works</td>
</tr>
</tbody>
</table>

The size of the U.S. water management industry may impress upon us the importance of the problem of improving productivity through knowledge transfer. Let's estimate the total annual expenditure on water resources management and research and development expenditures as a fraction of the total GNP, which is devoted to water development and management. Expenditures are by government at all three levels, by industry, and by individuals.

The writer currently knows of no estimate of the total amount being spent on water management activities in the United States. A reasonable speculation, however, would be that the total is about $50 billion annually, not including agriculture. In support of this estimate, we can cite a case study of Hartford, Connecticut, for 1965-68 which showed urban water expenditures to be on the order of $50/capita/year (Clem, 1969). These figures would surely reach nearly $100 by 1977, with inflation. If the average cost for each of 220
million Americans were $100 annually for water, sewer, and drainage service at home, that would come to $22 billion. Adding flood control, cooling water for energy, navigation, and pollution control would surely bring the total to over $50 billion.

Howells (1974) reported that federal spending for water development was about $3.3 billion annually in 1973. His analysis for the period 1965-1973 pegged R&D in the range of 4.6 to 6.9 percent of development costs. The size of federal research investments has more recently been estimated at $225 million annually by summing the related research budgets of all federal agencies doing water research (Cobb, 1977). Federal research expenditure is probably about 2 to 3 percent of federal water activities. The Federal Government research, however, also provides information of use to state and local governments.

In order to estimate total national R&D expenditures on water, a method is needed to estimate the investments in water resources research or the generation of knowledge by state and local government and by private industry. In all probability, these expenditures are much larger than commonly believed. Expenditures in only one portion of the water sector, urban areas, comes to about $22 billion annually. These design, construction, and maintenance funds are largely spent on staff, consulting firms, construction, and equipment. If 5 percent of these funds (albeit a guess) were considered to be "knowledge generating," this $1.1 billion would amount to almost five times the estimate of annual federal investment in all of water research, and it is only for urban water. The total R&D could reach several billion.

With all this research activity going on, the capture and application of new useful knowledge (including practical "know-how") generated in the construction, operation, and management of the nation's $50+ billion (presumed) water economy is a serious problem.

To complicate the problem, many practitioners prefer to learn new techniques from other practitioners, not from researchers. One need is to capture, process, and disseminate the knowledge of the key professional practitioners.

In facing this problem, we should recognize that there are general problems inhibiting the transfer of knowledge. One of these is quoted by Slamecka (1977):

"We all know what information costs; the problem lies in attempting to put a value, monetary or otherwise, on it. The answer appears to be that information is valueless except when you need it, when it becomes priceless. In this respect, it is like insurance, 99% of the time one does not need insurance but for the 1% the need is critical. Now, we all have rationalized the need for insurance, and have worked out some sort of subjective cost effectiveness value for it. It is basically this: we recognize the value of paying a relatively small sum on a regular basis now, so that we have access to a relatively large sum at some undefined point in the future, if we need it. Surely this is precisely what we do in building up an information resource. That being the case, the same cost benefit arguments can be applied."

****McVillien, 1977

TECHNOLOGY TRANSFER: AN OVERVIEW

The U.S. Federal Government uses the term "Technology Transfer" (TT) extensively. Linhares states that:

"In its broadest sense, technology transfer encompasses the collection, documentation, and dissemination of scientific and technical information, including data on the performance and cost of using the technology, the transformation of research and technology in the processes, products, and services that can be applied to public or private needs; and the secondary application of research and technology developed for a particular mission that fills a need in another environment."

****Executive Office, 1977

The Federal Directory describes the TT programs of a number of agencies. These programs are developed to meet the different missions of the separate departments. Some of the models for technology transfer are applicable to the water sector, whereas others are not. Use of the term "Technology Transfer," in private industry normally refers to the diffusion of an invention or innovation throughout the economy or from one group to another. This concept is useful for the water sector, and the public nature of the water sector requires a very careful analysis.

Some definitions and basic principles are needed at this point. In their "Guide," UCOWR distinguished between the terms "information dissemination" and "technology transfer." They stated that:

"...we have defined information dissemination as the act of informing or providing information about technological changes and advances through visual, audio, and written media."
"Technology transfer is the sum of those activities leading to the adaptation, adoption, or demonstration of new technology where the audio, visual, and written media provide a partial vehicle for accomplishing the transfer. As such, it includes but is not limited to information dissemination."

---UCONR, 1977---

These definitions seem quite workable. We really need a more precise term for water resources technology transfer because of the confusion with the industrial model, however.

At a more basic level, technology might be understood as being a subset of knowledge. Language is often imprecise, but technology might be defined as applied science. Science can be defined as knowledge based on observed facts (Barnhardt, 1976). We must conclude that technology is applied technical knowledge. Knowledge must be produced before it can be transferred. Fritz Machlup says that producing knowledge includes discovering, inventing, designing, planning, disseminating and communicating (Machlup, 1962). When using technology transfer or knowledge transfer in the context of water resources, knowledge can include the dissemination/communication process.

In economic terminology, the production of knowledge is followed by consumption. Knowledge, however, is conservative in that consumption does not diminish the supply. It can, however, be lost or become obsolete. The UCONR terminology seems reasonable, but a model based on Machlup's work might, however, have some merit. Such a model could take the following form:

1. Production of Knowledge includes:
   - Invention
   - Discovery
   - Development

2. Storage and Communication of Knowledge includes:
   - Acquisition
   - Storage
   - Dissemination

3. Consumption of Knowledge includes:
   - Adaptation
   - Utilization

Using the above classification, technology transfer becomes a term which means taking knowledge from the production stage to the consumption stage.

Hough (1975) also presents some useful definitions of key terms associated with technology transfer. He defines technology diffusion as "publicizing, adapting, adopting, and ingesting a new item of technology, which may be a product, process, technique, procedure, or other application of available science or technology. Vertical and horizontal diffusion refer to transfers within and between agencies respectively. In technology transfer, the application of knowledge serves a purpose other than the original intention. This definition of "technology transfer" seems to appear quite frequently.

Abt Associates presents two definitions:

"Technology transfer is the process of solving a social or economic problem through the application of an existing technology--one developed for a different problem, in a different environment."

"Technology transfer is the application of technology to a new use or user."

---Abt, 1976---

In spite of the great expenditures by the federal government on the development of technology, a recent study by the National Academy of Engineering concluded that:

"...The vast technology developed by federally funded programs since World War II has not resulted in widespread spinoffs of secondary or additional applications of practical products, processes, and services that have made an impact on the nation's economic growth, industrial productivity, employment gains, and foreign trade."

---NAE, 1974---

The NAE report recommends shifting the focus of federal concern from disseminating information about technology to transforming technical information into ultimate uses for public or private socioeconomic needs. The committee proposed that the federal government spend about one billion dollars annually on this program.

In studying the flow of technology from producer to consumer, there are several cases to consider. Two of the most obvious are the case of transfer from organization to organization (horizontal) and transfer within organizations (vertical). Transfer within organizations is complicated enough itself. A recent comprehensive study at MIT (Allen, 1977) points out some rather obvious problems. He states that the primary reasons that engineers do not read technical literature is that they simply cannot understand the material published in the journals. This is apparently the result of modeling professional societies after old scientific societies that present the new without describing it as it gets into what was known before and that use a highly technical form...
of presentation. The professional societies obviously need to pay more attention to technology transfer and less to pure dissemination.

An interesting concept found in Allen's book (1977) is a detailed discussion and analysis of the Technology Gate Keeper function within an organization. The Technology Gate Keeper is an easily identified person who is interested in new technology and who communicates well with others within the organization. Studies show that communications with gate keepers were at a much greater level of intensity than with many others in organizations and that the gate keepers were very often open to new technology and likely to work to promote its adoption. To this point we shall return.

The specific problem of technology transfer in the water sector is rather complex because of the number and variety of producers and transfer agents as well as the diffused audience of recipients and users of technology. There are several operating models of TT processes that one can examine for ideas. One of the earliest and most visible models is the Agricultural Extension Service in the U.S. The Extension Service carries technology from the university to the user community (usually farmers) and works to have new and useful techniques adopted in the marketplace. Although its job is often stated to be rather simple compared to technology transfer in the commercial-domestic sector, the fact is the Extension Service has received a continuous commitment of funding and large inputs of scientific effort over the years. The large input of effort explains its success much more than any perceived simplicity. As the Extension Service is rather successful, it has been used as a model for a number of other proposed and operational small efforts.

A recent report by Pease (1971) looked at the utilization of university capabilities for environmental problem solving. Recommendations included the establishment of problem-solving action centers and systems research centers. Pearson (1977) describes a possible technology transfer which could provide technology extension agents to industry. He lists five prerequisites for the success of such an agency such as: (1) university affiliation, (2) experiment stations, (3) resident experts, (4) local advisers, and (5) a coordinated education and training program. Memphis State University has been experimenting with a Regional Economic Development Center funded through the Economic Development Administration which has as its objective to provide assistance to the public and private sectors to stimulate economic growth (Memphis State U., 1975). The University of Oklahoma has developed a Center for Local Government Technology which serves local government with essentially the same objectives as the other extension services (Mize, 1977). The National Science Foundation, through its Division of Intergovernmental Science and Public Technology, has sponsored other studies and investigations on how to apply and disseminate technology in the public sector. One of these is the Pennsylvania Technical Assistance Program designed to deliver public technology to local government (Penn State U., 1975). Certainly, we should also mention the activities of the nonprofit firm, Public Technology, Inc., a spinoff from the International City Management Association. We also are about to see a new energy extension service within the U.S. Department of Energy.

With so many new efforts to apply technology for improving productivity, a bandwagon effect is developing. Questions now revolve around methods to improve the effectiveness of these transfer efforts and to achieve a correct balance between technology development and its application.

Evaluating effectiveness of knowledge transfer activities remains an elusive problem. Slamecka (1977) says that the problem has three aspects:

"The process of information communication requires and/or affects three classes of individuals: the originator or proprietor of information, the information vendor, and the information buyer or user. The functions of these three parties in the communication process are different as are their objectives, and hence when asking how effective is information transfer, one must ask 'effective from whose viewpoint?' In another context, effectiveness may relate to the objectives of an individual, a group of individuals such as a corporation, or of a society as a whole; the assessment of the effectiveness of information communication will be radically different if made by a totalitarian government on the one hand, and by a citizen of such a government on the other hand. The notion of the effectiveness of information transfer is thus relative: it is time dependent, situation dependent, and often subjective."

Water resources knowledge transfer in western countries is much the same as in countries with centrally planned economies. This is because water is almost entirely managed at the macro level by government. Micro-level problems may be at least as significant. This leads to special problems of management, improving productivity, and introducing innovations. Slamecka (1977) describes it this way:

"Whereas in a market economy, the need for and the use and value of information are implicitly assessed in each single instance of each technician's or
manager's desk (i.e., at the place at which the financial resources for such information are justified and expended), in the planned economy, the greatest concern with evaluating the effectiveness of information services and systems is at the level of the central government. This is so because the central government is primarily responsible for the design and operation of the national system of scientific and technical information services, and for the direct or guided appropriation of financial resources to cover its operating costs."

Later in the report I will make the point that local and state government know-how is not captured in the water resources STI system and needs to be systematically introduced. This is a problem of general concern in other sectors and is accurately described by Slamecka (1977) as follows:

"Convincing users to make effective use of scientific and technical information is particularly difficult because the formal recorded literature (documents, patents, etc.) does not transmit the experiential component of knowledge (the know-how)."

"As a result of such a policy, however, the information resources being systematically collected and organized by the Soviet Union may soon be the world's most comprehensive, particularly with respect to the technical information and know-how generated by the developing nations (which is all but ignored by the information systems of highly industrialized nations, yet which is likely to be exceedingly valuable to the developing economies of the Third World)."

Also, Slamecka (1977) describes the value of pragmatic information to decision makers. This is of considerable interest to the water sector because it squarely hits the water decision-making problem.

"Another research effort attempts to derive a measure of 'pragmatic' information by observing actions that have resulted from acquired information and comparing these with actions that did or would have taken place without the information. In a general sense, information should resolve or reduce uncertainty; in this research, information must then be related to the various kinds of uncertainties that decision makers deal with—uncertainties as to goals, methodologies, states of the environment, interaction of parameters affecting problems, etc. 'Decision states' are defined by the probabilities of choice regarding courses of action at time t; the impact of information on the distribution of such probabilities is said to be a measure of information. Interestingly, the impact of information on the value of a decision state can be shown to be a measure of information value. This so-called pragmatic measure of information is not, in its present state of development, suitable to assess the utility of information transfer; ideally, such a measure should be used prescriptively; that is, it should quantify the information contained in a set of data with respect to its overall usefulness for a range of decision makers and time."

**TECHNOLOGY TRANSFER IN THE WATER RESOURCES SECTOR**

In the water resources sector, knowledge has exploded in the same way it has in other sectors. The dimensions of the explosion of knowledge can be readily seen from a recent NSF report (King). How can we harness this explosion of knowledge for solving local, national and international water resources issues?

The water industry is not organized neatly into producers, transferers, disseminators, and consumers of knowledge. In general, universities, agencies, and private research organizations are regarded as producers of knowledge, and agencies and private groups are regarded as primary users. Librarians, editors and operators of scientific information systems are regarded as transferers, storers, and disseminators. The picture is not this clear, however. In fact, universities engage in production as well as utilization; and transfer agents are not restricted to the traditional areas named above. The situation might be summarized as shown in Figure 1.

The ranges of application shown on Figure 1 will certainly be controversial. A more complete inventory of groups working in the water resources industry is given in Table 1.
Transfer of water resources knowledge has similarities to transfer of agricultural knowledge. In both cases, the research findings are produced in agencies, universities, and private firms. The users of the agricultural knowledge are, by and large, farmers, but industrial development has been stimulated by agriculture. In transfer of water resources knowledge the user community may be more complex. Normally, new water resources knowledge is applied to improve the quality of life rather than to increase production.

In a careful analysis, Axinn and Thorat (1972) state that the element responsible for the success of agricultural extension education--the heart of transfer--is "the integration of research and education with governance, with supply, with production, and with marketing." The governance activity is included to provide for monitoring the linkages between the other activities.

Table 1. The Water Resources Knowledge Industry

1. The producers and processors of water resources knowledge:
   a. Universities
   b. Government agencies (federal, state, local)
   c. Non-profit research firms
   d. For-profit research and consulting firms
   e. International and national organizations and associations
   f. Innovators who try new ideas in actual water management situations

2. The transfer agents:
   a. Universities
   b. Professional and user associations
   c. Non-profit and for-profit teaching firms
   d. Information processors
   e.Libraries
   f. Publishers closely linked to producing sectors
   g. Primary and secondary journal publishers

3. The users of water resources knowledge:
   a. Government agencies (federal, state, local)
   b. Farmers
   c. Private consulting firms
   d. Industrial firms
   e. Utilities
   f. Citizen groups
   g. Researchers and students
   h. Elected officials
   i. Interest groups

We need to develop a conceptual model of the transfer of water resources knowledge which will take advantage of the vast storehouse of related experience developed by the agriculturists. Development of such a conceptual model will allow more effective analysis of needed directions in improving the delivery of service.

Water resources knowledge (WRK) is a commodity, like other types of knowledge, that can be produced, stored, transferred and used. It is neither a renewable nor non-renewable resource but a permanent resource, once produced. Because knowledge is not readily exchanged through the market process and government has moved into the void of the chief knowledge producer, there is no market available to ensure the efficient production and distribution of knowledge. The flow of WRK is, therefore, financed mostly by government and quasi-government decisions about priorities. Some WRK has been produced through private invention but this total is probably small compared to total WRK. A very simple model for WRK flow is illustrated in Figure 2.

![Flow of Water Resources Knowledge](image-url)
legislatively mandated programs. NAS also con-
cluded that:

"...It is not reasonable to expect every
scientist and technologist working on
environmental problems to be proficient
in the completed task of information
transfer to regulatory decision makers.
Special talents are required; prime among
these is the understanding and apprecia-
tion of the use to which the information
will be put that comes with experience
with the decision-making process itself.
Another necessary characteristic is the
ability to look beyond one's own techni-
cultural discipline experience, to integrate
disciplinary knowledge into a multi-
disciplinary whole."

.....NAS, 1977

NAS concluded that EPA needed a special office and
technical staff to assess and integrate relevant
technology and to transfer the results to decision
makers who would use the information. This is,
again, a reaffirmation of the need for inter-
preters of technology to the appropriate audiences.

Most proposals for new extension service activity
are developed from the perspective of the research
and development agency looking for markets to
serve. In a study devoted to the water sector,
Stewart and Howells (1972) pointed out that three
perspectives must be considered. These were: the
research, development diffusion perspective, the
social interaction perspective; and the problem-
solving perspective. In their report, recommenda-
tions are made for the adaptation of a communica-
tions model for the results of water resources
research.

The ASCE Urban Water Resources Research Program,
through its Director Murray B. McPherson, has ini-
tiated some very effective efforts in technology
transfer. His work is summarized through 1974 in
(McPherson and Mangan, 1975). Basically, McPherson
works through cooperators who fit the description
and
torical gate keepers described by Allen
(1977). The cooperators number some 200-300 in the
U.S. alone and include the most outstanding innova-
tors in state and local government water manage-
ment, universities, and the Federal Government.
McPherson (1974) has some keen insights about
innovation in the water sector:

"Experience in urban water affairs has
shown conclusively that fractionalized
technical information is a source of
frustration for those local officials who
are actively seeking innovative improve-
ments and a defense for those local official-
s who are confounded by rapidly
changing policies. A mechanism for
facilitating innovation is, therefore,
the relaxation, reduction or removal of
such frustration and defense. There are
commonly long delays in the wholesale or
general application of innovative con-
cepts from urban water resources re-
search. Again, experience in urban
water affairs has shown conclusively
that when an advanced idea is developed
in a transferable form, the actuality of
its existence creates a broad immediate
market or demand elsewhere. Public
officials have built-in incentives to
reduce costs, to constantly improve
service, and to be in tune with the
times. Imposition of additional pres-
sures or employment of grant-in-aid
incentives will not in themselves neces-
sarily bring about real, wholesale inno-
vations. It is necessary first to show
that an innovation is practicable, pos-
sible, and has a potential for improving
a local public official's standing,
either politically or professionally or
both.

"Appropos of these last arguments is the
aversion of one of our outstanding local
government innovators to the term 'tech-
nology transfer' for which he would sub-
stitute 'transferable technology,'
referring to demonstration of the utility
of transferring a given technology.
Commenting on the use of computer simu-
lation models, he has argued that it is
necessary to show the design or operat-
ing engineer something that can help
him, something for which it is worth the
trouble of building a good data base,
something that he himself can operate
with confidence. He believes that new
technology will be applied when methods
are offered which are truly applicable,
objectively useful, and which are cost-
effective in that they reduce the overall
input of society's finite resources
as user objectives are met."

"In speaking about the problem of commu-
icating water resources research find-
ings to the user, or technology trans-
fer, it has been avowed that the user
must be willing to experiment with new
methods that have promise of success
even if an element of risk is involved,
and the researcher must make a special
effort to insure that the researcher's
results are readily used.

"Perhaps the 'standard' pattern of inter-
action between industry and the univer-
sity is at least nominally applicable to
the water research transfer riddle: 'The
taxonomy of the methods of university-
industry scientific and technical interaction is not very complicated. The practices involved are standard; innovators are few and far between, since the person who can survive in a hostile environment from both camps is extremely rare.' Also noteworthy is the fact that the university-industry coupling 'has never been tried seriously' and perhaps only a quarter of our major educational institutions 'have the philosophy, willingness, and performance necessary for interacting with industry.'

CONFERENCE BACKGROUND AND RESULTS

The Second International Conference on Transfer of Water Resources Knowledge was held at Colorado State University June 29-July 1, 1977. The First International Conference was in 1972. At the Second Conference approximately 180 attendees from 28 countries were represented. Technical sessions were divided into three groups: research management, scientific information systems, and rural development. The basic conclusions from the Conference are presented later. Appendix B lists the titles and authors of all 98 papers which were presented. After the papers were presented, the attendees were organized into panels for the purpose of developing what they heard into conclusions and policy recommendations. The definition statements for the problems addressed by the Conference are presented in the following sections.

First, the Conference was addressed strategically to a set of important questions such as the following:

1. How much water resources research is necessary to provide a continuous, reliable input to national policy deliberations,
2. How much and what kind of technology transfer is needed to support the research effort,
3. What institutional structures will best serve national needs and ensure a continuous effective flow of needed information to agencies responsible for upgrading life quality,
4. How should production, transfer, and utilization tasks be assigned among the involved groups,
5. What information networks can serve national and international interests best in the water resources field, and
6. What are the strongest linkages between water resources knowledge and the development process and how can these linkages be improved to ensure effective transfer of research results?

These questions hold for local, national, and international groups concerned with WRK. In organizing the Conference, we found that the policy questions above were too specific and needed more focused attention than that allowed by the brief nature of the Conference. Accordingly, the following three more general questions served as the Conference framework:

1. How can water resources research be managed so that useful results can be transferred to users? Useful results refer to past, present, and future research activities.
2. How can Water Resources Scientific Information Systems (SIS) be developed and managed to enhance knowledge transfer? The SIS include databases, computer abstracting services, scientific and trade journals, newsletters, and other information dissemination activities.
3. How can water resources knowledge be applied to improve living conditions for the rural poor, wherever they are found? This question necessarily refers to providing basic water and sanitation services as well as irrigation water to citizens whose living standards are still too low.

The following are specific points made by the Conference summarizers. Additional information is in the Conference Proceedings:

Research Management (Panel chaired by Dr. Warren A. Hall)

The decision maker encounters a deluge of raw information, reports, and data that are at least superficially related to his decision making. The research community needs to find a way to build filters into the knowledge dissemination process so that decision makers will be supplied with clear, credible, and pertinent information.

Summary points at the Conference were really all related to Research Management. An excellent paper by James is reprinted as Appendix E to describe a specific approach to research management. Specific recurrent themes which arose at the Conference included these:

1. Piecemeal R&D efforts must be pulled together to win visibility for the water resources research process and improve legislative support.
2. There is a need for continued attention to improving the transfer of research results.
3. For a number of reasons, it is important to increase communication between researchers and users of research results.
4. State-of-the-art reports, if prepared with a balanced viewpoint, can be very valuable to water resources managers.
5. There is a need for improving the receptivity and mutual trust between researchers and users.
6. The transfer of research results must be more closely keyed to actual demand for the information.
7. There is a need for the translator function in the delivery of research results to users.
8. Abstracts of research reports and articles should be more carefully prepared and informative.
9. The importance of interdisciplinary work must be recognized.
10. There is a need for recognition by decision makers of the lead time required by a cost-effective R&D process.
11. Researchers should engage in post facto evaluative research, but they should avoid irresponsible criticism of agency and private sector decisions.
12. It must be recognized that the research manager cannot pre-establish the results of a project. He cannot order any new scientific discovery.

Development of Effective Water Resources Scientific Information Systems (Report by Panel Chairman Dr. Norman Wengert)

Conference Chairman Neil Grigg gave each of the three panels six questions to guide them in formulating recommendations. Panel "B" sought to respond to these questions.

But before outlining its recommendations, this panel set forth six basic premises important to its deliberations and implicit in many of the papers presented in its (simultaneous) sessions as well as in many of the plenary sessions.

First, it is apparent to the panel that internationally as well as nationally many scientific information systems relating to water are available and in use, ranging from traditional literature indexes in printed form to highly sophisticated computer based systems allowing remote terminal access to large data bases.

Two basic types of computerized systems exist -- the relatively simple systems storing numerical data arranged for quick computerized access, the highly complex systems storing mixed alphanumeric data and providing bibliographic access to the world's scientific literature. The numerical data systems are at this time primarily serving the needs of specialized groups engaged on specific data gathering missions although a trend toward computer access to basic data, such as properties of materials, seems to be developing. The more complex systems are increasingly available to information specialists including those internationally involved in servicing the literature needs of the scientific community. Once bibliographic information is gathered via the data base search, the resources of the libraries of the world are available to the searcher. Effective use of existing library systems should be facilitated.

Existing systems are often less than comprehensive, and there is a disparity of system availability among developed and developing nations. But equality in this regard among nations is probably neither necessary nor desirable -- particularly if more effective international collaboration can be developed.

Second, while a long-range national and international objective should be integration and simplification of information systems, at present the panel sees value in diversity to encourage local data gathering and control. At the same time greater attention should be directed to coordination of effort so that higher levels of compatibility and interchangeability might be achieved and linkages among subject matters and systems operations might be realized. User education must accompany these developments.

Third, consistent with the thrust of the entire conference, this panel stresses the importance of users in both system design and management. It is imperative that users become more familiar with the State-of-the-Art in information system design and operation so that a more fruitful partnership may develop between water resources experts and those who are knowledgeable in information storage and retrieval. At the same time, it is recognized that -- at least in the short run -- concern for user needs may tend toward diversity and structuring of plural systems. Serving users effectively, as a corollary, requires that information and data inputs generated by research must also (ideally) be directed to user needs and problems.

Fourth, for this reason this panel stresses that the goal of compatibility, interchangeability and coordination should not initially lead to a single, centralized international water information system but rather should direct attention to devices and techniques that maximize effectiveness of diverse and plural systems. Water resources is a multi-dimensional, multi-disciplinary field -- the information systems that serve the needs of the workers in the field must reflect and address this diversity if they are to be effective. Future conferences may wish to address questions of greater international centralization and accessibility of materials.

Fifth, this panel stresses, as have many of the formal papers, the range of specialized roles of government agencies, universities, professional associations and commercial organizations in the future development of effective water information systems and urges that coordination and integrative efforts must include all of these sectors and interests. Inputs as well as outputs should reflect these diverse and specialized roles.
Sixth, development and management of effective water resources information systems is a continuously changing process and, while subject to guidance, cannot be constrained by strictly rational models. Political, social, and behavioral variables often are of overriding importance. Emphasis at this stage should begin with the local and particular, the development of elegant structures and processes being postponed for later attention. However, existing systems should be recognized and utilized whenever possible.

Recommendations and Conclusions

1. The products of research (data, information) and methods of "marketing" them (dissemination and application) must be recognized as an integral part of the research process and an area of concern itself requiring research. The imperatives of the information transfer function should be recognized by researchers and research sponsors, and provided for in research programs and budgets. At some point, the transfer function (marketing, dissemination, application) must be institutionalized (if institutional structures are not already available). The functional suitability and appropriateness of information transfer institutions must constantly be reassessed and reappraised.

2. Adequate resources should be provided to support and encourage interaction among librarians, information scientists, transfer agents, data and information producers, users, and system managers. Content outputs (and hence inputs) as well as format (packaging) must be geared to user needs and problems, based on user participation in identifying needs and problems, as well as on his perceptions, knowledge of principles of information retrieval, and an analysis of his situation. Users, however, being numerous and extremely varied, must be specifically identified and categorized and in this process of aggregation the most reasonable compromises should be reached.

3. Information and data retrieval systems should be interrelated; appropriate networks should be developed out of continuing dialog among producers, users, and others responsible for both inputs and outputs and concerned with system effectiveness. As appropriate, "reformatting" (packaging) to meet user needs and problems optimally should be considered -- as defined by such dialog reflecting user and producer experiences and perceptions. Both nationally and internationally, directories describing purpose, scope, content and function of systems must be readily available.

4. The information systems community should work toward developing guidelines that might contribute to coordination among systems and increase system compatibility. Development of standardized thesauri, with due allowance for growth and change of emphasis within the field, can do much to allow competent access to stored information in bibliographical form. A continuing awareness of the State-of-the-Art in standardization is vital.

5. Panels composed of members of the varied groups involved in water resources information transfer (producing, users, transfer agents such as libraries and system managers) should be established and meet regularly to encourage coordination, avoid duplication and review system effectiveness in general. Approaches should, as appropriate, be multi-disciplinary.

6. System effectiveness must be measured by use and by the needs inherent in the use situation, reflecting needs, training and capacity of users. Feedback and interaction among information system users, librarians, producers, managers and others responsible for the acquisition, and storage of written materials organized for use is essential. No system is truly effective unless materials are made available as required once their existence is known. Research to identify the entire spectrum of potential users and to guide output marketing as well as input may be required.

7. Systems and arrangements for interrelationships should be flexible and experimental to maximize adjustments to changing needs and opportunities. Simplification, integration and coordination should perhaps be regarded as continuing long-range goals.

8. It is imperative that attention be given to the special problems of ephemeral materials, as well as to conference proceedings and papers, contractors reports, and specialized reports of work done on local or international projects -- most of which are not reflected in standard publisher's lists and are often available only through specialized sources and only for brief periods of time. The efforts of those actively working in the water resources field are essential in acquiring this sort of material and depositing it in specialized collections where it can be made available as needed. In the absence of such cooperation between engineers, scientists, and others in the field and librarians it is very unlikely that this sort of material, often badly needed, will be available for use. Standard library organizations deal poorly with this sort of publication and specialized libraries are often better able to organize and utilize such valuable resources.

9. Information on the State-of-the-Art of new and current technology and techniques should be provided so that information systems as a whole become more dynamic, responsive to user needs.

10. Researchers and users need complete information to prevent unintentional redundancy in research activities and technological development, and to minimize conflicts and inconsistencies.
11. There needs to be better communication among new and existing system developers, managers and users, and more effective integration among automated and non-automated technologies should be encouraged.

Additional Notes

(Provided by Ms. Marjorie Rhoades, Rapporteur for Panel, Associate Professor, Engineering Science Librarian, Colorado State University.)

Concepts and problems deserving of further attention at future international conferences:

1. Research to determine user needs.
2. Better funding and solutions to copyright restrictions to expand response capability (such as document delivery).
3. Clearer definition of subject parameters.
4. Recognition of the relative roles of a) Information Systems, b) Research Libraries, c) Special Libraries and d) Information Centers. Each has definite capabilities and limitations as suggested in the following paragraphs:

   a) Information Systems - the network of all communication methods within an organization (or in this case, a field). Information may be derived from many sources other than a data-processing unit, i.e., by telephone, by contact with other people, or by looking at an operation. In many cases, within the field of water resources such information takes the form of citations to bibliographic materials which in turn makes it possible to obtain specific pertinent books, journal articles and technical reports.

   Information in traditional written form (as opposed to data bases containing specific data, usually numerical) is usually housed in one of three categories of libraries described in the following paragraphs:

   b) Research Library - an organization which acquires and organizes a collection for use by information seekers. May be specialized but commonly expands to cover larger fields of human knowledge. Excellent for storing and retrieving journals and books. Strengths: large collections; long lifespan and continuity; professionally trained personnel; established links with the library community both national and international. Weaknesses: Complexity of organization sometimes defeats user; materials difficult to find without the services of knowledgeable professional or clerical staff person; tend toward rigidity; response usually slow.

   c) Special Library - a library maintained by an individual, corporation, association, government agency or other group for the collection, organization, and dissemination of information, primarily devoted to a special subject and offering service to a specialized clientele. Strengths: Good flexibility; small staff of dedicated professionals who know the subject field thoroughly; specialized cataloging and organization. Weaknesses: Limited numbers of staff; sometimes untrained, narrow subject range; lifespan as an organization and funding vary from stable and useful to short lifespan due to cessation of funding.

   d) Information Center - usually an office, or a section of a research organization, which compiles and offers information about books or on a subject with which the parent organization is concerned. Staffing varies. Strengths: Close contact with subject experts; commitment to subject goals; flexibility; access through experts to specialized and ephemeral materials. Weaknesses: Commonly lack professionally trained personnel; are apt to have very short lifespans; small collections; funding varies; may lack knowledge of and contact with the network of worldwide conventional libraries and other information sources.

Rural Development - (Chaired by Dr. Evan Vlachos)

The full report of the Rural Development Panel, chaired by Dr. Evan Vlachos, will be in the Conference Proceedings. The issues below are those reported verbally at the Conference by Reporter Ann U. White.

Rural Development issues must necessarily be viewed in their larger context. It is clear that the most important water problems are community water supply, sanitation, irrigation, and flood control.

Three types of issues predominate: what types of information are needed; what types of communication are needed; and how can one increase sensitivity and receptivity on both sides of the information exchange process.

An overriding need in poor rural areas is for low-risk, high-reliability technology. Research results and knowledge transfer activities must recognize this as a given factor. It must be recognized that transfer takes place best within countries and between countries at similar levels of development with similar problems.

The visiting expert traveling to developing countries should stay longer as the process of transfer of knowledge becomes more efficient after the familiarization problem is overcome.

The difficult problem of transferring knowledge from the bottom to the top of the socioeconomic
scale deserves greater attention. In development activities, self-reliance must be built into the process, but villagers are limited as to the volume of self-help activities they can undertake.

Some other important elements that deserve further attention are:

1. the health effects of different management strategies,
2. the site-specific nature of most development problems,
3. the question of equity--who pays and who benefits from knowledge transfer activities, and
4. the time lag necessary between the conception of research projects and the delivery of results.

Policy Analysis and Recommendations

There is continuing need to improve knowledge transfer in water resources to take greater advantage of existing technology and future research results as they are achieved. We must improve the effectiveness of the research process in terms of our ability to disseminate knowledge so that those who need it can apply it. We do not have perfect water resources management and we need to improve the yield of water resources for energy and other beneficial uses. No specific assessment of any TT programs has been carried out, and the following discussion is focused on policy and program needs rather than on specific techniques for improving technology transfer.

The policies adopted should encourage the efficient production of timely high quality research and the transfer of the results to water resources managers and technical personnel who need the technology. While it is not clear how to achieve this goal in the context of the fragmented and diffuse nature of the water sector, total water technology needs should be analyzed so that adequate national and international models can be formulated. We have some models, but they have not been implemented and may not be implementable.

An excellent model is recommended in A Plan for a Comprehensive Water Resources Research Information Exchange System (Banks and Wolfe, 1969). The report makes a detailed analysis of total water resources information needs and presents the results in the form of 26 recommendations and a hypothetical model. The basic models are shown in Figures 3 and 4. These show the recommended flow of information on research problems in water resources (research needs) and the recommended flow of dissemination of research results. In this present report, we are more concerned with the means of dissemination of research results, so it is to Figure 4 that we give most of our attention. This figure shows OWRR (now OWRT) at the center of the dissemination of research results picture.

The model highlights OWRT because they were the client for the study. Other agencies are shown in a smaller box, and the model really includes a place for every actor in the water resources research business. As this model was presented some eight years ago, it would be very interesting to examine the extent to which it has been implemented. The writer feels that the basic reasoning leading to the model was very sound, and it needs more aggressive implementation. The model we will recommend builds on this earlier recommendation and extends some of the concepts from the perspective of eight years later. Banks' 26 recommendations are included in Appendix A.

One of the basic problems in the transfer of water resources knowledge is that state and local governments do not have adequate access to the research results which are needed to help them solve their problems. While many of their problems are those of training, inadequate finances, and other constraints, the system of delivery of technology could be greatly improved. On Figure 4 we see several places where state and local government interface with the national technology system. One is through the state institutes in technology transfer. Another is by participation in local sections of professional organizations. A third is in conferences and the technology transfer activity of national offices of professional organizations. A fourth would be direct access to national activities such as WRSIC. Most of these points of access are inadequately attended to at the present time and sometimes not sufficiently funded. One clear example is the state institute activities in technology transfer. At the North Carolina WRRI, a modest technology transfer program is underway at an average annual cost of about $50,000. About three times this figure would be needed to do a satisfactory job. Most state water research institutes have little, if any, technology transfer programs because of the absence of funding and other constraints.

Another serious problem in the transfer of knowledge at the local level and to state and local governments is that the role of the professional associations has never been adequately recognized. These associations represent the constituencies and users for water resources research results much better than any federal or state office might. These include, among others, organizations such as AWWA, WCPF, APWA, and ASCE. These organizations have credibility among the users of technology because they are organizations of the users themselves. It seems to the writer that U.S. Federal agencies have generally bypassed the professional associations except for some isolated incidents. The professional associations have inadequate input to Federal water resources research programs and have developed staffs which sometimes propose innovative projects much as another organization might. The utilization of professional associations needs a great deal more
Figure 3.
attention. This is one of the key points in the national model to be presented now.

Figure 5 shows a hypothetical national U.S. water knowledge transfer system. The model contains little that is new but seeks to clarify the ideal flow of water knowledge with particular emphasis on state and local government. It also highlights three additional entities in a clearer fashion than before. These are the professional associations; state water resources institutes, academic departments, and other firms that serve the water knowledge consumer with a geographical focus; and national technology transfer centers such as WRSIC.

There are some differences between this model and the one from Banks' study; but by and large, the models are showing the same general patterns. Banks' model was shown in greater detail. This present model is meant to demonstrate trends which should be improved.

The model begins with the knowledge producer function and is laid out like the familiar economics market mechanism flow chart showing how prices are established through the supply and demand markets.

The knowledge producers include those Federal agencies who invest in water resources research. These investments currently amount to about $225 million; but as we pointed out earlier, they are only a part of the substantially greater knowledge-producing activities underway in the country. Therefore, the knowledge producers should not be regarded as just Federal agencies; they include all places where knowledge is produced. We include federally financed university research in the above discussion. The sources that are lacking are state and local government activities and activities by private industry (within or outside the university) where knowledge is produced but not currently identified, captured, and transferred. Many mission agencies develop technology for their own use. The double-lined arrow loop on top shows the internal consumption of the technology produced by these mission agencies. There are some cases where little transfer is expected.

Knowledge generally flows from the producers to the consumers. In the past, much water resources management was carried out by the Federal Government. This responsibility is increasingly passing to state and local government now, and the trend will no doubt continue. Knowledge consumers should be recognized primarily as state and local agencies and the private firms that serve them. Some Federal agencies remain, of course, to consume the knowledge produced by other agencies. The consumer sector includes practically everyone--water resources managers, engineers, researchers, technicians, operators, etc. They look for knowledge transfer activities with functional and geographical focal points. The geographical focus offers nearby technical activities for participation whereas the functional focus allows access to best technology in particular problem areas. Let us begin with the functional focus. Here, we introduce a major point of this discussion.

It was pointed out earlier that with the exception of journal articles, professional associations have had less role in the transfer of knowledge than they should. Professional associations are the leaders, and their members represent cutting edges of applied knowledge in particular water sectors. As an example, the American Water Works Association is regarded as a national and world leader in the technology of supplying water. The AWWA represents a constituency of nearly 30,000 water professionals who collectively know more about this problem than any other group. It has a research foundation and is active in training and information transfer. It is interested in developing literature services and maintaining a repository of documents representing the best available in this problem area. A paper by AWWA Executive Director Johnson (Appendix C) describes AWWA knowledge transfer activities. The Water Pollution Control Federation (WPCF) has a journal recognized as the best in the world in water pollution control technology. In addition, it has other activities similar to AWWA. Other professional associations are active as well. The American Public Works Association, although it operates across the board in public works management activities, is probably the best source of practical drainage and flood control activities. ASCE through its urban water resources research council has probably done the most advanced research on this topic and needs to cooperate better with APWA since APWA represents the public works constituency that implements the drainage.

These professional associations need greater roles in the transfer of knowledge. Possibilities for expanded activities include: (1) the expanded collection and processing of new research literature to deliver it to their constituencies in just the forms needed; (2) operation of literature capture and dissemination services, on a centralized basis in cooperation with a federal center; (3) operation of training courses for constituencies in cooperation with water resources research institutes and other local groups; (4) state-of-the-art research on topics not covered by other agencies.

Let us turn now to the entities known as national technology transfer centers shown on Figure 5. There are several possibilities for such centers and different needs. WRSIC represents one such center for scientific and technological information. One deficiency in WRSIC is that it does not have a formal mechanism to interact with professional associations to capture and disseminate practical how-to knowledge that is available in the user constituencies. If it had such a mechanism, it might find that it would be used more heavily by these people. It is proposed that WRSIC develop a mechanism for locating, processing, capturing, and disseminating the best technology produced and implemented by local water
Figure 5. Hypothetical US National Water Knowledge Transfer System
supply, wastewater, and drainage managers. This will probably require some financing to stimulate the pouring out of this technology, and no proposal is given here as to how this can be done. What we are really describing is the experience and successes that these managers have which could be shared with others.

It is well known that water resources managers confronted with difficult problems do not as a general rule search the literature for solutions. A much more popular solution is to find out who has solved that problem and call them on the telephone. One possibility for WRSIC might be to distribute a list of key contact persons who have solved particular problems and refer inquirers to these persons. This would, in effect, be a telephone referral service. The old saying "it's not what you know but who you know" operates in the water management sector as well.

One other example of a national center will be given. The U.S. Army Corps of Engineers operates the Hydrologic Engineering Center (HEC) in Davis, California. This center engages in technology development and transfer on a practical basis. The concept was described by Leo R. Beard (1977) as a center of competence (Appendix B). Beard developed the concept of the HEC and presents principles upon which such centers should be developed. The HEC is a highly successful experiment in the development and transfer of technology, especially in computer-based hydrologic modeling. In the opinion of the writer, some of the best models have been developed by HEC and the Corps; and the dissemination and application of these techniques is, without a doubt, very successful. Short courses and workshops are offered in general topics which utilize the models but are not restricted to them.

The HEC is limited in its scope and capacity and is not well located to serve the population centers of the East Coast. The HEC needs to be augmented by a new center located on the East Coast in the center of the population distribution. This HEC-East should have an expanded role to include the development and dissemination of techniques developed by agencies other than the Corps as well as those developed by the Corps. Such a new center would include models and techniques developed by EPA and Interior as principal additions and would seek to meet the training and technology transfer needs of state and local government as well as Federal government in cooperation with the HEC. As the budget of the HEC is some $1 million annually, it is envisioned that such a new center might require approximately $2 million annually, bringing to $3 million the total expenditure for technology transfer and training in this sector. It is the opinion of the writer that the effectiveness of this $3 million investment would be many times that of the same sum directly spent on research. The activities of the new center might be linked to WRSIC and might include the preparation of state-of-the-art reports and other technology development and transfer activities. There may be a requirement for additional centers on the West Coast as well.

Obviously, there is a need to utilize water managers better in the research needs identification and technology transfer processes. The apparent first step is to improve the inputs of the existing professional associations into the knowledge transfer process. A second need is to inventory the coverage of the professional association to see if participation by all sectors of the water management community can be improved. It is well known that such participation is inadequate and incomplete. The writer does not know the approximate figures but estimates that about one in three water practitioners actually participates in the appropriate professional associations. Some problem areas are not covered by professional associations. Others are covered by political organizations rather than professional organizations. An example of this is found in the category of state water resources managers. In this group we include water resources development and management and water pollution control. It might be argued that organizations such as the Interstate Conference on Water Problems or the Association of State and Interstate Water Pollution Control Administrators meet the needs. These organizations are apparently more for the purpose of coordination than for professional development at the present time. It might also be argued that these state officials have their professional development needs met by participating in professional associations. A close examination would probably reveal that deficiencies still exist, particularly in terms of lack of organization to develop research needs and to process and disseminate water resources knowledge. The writer does not propose that the operation of the existing organizations is not good. Certainly, many administrators participate actively. However, as shown on Figure 6, no single professional association serves this sector. It is proposed that the organizations ICWP and ASIWPCA could jointly develop a professional association activity to complement their current organizational activity.

If state and local government are continually to carry greater portions of the water management burden, certainly greater attention should be given to organizing them to have inputs to the research process and to participate actively in knowledge transfer. We must eliminate the communications problems that exist between federal agencies, universities, and state and local water managers. New and innovative national approaches are needed to this general problem. One such innovative approach might follow the model of the American Society for Civil Engineers. We discussed earlier the concept of the organizational gate keeper as presented by Allen (1977). Recall that the technological gate keeper was that person or persons located in organizations who has the greatest interest in new technology and who communicates well. The ASCE through its Urban Water
Resources Research Program directed by Murray McPherson has developed an approach such as this in cooperation with state and local government. McPherson has developed a group of *cooperators*, most of whom are in agencies or universities or consulting firms, who serve as these gate keepers. He does not use that terminology; but in fact, the system works the same. McPherson serves to collect, process, and disseminate new technology to these gate keepers. He has done this through his series of technical memoranda which now number in the thirties. There have been a number of additional reports as well. Although his program has suffered from difficulties in developing adequate financing in recent years, it should be recognized as an excellent innovation with considerable promise as a national model. McPherson is a gate keeper himself with the ability to operate nationally, and his drive is the single key factor behind the success of the program. The model could be operational, however, if given adequate financial attention, organized properly, and operated by the right personnel.
REFERENCES


Cobb, Gary (OWRT Director), Speech to Institute Directors, October 20, 1977.


APPENDICES

A. Recommendations from Banks and Wolfe (1969)

B. List of papers presented at Second International Conference on Transfer of Water Resources Knowledge

C. Paper - "Role of Nongovernmental Organizations in Water Resources Knowledge Transfer" by Eric F. Johnson

D. Paper - "The Transfer of Technology Through Centers of Competence," by Leo R. Beard

APPENDIX A

RECOMMENDATIONS FROM BANKS AND WOLFE (1969)
Concept of a Water Resources Research Information Exchange System

The most effective system for disseminating research information and communicating information on research needs among users, researchers, and research administrators would be one which provides both National and local levels of communication. In the National level system, organizations having country-wide facilities and interests such as professional organizations, National technical magazines, various information communication services, and OWRR would work together to disseminate information obtained in one locality to potential users in other regions, to gather information on water problems of national concern, and to provide those information exchange services which are otherwise beyond the capacity of local agencies. At the local level, the State Institutes, with Federal financial assistance, would be responsible for augmented information dissemination and retrieval programs and would work with local sections of their professional societies, news media, and various other communication devices available to them as a result of their connection with an university.

This concept of a two level—National and local—information exchange system will reach the greatest number of potential users and will provide an opportunity for multiple contact with the same individual user. Plates I and II illustrate the recommended flow of information on research needs in water resources and recommended means for disseminating research results using the two-level concept.

An Information Exchange Program for OWRR-Sponsored Research

Based on the studies and findings reported in this report, and utilizing the concept proposed for a two-level information exchange system, establishing and carrying on an effective water resources research information exchange system for the OWRR program would involve the following actions:

(1) INFORMATION EXCHANGE IS AN IMPORTANT AND INTEGRAL ASPECT OF A WELL BALANCED RESEARCH PROGRAM, AND OWRR SHOULD MAKE A DETERMINED EFFORT TO SECURE THE NECESSARY LEGISLATIVE, ADMINISTRATIVE AND FINANCIAL SUPPORT TO GREATLY EXPAND ITS OWN INFORMATION EXCHANGE SYSTEM AND SHOULD ENCOURAGE THE STATE INSTITUTES TO AUGMENT THEIRS.

The following quotation taken from "Science, Government and Information" prepared by the President's Science Advisory Committee in 1963, sets forth the proper role of information exchange in relation to a research program:
"Transfer of information is an inseparable part of research and development. All those concerned with research and development—individual scientists and engineers, industrial and academic research establishments, technical societies, Government agencies—must accept responsibility for the transfer of information in the same degree and spirit that they accept responsibility for research and development itself. The technical community generally must devote a larger share than heretofore of its time and resources to the discriminating management of the ever-increasing technical record. Doing less will lead to fragmented and ineffective science and technology."

All evidence indicates that the existing information exchange system for water resources research needs to be expanded in order to avoid "fragmented and ineffective science and technology." OWRR may not have all of the legislative, administrative and financial support necessary to expand its information exchange activities along the lines recommended in this report, and should seek any necessary authorizations and appropriations. OWRR should assist the Directors of the several State Institutes in providing better dissemination of research findings and in achieving broader understanding of problems requiring study, and should encourage them to undertake expanded programs.

(2) OWRR AND THE STATE INSTITUTES SHOULD ADOPT AND IMPLEMENT THE TWO-LEVEL CONCEPT OF A WATER RESOURCES INFORMATION EXCHANGE SYSTEM PROPOSED IN THIS REPORT. OWRR SHOULD ASSUME RESPONSIBILITY FOR THE NATIONAL AND REGIONAL DISSEMINATION OF RESEARCH RESULTS OBTAINED BY STATE INSTITUTES AND TITLE II CONTRACTORS, AND FOR SECURING INFORMATION ON NATIONAL PROBLEMS REQUIRING WATER RESOURCES RESEARCH. THE STATE INSTITUTES SHOULD BE RESPONSIBLE FOR EXCHANGE OF WATER RESOURCES RESEARCH INFORMATION AT THE LOCAL LEVEL.

Plates I and II of this report, which illustrated the recommended systems for flow of information on research problems and for dissemination of research results, showed the recommended roles of OWRR in the National information exchange system and of the State Institutes in the local level system. No formal procedure exists at the present time for National dissemination of water resources research results obtained by the 51 State Institutes and by Title II contractors. Thus, a large body of useful information is not being made fully available to potential users.
Since OWRR has nation-wide responsibilities and interests in water resources research, it is the logical agency to carry out National and regional aspects of a comprehensive research information exchange system. The State Institutes are the logical agencies to carry out a water resources research information exchange program at the local level.

The recommended system for flow of information on research problems is intended to apply to all types of problems, not merely those of particular concern to OWRR. With this information, the State Institutes will be in a better position to formulate their own research programs, and OWRR will have a better basis for establishing its research priorities and will also be able to provide advice and counsel to other Federal water research agencies.

The recommended systems for disseminating research results should be applied to all results obtained from research conducted through the various State Institutes and by Title II contractors. Although some of the water resources research conducted by State Institutes may not be funded through OWRR, the lack of formal nation-wide dissemination procedures suggests that OWRR should undertake the obligation for such dissemination. In those cases where the research has been sponsored by some other Federal agency, OWRR should ascertain whether that agency intends to make a country-wide dissemination, and, if not, and the results merit wide distribution, then OWRR should include the report in its own National and regional information dissemination program.

(3) THE INFORMATION EXCHANGE SYSTEMS OF OWRR AND THE STATE INSTITUTES SHOULD INCLUDE USE OF AS MANY MEANS OF COMMUNICATION AS POSSIBLE BETWEEN POTENTIAL USERS AND RESEARCHERS SUCH AS PUBLICATIONS, PROFESSIONAL ORGANIZATIONS, NEWS MEDIA, CONFERENCES, SEMINARS, AND AVAILABLE INFORMATION DISSEMINATION SERVICES.

An effective information exchange system must provide a variety of means for communicating information on research needs and disseminating findings resulting from research projects. The results of the User Awareness Survey show that many methods are used by potential users for obtaining research results; no user limits his acquisition of research information to a single method. Similarly, a wide variety of channels should be available to those in the water industry for transmitting information on problems to the researchers.
(4) OWRR AND THE STATE INSTITUTES SHOULD RECOGNIZE
THE DIFFERENCE IN SIGNIFICANCE OF REPORTS AND IN THE QUALITY
OF RESEARCH, AND SHOULD ADOPT DISSEMINATION PROCEDURES TAKING
THESE FACTORS INTO ACCOUNT.

There is basic research and applied research, and not
all classes of potential users are necessarily interested
in both types. Similarly, not all basic research or applied
research is of the same caliber and quality. Reports
should be judiciously examined by OWRR to determine those
that merit extensive national or regional dissemination,
those that should be given only limited distribution, and
those which simply should be cataloged for future reference.
The State Institutes should similarly provide for dissemination
programs geared to the type and quality of research.

(5) OWRR SHOULD ORGANIZE ITSELF TO CARRY OUT AN
AUGMENTED RESEARCH INFORMATION EXCHANGE SYSTEM.

At the present time, there is no single focal point
within OWRR for information exchange activities. The proper
management of information gathering and disseminating programs,
particularly of the size and magnitude recommended herein,
requires that the responsibility for such programs be
specifically assigned within the organization. OWRR could
establish and staff a new division or post at a high level
in its organizational framework to coordinate information
gathering and dissemination activities, to publish a newsletter,
to prepare press releases and technical articles, to work with
professional organizations, and to do all other things to
carry out its recommended augmented role in the research
information exchange system, or it could assign such ac-
tivities to one of its existing divisions.

The Water Resources Scientific Information Center
(WRSIC) is the logical division of OWRR to be delegated the
prime responsibility for carrying out the augmented information
exchange program. WRSIC is already carrying out most of the
information dissemination functions of OWRR and has estab-
lished relations with various outside groups such as the
Science Information Exchange and the Commerce Clearinghouse.
The staff of WRSIC would have to be expanded to carry out
the program recommended herein.
(6) OWRR SHOULD ORGANIZE ITS OWN CONTINUING ADVISORY COMMITTEE, CONSISTING OF REPRESENTATIVES OF STATE AND LOCAL WATER AGENCIES, PROFESSIONAL AND TECHNICAL ORGANIZATIONS, AND OTHER NON-FEDERAL GROUPS SUCH AS CONSERVATION ORGANIZATIONS HAVING AN INTEREST IN WATER RESOURCES RESEARCH AND THE APPLICATION OF FINDINGS DERIVED THEREFROM.

The consensus among knowledgeable persons in the water research field is that a broadly-based advisory committee is valuable for obtaining information on research needs and for disseminating information on research findings. The special panel which OWRR convenes once each year to review its activities and program for the previous year does not have continuity of membership and does not meet frequently enough to provide the full effectiveness which can be obtained from a large advisory committee composed of a variety of individuals with varied backgrounds appointed to serve for a longer period of time. OWRR should make some provision for paying for the time and expenses of members appointed to serve on an advisory committee in the event the organizations they represent are unable or unwilling to do so. The advisory committee envisioned herein should be asked to provide meaningful guidance to OWRR in formulating the research program, reviewing research proposals, developing augmented information exchange activities, fostering suitable relationships with other water-related programs and organizations, and in other matters relating to the mission of OWRR. The principal advantage of such a committee to OWRR would be its use to disseminate information about the OWRR program and pertinent research findings derived therefrom. It is expected that each of the advisory committee members would report to his parent body from time to time, thus providing several additional paths for increasing user awareness of the program.

(7) OWRR SHOULD DEVELOP FORMAL PROCEDURES FOR OBTAINING INFORMATION ON RESEARCH NEEDS AT NATIONAL AND LOCAL LEVELS.

At present, OWRR obtains information on research needs mostly by incidental means such as through membership of its staff members on various committees or by personal contacts with representatives of various organizations in the water industry. A more formal procedure following the scheme shown on Plate I should be established. At the National level, the formal procedure should provide for participation by various professional societies such as ASCE which have committees devoted to the development of information on research problems, should make use of an OWRR advisory committee, and should allow communication with Federal, State, and local water agencies and with the State Institutes with their own more formalized information-gathering procedures. OWRR should also continue to have special studies made of research needs in specific fields. OWRR should summarize the information it
obtains on research needs and make it widely available.

(8) OWRR SHOULD SPONSOR THE PREPARATION AND PUBLICATION OF "STATE-OF-THE-ART" REPORTS SUMMARIZING RESEARCH FINDINGS IN A SPECIFIC FIELD AND THEIR APPLICATION.

It is not easy for the general user of research results to meld the research findings pertaining to a given subject from the multitudinous source documents, nor does he usually have the time. OWRR could provide a useful service by having reports prepared periodically which summarize the many separate findings in a given field. OWRR has financed such studies in the past primarily for the purpose of identifying additional subjects needing research. The State-of-the-art reports recommended herein are aimed at bringing together in one place, and making understandable to the potential user, the interrelationship among many independent studies and their applicability and value in the solution of current problems. Such reports should be distributed to researchers as well as to potential users.

It is probable that at least some of the professional organizations with interest in water problems would publish and disseminate such reports to their membership, particularly if some financial support were provided for printing.

Such State-of-the-art reports might be in the form of demonstration projects, wherein methodology and techniques developed in recent research studies are applied to "real life" problems, and the new procedures evaluated by comparison with more conventional methods.

(9) OWRR SHOULD DEVELOP A PROGRAM FOR INFORMING NON-TECHNICAL ADMINISTRATIVE PERSONS SUCH AS STATE OFFICIALS, MAYORS, COUNTY SUPERVISORS, FISCAL AGENTS, ETC., OF THE VALUE OF USING WATER RESOURCES RESEARCH FINDINGS IN THE SOLUTION OF LOCAL WATER PROBLEMS

Such a program would help in overcoming one of the constraints on use of research findings: the lack of understanding and initiative of local officials to accept or allow the use of new methods, or to provide a climate conducive to change. A series of easily understood brochures, articles, or news releases describing the research program and pointing out some of the more dramatic findings would help in creating an appreciation of research within local political and administrative structures. This information should be made available to the organizations and publication which normally reach these groups.
There are many National and local organizations which have contact with non-technical state and local officials such as the League of Women Voters, National Association of State Budget Officers, National Association of State Purchasing Officials, County Supervisors Association, and League of California Cities, to name a few. By working with such groups, OWRR and the State Institutes could enhance the appreciation of water resources research among persons in responsible administrative capacities. Board members from the many local water districts and agencies can be reached through such organizations as the Irrigation Districts Association of California, the National Reclamation Association, the Ground Water Institute, and the National Association of Soil Conservation Districts.

Information prepared for presentation to such organizations should stress particularly the cost savings which might be expected, or the improved service which could be provided, if a specific research finding were utilized. If possible, the presentation should use examples of actual cost savings or improved services realized by specific users of research results.

(10) OWRR SHOULD NOT REQUIRE TITLE II CONTRACTORS TO DISSEMINATE RESULTS OF THEIR OWN FINDINGS, EXCEPT FOR DISTRIBUTION OF FINAL REPORTS TO CERTAIN DESIGNATED AGENCIES, AND SHOULD ASSUME ALL DISSEMINATION OBLIGATIONS.

A special problem of research dissemination occurs in the Title II program. While many of the contractors in this program are universities or large organizations with capabilities and experience in disseminating research findings to potential users, others are private research organizations, engineering firms, or individuals without such background. As a general rule, OWRR should assume the responsibilities for disseminating Title II findings, other than the transmittal of reports to OWRR and each State Institute, which should be a contractual obligation of the research agency. OWRR should work with State Institutes to develop procedures for local level dissemination of Title II findings.

It is expected that some Title II contractors will voluntarily disseminate the findings of their research projects by distribution of reports, presentation of papers at meetings of professional organizations, participation in seminars and conferences and other means. OWRR should encourage such dissemination, and take it into account when planning its own dissemination program for the findings.
(11) OWRR SHOULD PUBLISH AND DISTRIBUTE A MONTHLY OR QUARTERLY NEWSLETTER CONTAINING INFORMATION OF GENERAL INTEREST ABOUT THE OWRR AND STATE INSTITUTE PROGRAMS, SUCH AS NOTICES OF NEW STUDIES UNDERWAY, SUMMARIES OF RECENT FINDINGS OR NEW TECHNIQUES, ANNOUNCEMENTS OF MEETINGS OR PLANS FOR FUTURE STUDIES, AND OTHER NEWS OF CURRENT INTEREST TO RESEARCHERS AND PRACTITIONERS.

The newsletter should be distributed to State and local water officials, private engineers, lawyers, biologists, planners, magazines, professional organizations, news media and others interested in water development or engaged in dissemination of information on research findings. A National newsletter on water resources research would provide a means whereby persons in one region of the country could become aware of happenings in another part; a newsletter would also assist the development of an interest in research programs among potential users. It would undoubtedly be used as a source document by various commercial and trade association newsletters.

The compilation, publication and distribution of such a newsletter would require a specialized staff of public information writers, and necessary funds for printing and mailing.

(12) OWRR SHOULD PREPARE EASILY UNDERSTOOD TECHNICAL ARTICLES BASED ON REPORTS PREPARED ON RESEARCH STUDIES HAVING WIDE INTEREST CONDUCTED UNDER ITS AUSPICES, FOR PUBLICATION IN NATIONALLY-CIRCULATED TECHNICAL MAGAZINES.

One of the popular ways for obtaining information on research results is through articles in technical magazines such as Engineering News Record, The American City, Public Works, Water and Sewer Works, and Water and Wastes Engineering. Such articles serve to alert potential users of the availability of research on a topic which may be vital to them. Well written articles would be published by various Nationally circulated magazines and thus would receive wide circulation. It is improbable that the researchers themselves could all be induced to write such articles, or would have the talent or inclination needed to do so. A team of technical writers would be required in order to identify those reports which could be used as a basis for such articles and to prepare the necessary write-up. It is possible that the State Institutes, by using the services of the public information office at the University at which they are located, could prepare such articles.
(13) FOR STUDIES APPEARING TO HAVE SPECIAL MERIT AND WIDE APPLICATION, OWRR SHOULD ENCOURAGE THE RESEARCHER TO PREPARE A PAPER FOR PUBLICATION IN A JOURNAL OF A DESIGNATED PROFESSIONAL ORGANIZATION AND/OR PRESENTATION AT A CONFERENCE OR MEETING OF THAT ORGANIZATION.

As noted earlier in this report, reading journals of professional organizations and attending their conferences are two of the primary methods for obtaining information on research results used by many potential users of such findings. In the past, OWRR has allowed individual researchers to decide whether or not to prepare a professional paper and to choose the organization to submit it to for presentation or publication. This policy has sometimes resulted in publication of findings of widespread interest in journals of limited distribution, and thus hampered effective dissemination.

The staff of OWRR is probably in a better position to assess the audience which can profit most by a given research report than is the researcher or even the Director of a State Institute. Following review of final reports submitted to it, OWRR should determine if the results warrant preparation of a professional paper. OWRR should also select the professional society which it believes would be most appropriate for publication of the research results, and suggest to the researcher that a professional paper based upon his research report be submitted for publication or be read at an appropriate conference. OWRR might finance the preparation of such a paper as a means of encouragement.

(14) OWRR, EITHER SINGLY OR JOINTLY WITH PROFESSIONAL ORGANIZATIONS, THE ENGINEERING FOUNDATION, STATE INSTITUTES, OR OTHER AGENCIES, SHOULD SPONSOR PERIODIC NATIONAL OR REGIONAL SEMINARS OR CONFERENCES TO PRESENT RESEARCH FINDINGS OBTAINED FROM OWRR-SPONSORED AND OTHER STUDIES, AND TO ALLOW INTERCHANGE OF IDEAS BETWEEN RESEARCHERS AND POTENTIAL USERS.

One of the most effective methods for transmitting information on research findings to potential users is through conferences or seminars where there is an opportunity for dialogue between the user and the researchers. Such meetings also provide the opportunity for researchers to obtain information from users as to current problems which may require further study. The study reported by Carter and discussed in an earlier section of this chapter points up the need for face-to-face meetings between researchers and potential users before results can be applied. The various professional organizations and the Engineering Foundation are already organized to conduct national meetings and conferences, and most of the State Institutes have conducted local seminars, conferences and meetings. It is probable that OWRR, working
with these groups, could make use of their organizational structure and knowledge of techniques for conducting successful meetings. OWRR would have to take the initiative in selecting subjects suitable for presentation at such meetings and securing necessary speakers.

(15) OWRR SHOULD EXPLORE THE FEASIBILITY OF FINANCIALLY ASSISTING PROFESSIONAL ORGANIZATIONS IN PUBLISHING RESEARCH PAPERS RESULTING FROM OWRR-FINANCED STUDIES, IN CONDUCTING CONFERENCES OR SEMINARS TO DISSEMINATE FINDINGS, OR IN DEVELOPING AND CONDUCTING TRAINING COURSES IN NEW METHODS OR TECHNIQUES. THE AMERICAN SOCIETY OF CIVIL ENGINEERS, AMERICAN WATER WORKS ASSOCIATION, AMERICAN WATER RESOURCES ASSOCIATION, AND WATER POLLUTION CONTROL FEDERATION SHOULD BE CONTACTED INITIALLY IN DEVELOPMENT OF SUCH A PROGRAM.

The majority of potential users of water resources research results belong to one or more of the four professional organizations named above. The publications of these societies and the meetings they sponsor offer ready-made vehicles for disseminating information on research findings. The Federal Water Pollution Control Administration has established a precedent for financially assisting the publication of research papers by professional societies through its assistance to the Water Pollution Control Federation. OWRR might achieve valuable dissemination of its research findings at minimal cost by using the services of the professional groups, but this might require some financial assistance.

ASCE, for example, has the demonstrated capability to develop training courses in new techniques but does not have sufficient funds of its own to undertake the development of many such courses. OWRR could provide financial assistance to ASCE and other professional organizations in working out educational courses for use by the members of these societies in new techniques resulting from research sponsored by OWRR.

(16) OWRR SHOULD ESTABLISH A STANDARD FORMAT BASED ON THE GUIDELINES PROMULGATED BY COSATI IN DECEMBER 1968 FOR ALL FINAL REPORTS PREPARED ON EACH STUDY CONDUCTED UNDER ITS AUSPICES.

There is no standard format used for publication of final reports prepared by researchers working on studies financed wholly or in part by funds supplied through OWRR. In fact, OWRR has accepted publication of research findings in professional journals or in graduate theses as meeting requirements for publication of a final report. As a result,
there is no single series of reports which can be identified as those published under OWRR auspices, or even by a given State Institute. Also, many of the reports which have been submitted to OWRR are lacking in supporting details and documentation. The space restrictions imposed by many professional journals often limit the thoroughness of presentation.

Establishment of a standard format for final reports would assure uniformity of presentation, encourage completeness, and would facilitate microfilming and reproduction by the Commerce Clearinghouse. COSATI, the Committee on Scientific and Technical Information of the Federal Council for Science and Technology, published "Guidelines to Format Standards for Scientific and Technical Reports Prepared by or for the Federal Government" in December 1968.

OWRR could use the COSATI standards as a basis for its own standards, making such modifications as might be necessary to allow for the separate series-type reports issued by many of the State Institutes and other special situations pertinent to the OWRR program. It is specifically recommended that publication of a professional paper or graduate degree thesis not be accepted as a final report.

(17) OWRR SHOULD PUBLISH PERIODIC CUMULATIVE INDEXES TO ALL REPORTS PUBLISHED UNDER ITS AUSPICES.

As noted earlier in this report, OWRR does not have available for public distribution a single list of all reports which have been submitted to it. It should remedy this situation as soon as possible and, in addition, should provide a series of indexes by subject matter, by investigator, by responsible agency, etc. These indexes should be brought up to date periodically, and be given wide distribution.

(18) OWRR SHOULD REQUIRE OR ASSURE THAT COPIES OF ALL SUBSTANTIAL PROGRESS AND FINAL REPORTS ON RESEARCH PROJECTS CONDUCTED USING ITS FINANCIAL ASSISTANCE (ALLOTMENT PROGRAM, MATCHING GRANT, AND TITLE II) ARE DISTRIBUTED TO AT LEAST THE FOLLOWING AGENCIES: OWRR, EACH STATE INSTITUTE, THE CLEARINGHOUSE FOR FEDERAL SCIENTIFIC AND TECHNICAL INFORMATION, AND THE ENGINEERING SOCIETIES LIBRARY.

A comprehensive research information exchange system must make provision for making technical reports available to the many potential users of research findings. This can be accomplished both by distribution of the reports and by creation of libraries for use of those needing only occasional reference service.
At the present time, there is no National program for disseminating the final reports emanating from OWRR-sponsored studies. Nationwide distribution of such reports could be accomplished most effectively by making sure that all substantial progress and final reports are transmitted to the Clearinghouse for Federal Scientific and Technical Information (Commerce Clearinghouse) and the Engineering Societies Library. The use of the Commerce Clearinghouse to distribute reports prepared under OWRR auspices would relieve OWRR of the management problems associated with such work, and would provide a single point of reference for all requests for such reports. Also, by using Commerce Clearinghouse, reports would be available in either microfilm or paper copy to suit a particular user's convenience. By making its reports available to the Engineering Societies Library, OWRR will assure that these reports will be available through a National engineering reference library, and will be included in the Engineering Index. OWRR should act as the central point for transmitting reports from the State Institutes and Title II contractors to the Commerce Clearinghouse and Engineering Societies Library in order to insure uniformity of procedures, prevent duplication, and maintain proper administrative control.

The only known collection of all the reports which have been prepared on OWRR-sponsored projects is that in the offices of OWRR in Washington D.C. This library is not convenient to the large majority of potential users of such reports who might wish to browse through the library from time to time. Each State Institute should have a similar collection, both for internal use by the Institute researchers, and for providing a reference library for use by local workers in water-related agencies and companies for whom such research results may have applicability.

As part of its financial support, OWRR should require that all State Institutes and Title II contractors distribute copies of their final reports to OWRR and to all of the State Institutes. In addition, it should require that sufficient copies also be made available to OWRR for transmittal to Commerce Clearinghouse and the Engineering Societies Library.

(19) OWRR SHOULD WORK WITH THE CLEARINGHOUSE FOR FEDERAL SCIENTIFIC AND TECHNICAL INFORMATION (COMMERCE CLEARINGHOUSE) TO MAKE ITS SERVICES BETTER KNOWN AND MORE APPROPRIATE TO POTENTIAL USERS OF FEDERALLY-SPONSORED WATER RESOURCES RESEARCH REPORTS.

At the present time, Commerce Clearinghouse is not widely known among potential users of water resources research results. This awareness should grow since Commerce Clearinghouse is now publishing Selected Water Resources Abstracts for OWRR, and subscribers and other recipients of this journal
will develop some familiarity with Commerce Clearinghouse and the services it can provide. OWRR could assist in making Commerce Clearinghouse more widely known among those in the water industry by encouraging that agency to advertise its services directly to users of water resources research results. This could be done by including a descriptive brochure with the Selected Water Resources Abstracts, for example. OWRR could also work with Commerce Clearinghouse to make its subject categories more applicable to water resources categories, and thus enhance the services that agency can provide.

(20) OWRR SHOULD CONTINUE ITS EFFORTS TO BROADEN THE INFORMATION BASE OF THE WATER RESOURCES SCIENTIFIC INFORMATION CENTER (WRSCIC) TO INCLUDE ABSTRACTS AND CITATIONS FOR REPORTS, MONOGRAPHS, BOOKS, ETC., DEALING WITH WATER WHICH ARE PUBLISHED BY STATE, LOCAL, AND PRIVATE AGENCIES, AND PROFESSIONAL ORGANIZATIONS AND FIRMS WHICH ARE NOT NOW INCLUDED IN THE LITERATURE BEING REVIEWED. OWRR SHOULD EXPLORE THE POSSIBILITY OF OBTAINING SUCH ABSTRACTS BY MEANS OF COOPERATIVE AGREEMENTS.

If the Water Resources Scientific Information Center is to become all that its name implies, the broadest possible selection of published material must be included in its information base. It would appear that any published material relevant to water problems and their solution should be incorporated into the WRSCIC data base, and thus be available for recall by investigators of particular subjects, areas, or problems.

It is known that many worthwhile reports are prepared by State and local agencies, most of which would undoubtedly be willing to provide abstracts and bibliographic information for inclusion in the WRSCIC data base if requested by OWRR. Thus, the costs of expanding the data base would essentially be those of the additional key punching and machine time necessary to include the information in the tapes now used for preparing the semi-monthly Selected Water Resources Abstracts. It is probable that professional organizations such as ASCE, AWRA, AWWA, WPCF, and AGU would also be willing to cooperate in expanding the data base by providing abstracts and citations to papers published in their journals.

(21) OWRR SHOULD INCREASE THE NUMBER AND SCOPE OF THE "CENTERS OF COMPETENCE" WHICH IT HAS ESTABLISHED TO REVIEW LITERATURE AND PREPARE ABSTRACTS FOR INCLUSION IN THE WRSCIC DATA BASE SO AS TO INCLUDE AS MANY ASPECTS OF WATER RESOURCES OCCURRENCE, DEVELOPMENT, CONTROL, USE AND DISPOSAL AS POSSIBLE.
OWRR has so far organized eight centers of competence to provide input to the WRSTC data base. However, their fields of interest do not encompass the entire water resources field. For example, there is a center of competence in "Eastern United States Water Law," but none in western water law, or for any other region or section of the country. There are no centers of competence in water use, waste disposal, or various other aspects of water development. Thus, only a portion of the literature is being reviewed for inclusion in the data base. This situation should be corrected as soon as possible.

(22) AS SOON AS THE SELECTIVE DISSEMINATION OF INFORMATION SYSTEM (SDI) BEING OPERATED FOR OWRR BY THE UNITED STATES BUREAU OF RECLAMATION IS FUNCTIONAL, IT SHOULD BE OFFERED TO THE GENERAL PUBLIC, PARTICULARLY THOSE IN THE WATER INDUSTRY, ON A FEE BASIS.

OWRR has contracted with the Bureau of Reclamation to selectively disseminate abstracts of water resources literature among staff members of Federal agencies and State Institutes. The abstracts are those which are now published by OWRR in Selected Water Resources Abstracts. This is a valuable publication, but it lacks the personal service aspects that an SDI system provides.

Indications are that many potential users of water resources research results would be willing to pay for current awareness notification service if it were available. The experience of the Highway Research Board bears this out, and indicates that users are willing to pay for services specifically designed for their personal use. Many observers feel that an SDI system provides the most effective means at the present time for alerting users to articles of interest, and the number of applications of the SDI systems in various fields is increasing rapidly. At the present time, it is impossible to estimate what the cost of such a service might be, but presumably the incremental costs of providing such a service to private users would be minimal. If the costs are greater than customers are willing to pay, then the system should be abandoned.

The utility of Selected Water Resources Abstracts can be greatly enhanced by more frequent and thorough indexing. Care should also be taken to avoid inclusion of conflicting abstracts of the same document by different sources. OWRR should review and edit all abstracts for content and consistency before publication in Selected Water Resources Abstracts or before use in the SDI system. OWRR should also assume responsibility for selection of identifiers and descriptors in order to assure uniformity. Even with these improvements, Selected Water Resources Abstracts could not be
considered a substitute for an SDI system because of the bulk and variety of information it contains.

(23) OWRR SHOULD ESTABLISH GUIDELINES FOR, AND ENCOURAGE THE STATE INSTITUTES TO UNDERTAKE, THE BROAD INFORMATION PROGRAMS NEEDED AT THE LOCAL LEVEL TO OBTAIN DATA ON RESEARCH NEEDS AND TO DISSEMINATE FINDINGS RESULTING FROM RESEARCH STUDIES.

As a minimum, each State Institute should (1) have an advisory committee composed of non-academic users of research results such as representatives of State and local water agencies, consulting engineering firms, and others, which meets at least annually to review the Institute's program and evaluate its plans for further research (2) make periodic surveys of local research needs, (3) maintain mailing lists of potential users of research results in their States categorized by types of interest and activity, (4) publish its own newsletter and distribute it to a wide list of individuals and organizations concerned with water resources, (5) publish technical reports and distribute them to potentially interested users, (6) conduct a continuing series of seminars and conferences for disseminating results derived from studies conducted through its own Institute, and to the extent applicable, by other research organizations, and (7) maintain a library of its own research reports and those generated by other Institutes and Title II contractors under the OWRR program. The State Institutes should make as much use as possible of university facilities and services such as public information offices, libraries, extension services, and other information dissemination activities.

Section 104 of the Water Resources Research Act of 1964 states, in part, "The Secretary of the Interior is hereby charged with the responsibility for the proper administration of this act and, after full consultation with other interested Federal agencies, shall prescribe such rules and regulations as may be necessary to carry out its provisions." This section provides sufficient authority and responsibility for OWRR to establish guidelines for the information exchange programs expected at the State Institutes. OWRR has already cited this authority as a basis for stipulating the number of reports which must be prepared by each State Institute for each research project conducted using OWRR-supplied funds.
The Directors and Associate Directors of the State Institutes, and their technical staffs and researchers should be encouraged to participate in committees, professional groups, etc., outside the campus community working on local water problems.

A problem in implementing this recommendation will be the limited time available for such work by Directors of State Institutes, most of whom can spend only a portion of their time on Institute affairs under present conditions. In an augmented information exchange program, it will be necessary for the Directors to spend a considerably greater portion of their time on such matters, or to hire assistants specifically for this function.

Another problem in implementing this recommendation will be the limited space available at many Institutes for housing the library of water resources research reports which will be developed under the program recommended herein.

(24) IN DEVELOPING GUIDELINES FOR AUGMENTED INFORMATION EXCHANGE PROGRAMS AT THE STATE INSTITUTES, OWRR SHOULD GIVE SPECIAL ATTENTION TO THE PROBLEMS OF DISSEMINATING FINDINGS OBTAINED IN ONE STATE AMONG POTENTIAL USERS IN OTHER STATES, AND THE DISSEMINATION OF TITLE II FINDINGS AT THE LOCAL LEVEL.

Information obtained from the User Awareness Survey indicates that there is a general lack of knowledge among potential users of the research being carried on in State other than their own. Also, there is no mechanism available for dissemination of findings obtained by Title II contractors to potential users at the local level. The State Institute information exchange programs should take cognizance of these deficiencies by making provisions for participation of researchers from other states or Title II contractors in local seminars and conferences, by including announcements of reports prepared by other Institutes in their newsletters, and by other appropriate procedures.

(25) OWRR SHOULD EXPLORE THE DESIRABILITY AND PRACTICABILITY OF SPECIFICALLY DESIGNATING A PORTION OF THE ANNUAL ALLOTMENT TO THE STATE INSTITUTES FOR INFORMATION EXCHANGE ACTIVITIES.

Carrying out the augmented information exchange activities recommended herein will require that most State Institutes spend a greater portion of their annual allotment funds for such activities than heretofore. There will be a natural reluctance to do so, particularly since this could reduce the
amount available for financing research studies. Therefore, in order to achieve a suitable program of information exchange by the State Institutes, it may be desirable to specifically designate a portion of the annual allotment for such activities. In the event that doing so would impair ongoing research programs, the annual allotment should be increased, designating the incremental portion for information exchange programs. It would be necessary to amend the Water Resources Research Act of 1964 to increase the annual allotments.

(26) OWRR SHOULD MAKE CERTAIN THAT THE CAPABILITIES OF THE STATE INSTITUTES IN WATER RESOURCES MATTERS ARE BROUGHT TO THE ATTENTION OF THE NATIONAL REFERRAL CENTER OF THE LIBRARY OF CONGRESS.

By so doing, persons or firms seeking assistance in water problems will be directed to a local agency having competency and sources of information.
APPENDIX B

List of Papers Presented at
SECOND INTERNATIONAL CONFERENCE
on
TRANSFER OF WATER RESOURCES KNOWLEDGE
Conference Results

Objectives and Overall Results by Neil S. Grigg

The Management of Research to Enhance Knowledge Transfer by Warren A. Hall

The Development of Effective Water Resources Scientific Information by Norman I. Wengert

The Utilization of Water Resources Knowledge in Rural Development by Evan C. Vlachos

Plenary Session Addresses

The Role of Land Grant Universities in Water Resources Knowledge by A. R. Chamberlain

Knowledge Transfer: Some Practical Considerations by Al Linhares

A Conceptual Model of the Knowledge Transfer Process by Evan Vlachos

Management of the Explosion of Scientific and Technical Information by William W. Doyel

Utilization of Water Resources Knowledge in Rural Development by F. J. Gonzalez

Results of the First International Conference of Scientific Editors by Miriam Balaban

Some Problems in the International Exchange of Water Resources Knowledge by Sandor Csallany

Role of Non-Governmental Organizations in Water Resources Knowledge Transfer by Eric F. Johnson

The United Nations Water Conference: Scope for Transfer of Knowledge in Its Action Plan by Habte Neghassi

International Programs for Transfer of Water Resources Knowledge (Luncheon Address) by Leo Heindl

Potentials for Transfer Through the Cooperative Extension Service Concept by Lowell Watts

Water Resources Knowledge for the Solution of Food and Energy Problems by Maurice L. Albertson

B-2
Proceedings of Technical Sections

I. The Management of Research to Enhance Knowledge Transfer

Invited Addresses

The Need for Applied Water Resources Research in Governmental Problems by M. Frank Hersman

Anatomy of the Research Project: Objectives, Organization and Delivery of Results by Michael P. Graus

A. Alternative University Approaches to Water Resources Knowledge Transfer

General Report by M. W. Hall

Beard, Leo R. - The Transfer of Technology Through Centers of Competence

Bradley, Michael D. - Institutional and Policy Aspects of Water Resources Information Transfer

Childley, T. R. E. (Dr.) - The Application of the University Aston IHD/IT Schemes in Transfer of Water Resources Information

Flaherty, David C. - "Drowning in Data?"

Grigg, Neil S. - Videotape Instruction for Continuing Education in Water Resources Management

James, L. Douglas - Design of OWRT Annual Allotment Research for More Effective Technology Transfer

Kaufman, Robert W. - Translation of Technical Water Resources Knowledge

Kerns, Waldon R. - The Management of Research to Enhance Knowledge Transfer

Sharpe, William E. - Some Approaches to Solving Community Water Problems Through Technology Transfer

Singh, Vijay P. - Role of Computers in Transfer of Water Resource Technology

Stewart, James M. - How Institutes Implement Technology Transfer: An Example of University Technology Transfer Programs in Water Resources

Taylor, Donald C. - Interdisciplinary Research as a Primary Mechanism for Information Transfer
B. Alternative Non-University Approaches to Water Resources Knowledge Transfer

General Report by A. J. Frederich

RM2

Basso, Eduardo - The Central American Hydrometeorological Project and Its Contribution to the Knowledge of Hydrology in one Tropical Area

Clyman, Wayne - A Research-Development Process for Improvement of On-Farm Water Management

Conley, James F. - Impact of Urbanization on Water Quality in the Pequannock Watershed

Eichert, Bill S. - Experience of HEC in Disseminating Information on Hydrological Models

Farrell, R. Paul - How Knowledge of Low Pressure Sewer Research was Transferred - A Case Study

Fernandez, Ceferino Alvarez - The Binomial "Knowledge-Knowledge Transfer" in Water Resources

Grigg, Neil S. - ASCE Urban Water Resources Research Program

Halverson, W. F. - Strategies for Developing Nonpoint Pollution Curricula in K-12 Schools

Keyes, C. G. - Political and Social Aspects of Weather Modification Technology Transfer

Kindler, Janusz - Some Attributes of Water Resources Research to Enhance Transfer of its Results

Levy, Stephen M. - Protland's Bull Run Watershed: Conflicts Over Use of Public Lands

Madison, F. W. - The Washington County Project: Strategies for Information Dissemination


Peter, P. - Transfer of Water Resources Information and Its Constraints


Salmon, E. E. - Involving Wisconsin's Citizens in Water Quality Programs

Scullin, Ronald L. - Local Input: A Required Mechanism for Knowledge Transfer

Smith, J. E., Jr. - Technology Transfer Program of the U. S. Environmental Protection Agency
Torno - Stormwater Management Model Transfer of Technology
Tucker, L. S. - The Transfer of Urban Water Resources Knowledge

II. Development of Effective Water Resources Scientific Information Systems

Invited Addresses

Aspects of the International Exchange of Water Information by Marcel Mercier

Factors Affecting the Use and Non-use of Scientific and Technical Information Systems by James E. Freeman

A. Approaches to Development of Water Resources Scientific Information Systems

General Report by H. W. Lee and Marjorie Rhoades

SIS1

Boychuck, Leo - A System for the Transfer of Water Resources Knowledge: The Canadian Experience

Edwards, Melvin D. - The National Water Data Exchange (NAWDEX)

Jensen, Raymond A. - An Overview of the Water Resources Scientific Information

Riordan, Ann - Use of Data from the Smithsonian Science Information Exchange to Transfer Information on Water Resources Research

Wood, Jack S. - Public Use of Landsat Imagery in Wastewater Management

B. Non-Computer Based Scientific Information Systems

General Report by Gary Lewis

SIS2

Bard, Janina H. - The International Irrigation Information Center: A Specialist Organization for the Transfer of Irrigation Knowledge

Body, D. N. - Interchange of Hydrologic Data in Australia

Chitale, V. M. - The Role of Government Agencies in Transfer of Water Resources Information

B-5
Frenkil, Samuel M. - Development and Implementation of a Recreational Water Quality Index

Hasselbarth, U. - A Data Bank Concerning the Quality of Drinking Water--BIBIDAT

Kohn, Robert S. - Development of Inventories of Energy Research and Development Information Resources

Krutz, Michael - Development and Use of a Data Base System of Substance Harmful to Water

Manahan, Stanley E. (Dr.) - Information Dissemination in the Water Resources Field

Markovits, N. P. - Experiences in the Transfer of Water Resource Information


Mulloney, Paul F. - Providing In-House Information Services

Hoogendorn, W. K. - Towards an Improvement of International Transfer and Exchange of Information on Water Supply and Sanitation in Developing Countries

Walker, Richard D. - The Level of Awareness of Relevant Water Resources Literature

Wiggert, James M. - How Do People Get Water Resources Research Information

III. Utilization of Water Resources Knowledge in Rural Development

Invited Addresses

An Overview of Water Programs for Improving Life Quality in Rural Areas by David Donaldson

A Multidisciplinary Transfer Model for Water Management Knowledge Transfer in Developing Countries by Jerry Eckert

A. Macro-Level Approaches to Improving Knowledge Transfer in Rural Areas

General Report by W. W. Shaner

Abiodun, Adigun Ade - Constraints and Possible Remedies on the Transfer of Water Resources Knowledge in the Developing Countries

Brasseur, Robert E. - Constraints in the Transfer of Knowledge

Chaturvedi, M. C. - Second International Conference on Transfer of Water Resources Knowledge

B-6
Mehrkar, Mohsen ASL - "Study of the Problems of Rational Exploitation and Utilization of Water in Irrigation in Iran"

Muiga, Michael I. - A Water Demand and Wastewater Disposal Model for Optimum Transfer of Water Resources Technology in Developing Countries

Murthy, V. R. Krishna - Regional and National Constraints on the Transfer of Water Resources Information

Ogedengbe, Olusola - Water Resources Research in Developing Countries

Rojas, Rafael M. - CIDIAT Experience on Water Resources Knowledge Transfer in Latin America

Rosenburg, Myron S. - Managing the Transfer of River Basin Planning Technology to Less Developed Countries

Verma, Rameshwar D. - Technology Transfer for Irrigation Planning of Arid Lands

Woolston, John - Sharing Knowledge: A Key to Detente Between the Rich and the Poor

B. Micro-Level Approaches to Improving Knowledge Transfer in Rural Areas

General Report by Nathan Buras

RD2

Buckles, Patricia K. - The Training and Utilization of Rural Water Technicians in Guatemala

Chaturvedi, Abinash Chandra - Information Dissemination of Water Resources in U.P.

Dijon, Robert E. and Neghassi, Habte Mariam - Transfer of Water Resources Knowledge Through Activities of the United Nations

Gupta, R. K. - Operational Constraints on Transfer of Technology in Watershed Management in the Himalayan Hill Regions (Garhwal) of India

Holmes, R. C. - The Transfer of Irrigation Water Knowledge in the Underdeveloped World: Irrigation Water Use in the Arequipa Region of Southern Peru

Lowdermilk, Max K. - Social and Organizational Factors for Farm Irrigation Improvements: A Case Study

Rosenfield, Patricia - The "Appropriate Technology" Bandwagon: Transfer of Knowledge and Community Water Supply
APPENDIX C

Paper

"Role of Nongovernmental Organizations in Water Resources Knowledge Transfer"

by

Eric F. Johnson
"The Role of Nongovernmental Organizations in Water Resources Knowledge Transfer" is certainly a broad enough subject to let anyone wander at will in its discussion. Radio, television, newspapers, magazines, and the membership bulletins of special interest groups all qualify—usually unfortunately—as non-government transferrers of water resources knowledge, interpreted most often to serve their own ends. Because of my position on the staff of a scientific and educational society, however, I have assumed that your program committee wanted from me a discussion of the role of such an organization as the American Water Works Association in the transfer of water resources knowledge to the people responsible for using it to the benefit of the public.

Voluntary associations, whether they are of the trade variety—serving a specific industry group—or scientific and educational societies (such as the American Water Works Association) serving the public, are—or certainly should be—the principal agencies for transferring technological information to those who are responsible for applying it to the benefit of those they serve. Trade associations because they exist for the benefit of their members' commercial interests are less likely to concern themselves with water resources knowledge as such than they are with information concerning regulations,
rates, and personnel matters that affect their members' profits. Scientific and educational societies, on the other hand, are required to direct their programs and offer their services to members and nonmembers alike in the interest of serving the public as a whole. Both types of organizations, however, endeavor to interpret the technological developments in the field to their members so that they can be applied for the benefit of those they serve.

In either case, the practical application of new technology depends in large part on the understanding and interpretation of the technological semantics involved. And too often the world of academic research speaks a language foreign to those who could and should transfer the results of research to practical public advantage.

As an example of my point, I quote this paragraph from a research paper basically aimed at assisting the water system operator in improving his service to the public:

"However the system may be truncated, it will be necessary to rather explicitly describe the conditions which prevail at the boundaries, real or imagined. These 'boundary conditions' must indicate the properties of the water, in quantity and quality terms, that is transferred across. In a few instances, these properties will be those defined by particular transfer subsystems, such as Water Collection or Urban Hydrology. In the former case, the specific inputs may be diversions programmed from a distant
Role of Nongovernmental Organizations in Water Resources Knowledge Transfer

reservoir; in the latter case inputs may be streamflow and natural precipitation on the urban area. Inputs may be deterministic, as for controlled deliveries, or stochastic as for most hydrologic quantities. It will be noted that the structure of certain submodels of the urban system may be either deterministic or probabilistic depending on the kinds of input information provided and the type of response function desired."

I am sure that this language is perfectly understandable and useful to other professionals in the field of urban water resources. I am just as sure that it is virtually meaningless to most of the 42,500 "managers" of water utilities serving 5,000 or fewer people—in other words those who are working with a staff of five or fewer workers.

AWWA is a scientific and educational society which has, over its 97-year history, been able to direct the expertise of its member professionals to converting the technological advances of the water supply field into standards, manuals, seminars, workshops, and a wide variety of publications usable by those who are responsible for putting the technology to work in serving the public at all levels. Right now it has no fewer than 3,500 of its 27,000 members at work on committees translating technology into useful information. The review and editing processes of all AWWA periodicals and publications are aimed at making technical knowledge accessible, understandable,
Role of Nongovernmental Organizations in Water Resources Knowledge Transfer

and useful to all levels of personnel in the field. And AWWA meetings at international, state, and local levels also aim to carry the message, in understandable terms, to all concerned with providing safe water to the public whether they are served by a system serving millions or, by definition of the new Safe Drinking Water Act, a mere 25.

Some 7,000 registrants participate in AWWA's Annual Conference, where 160 speakers, 100 committee meetings, 300 exhibits of materials and equipment are on hand to inform. Another 700, mostly laboratory personnel, are on hand for the Association's annual specialty conferences. From 150 to 2,500 attend each of its 50 annual section meetings, and from 75 to 150 its 100 district and branch meetings. And all these meetings--reaching no less than 50,000 water utility people--are involved in the business of technology transfer at levels commensurate with the understanding of those attending.

Not only AWWA's publications and meeting programs, but its educational efforts are being scaled to the various levels of capability of those serving the field. Thus, in addition to its management level seminars, it is now developing basic and intermediate level operator training materials in cooperation with and under grants from the Environmental Protection Agency to help the smaller utilities meet the requirements of the new Safe Drinking Water Act that went into effect last week and to help operators meet the certification requirements of state agencies. Most of the personnel in the water supply
field are undereducated and undertrained, principally because the public has underrated the importance of good water service. For that reason, the transfer of water resource knowledge in the field has become as difficult as it is important.

What is considered eggheadedness in research and technological communication is, we are sure, necessary to the cause of technology transfer, too, and of ultimate benefit to society, but we are concerned that it often becomes not only too esoteric, but too self-serving. The quick-release syndrome that has affected too many researchers seeking additional financial support by dramatizing their speculations has been catastrophic so far as public understanding of water resources knowledge is concerned.

We are, we are to understand, running out of water. And yet we have all the water we ever had and the technology to make it available—when and where it is needed in the quality that is required—at a level never before approached.

But water supply, we are now given to understand, is what is killing us with cancer. The fact that the proof lies in the massive dosing of rats or mice with possible contaminants of drinking water supplies is, we are told, not only beside the point, but strictly anticonsumerist. Putting a granular carbon filter, which may do some good, in every treatment plant would cost, we learn, no more than one nuclear submarine—$2 billion, that is—and because this might
Role of Nongovernmental Organizations in Water Resources Knowledge Transfer

protect the public against a water constituent that MAY, but has not been proved to be, harmful to humans, we have, we are told, a responsibility to act.

"Chlorinated Water," so authoritative a source as the National Enquirer has labeled "A Major Cause of Cancer." And perhaps this is correct, in that water chlorination has so increased life expectancy through control of bacterial diseases that exposure to cancer has been increased. But the declaration by Dr. Robert Harris of the Environmental Defense Fund that: "Except for cigarette smoking we haven't identified anything else that accounts for potentially as much cancer as drinking water and chlorination" is the kind of irresponsible statement that must be called technology transmutation.

Similarly, well-meaning manipulators of statistical extrapolatory techniques have indicated that "soft" water supplies have been responsible for killing off 150,000 people per year in the United States through heart disease. Never mind that no medical link between soft water and heart disease has been found, the media, it seems, must be served.

Then there is the recent report that 25,000 people per day are dying of waterborne diseases, albeit that the definition of waterborne disease has been stretched to include those diseases caused by the lack of water supply and those caused by, for instance, mosquitoes, because they breed in water.

C-7
Role of Nongovernmental Organizations in Water Resources Knowledge Transfer

A modicum of morality in technological communication both to and by the media would, we are sure, help the cause of accurate technology transfer.

The public water supply industry and the Association are certainly concerned with the possibility that there is some truth in some of these sensationalized reports of harm to health, but they are hardly ready to prescribe unproved solutions for unproved problems at the expense of the public. Thus, the Association has endeavored to put information concerning potential waterborne threats to the public into perspective and through its own research efforts and those of responsible agencies in the field to keep its members informed of technological developments that will help them meet their responsibilities to the public. Where the Association has been deficient is in getting this message through to the public, but the kind of budget required to conduct an aggressive international public information campaign is beyond the present means of AWWA and it is unlikely that its principally municipally-oriented membership will soon be ready or able to support such a campaign.

AWWA's strengths in technology transfer therefore lie in less flamboyant fields:

AWWA's Research Foundation, for instance, has identified more than 100 priority research projects based on their importance to providing better water service to the public and is tackling these
Role of Nongovernmental Organizations in Water Resources Knowledge Transfer

projects as rapidly as it can develop support. One outstanding example of the Foundation's contribution to technology transfer is its role as a reporting and coordinating agency for a group of water utilities and government agencies conducting research in water reuse for potable purposes.

AWWA's education department has established a multi-media reference service to disseminate information on the technology of the field and is now in the process of developing a special library reference service on community water supply.

AWWA's technical services department answers thousands of requests for technical information each year and through thousands of volunteer workers produces a continuing series of standards and manuals to make new technology available in usable form.

AWWA's public information department transfers water supply knowledge directly to the public through releases and media contacts and indirectly through providing information and materials for dissemination through its utility members.

And AWWA's government affairs department seeks to transfer water supply knowledge to legislators and federal agencies by direct contact, by preparation of expert testimony, by participation on government advisory committees, and by keeping Association members aware of areas where personal technology transfer seems to be needed to assist in obtaining or avoiding legislative or regulatory action.
Role of Nongovernmental Organizations in Water Resources Knowledge Transfer

The role of nongovernmental organizations in water resources knowledge transfer, as I see it, is basically to make technology understandable and useful. This, of course, requires a perspective of practical benefit to the public rather than wistful thinking about zero discharge or zero risk. And it certainly requires an appreciation of the fact that an important part of water resources knowledge these days is a knowledge of financial resources—particularly in the municipal field.

The American Water Works Association has, as mentioned earlier, adopted that role throughout its programs and welcomes your participation in getting the information to where the action is.
APPENDIX D

Paper
"The Transfer of Technology Through Centers of Competence"
by
Leo R. Beard
Abstract

THE TRANSFER OF TECHNOLOGY THROUGH CENTERS OF COMPETENCE

by

Leo R. Beard

Analysis of comments and suggestions made by a number of academic leaders in water resources research and practitioners in water resources development and management leads one to believe that the great need for implementing research results can be met most effectively through intermediary organizations. Such organizations must be thoroughly familiar with ongoing research, sources of research competence and with problems faced by the practicing profession. They should consist primarily of academic individuals who are highly practice-oriented and practitioners with good academic background and interest. Perhaps the latter should dominate, since understanding of the complete problem is so basic to the implementation of practical research.

A Center of Competence would specialize in a well-defined area of expertise, consist of 15 to 30 persons, and be basically funded by an interested organization (government, foundation or association). Perhaps half of its budget would derive from services rendered on a not-for-profit basis, to assure that such services are worth at least as much as the price paid. Such services would consist of research (primarily at universities on a contract basis), methods development wherein new technology is put into manual form, training (primarily through short courses), and technical assistance in solving actual problems in cooperation with practitioners. Each center's program should be as unrestricted administratively as is practicable and judged on the basis of demands for services.

It would be vital that a center have no line authority over research or practicing organizations and that use of its services be entirely voluntary and uninfluenced by financial or political pressures. In such a setting, the drive for technical competence and for a high degree of responsiveness to needs of the practicing community would be fostered, duplication of research and development would be minimized, and the lag between research and application could be substantially shortened.

1Director, Center for Research in Water Resources and Professor of Civil Engineering, The University of Texas at Austin.
TECHNOLOGY DEVELOPMENT AND TRANSFER PROBLEMS

Among the many problems of information dissemination and technology transfer in the various fields of engineering, the one that is of primary concern in this paper is the problem of imparting new technology developments to practicing engineers. An associated problem is that of developing new technology in response to engineering planning, design and operation needs.

There is a tendency for professional experts, as their career develops, to become proficient in practical applications or in research, but ordinarily not in both. These two categories tend to develop separate technical jargon as well as different types of expertise. Thus, while researchers have the capability of solving new problems, there are two major factors that detract from the effectiveness of their work:

a. The researcher usually has difficulty in assessing the true nature of the problem and in dealing with the elaborate detail of practical applications, and

b. The practitioner has difficulty in understanding research potential and research results.

---

1 Director, Center for Research in Water Resources and Professor of Civil Engineering, The University of Texas at Austin.
RESEARCH FORMULATION

Whether a research undertaking is initiated by a researcher or a practitioner, there is usually a large gap in communicating the real need and the best potential solution techniques, due to the two major factors listed above. Because virtually every practical problem is highly complex, it is ordinarily not feasible for a practitioner to describe and explain in sufficient detail a problem for research. It ordinarily takes years of experience in working in a specialty area to appreciate adequately the many ramifications that are of major importance in planning a research project. Thus, an experienced practitioner must participate in formulating a practical-research problem.

On the other hand, it takes many years of special education and of research experience to visualize how new techniques might be developed or adapted and applied to some specific problem. Practitioners undoubtedly pass up research possibilities in many cases where research would be useful, simply because the practitioner is not aware of solution potential. It might appear obvious to him that research would be useless. Thus, an experienced researcher is also essential to the formulation of a practical-research project.

Given these two requirements, it might be concluded that a good practitioner having a problem might sit down with a good researcher qualified in the area and work out a good plan of research. This would ordinarily be true if the two could communicate effectively and if enough time is taken so that each thoroughly understood the essentials of the other's ideas and statements. However, this is ordinarily not
the case. In order to formulate good research, the practitioner must be sufficiently involved in research and the researcher must be sufficiently involved in practice to assure mutual understanding. In some cases, this might be accomplished by temporary exchange of personnel, but a much more effective means would be to maintain a center of competence as described below. It would probably not be often that work previously done under exchange agreements would fit both aspects of a research-formulation need.

CONDUCT OF RESEARCH

It is rare that a research problem can be formulated, a plan of research developed, and then the researcher left to proceed until the project is completed, without risking a high chance of failure. Frequent contacts between the researcher and practitioner should be made in order to assure that research is not misdirected and that it adequately responds to the problem. A plan of research is important, but not sufficient guidance. As the research progresses, the practitioner must assure that adequate reliable basic data are available to the researcher and that important aspects of the problem area are not overlooked. Furthermore, the practical usefulness of a research project can be judged best by implementing the results in a real-life application. Thus, after a research study is initiated, it is essential that the practitioner be in constant or frequent contact with the researcher and that he attempt to apply the research results to a specific problem.
Under these circumstances, the researcher may continuously adapt his approach as he more fully appreciates the problem ramifications, and the practitioner may reformulate the problem as he recognizes the relative difficulties and ease of various solution approaches. It is usually difficult or impossible for a practitioner to work this closely with a researcher when the practitioner has many other regular duties. Furthermore, unless a researcher and practitioner work together for a considerable period of time, the communication problem would usually seriously inhibit this coordination. Consequently, there would be a great advantage to maintaining a center of competence as discussed below.

IMPLEMENTATION OF RESEARCH RESULTS

Hopefully, research results will be of general value rather than simply responsive to a specific problem. In at least some sense, this is almost inevitable, if only because of the educational value of a good research undertaking. However, it is important to maximize the long-range usefulness of research, and this is the most common concern of technology transfer.

Means by which research results are made available to practitioners generally include research reports, professional consultation, and special short courses. Research reports often fail to be effective because they are not understood by the practitioner, because the practitioner is not aware of them, or because they do not contain sufficient guidance for varied applications. The first reason is probably the most prevalent by far, so again it is the communication gap that prevents maximum effectiveness of research.
Short courses are becoming increasingly popular and useful, because they allow substantial time for establishing communication. However, the tendency to cover the general case rather than the specific detracts from effective communication to a large degree.

Consultation by researchers is usually sporadic and diffuse, so it does not ordinarily constitute a major accomplishment in technology transfer. Occasionally, renowned authorities put together enough consulting practice to constitute an integrated compendium of expertise. It is believed that centers of competence, properly staffed and managed, can accomplish this effectively.

GENERALIZATION OF RESEARCH RESULTS

Perhaps the ultimate objectives in the transfer of technology are state-of-the-art reports and engineering manuals. Such documents must ordinarily be prepared by highly competent and highly experienced individuals who understand research and practice. State-of-the-art papers might more commonly be authored by researchers, whereas manuals of practice would normally be authored by practitioners. Still, there is need for thorough familiarity with both research and practice in order to accomplish either task satisfactorily.

Professional organizations often sponsor this type of document, and with some degree of success. However, most requests for such services go begging, simply because competent experts do not have the time and resources to devote to such tasks without reimbursement. On the
other hand, a center of competence as envisioned herein would have such tasks as primary goals.

CENTERS OF COMPETENCE

Adequately organized centers of competence should have four major functions that are mutually complementary and, in fact, mutually essential:

a. Research
b. Practice
c. Documentation
d. Training.

Any center of competence should be supported financially in part by a public agency or private organization in order to establish it as a not-for-profit organization dedicated to advancing the technology in some specifically delineated area of expertise. In general, this support would apply to research, training and documentation (which might be partially self-sustaining), but not to practice. Practice would constitute working with action organizations on their real problems on a reimbursement basis. The center will be viable as long as there are demands for reimbursable services. When such demands cease, it should be obvious that the center has failed to convince the profession of its over-all competence.

If the center is to succeed, it must be a top-quality organization utilizing the most modern facilities. Its staff must consist of individuals vitally interested in the work and in furthering the goals of
the center. While there must be adequate administrative and clerical staffing, administrative control should be minimal, because maximum attention to technical progress is essential. Thus, most of the staff should be technical. Of these, most should be professional, with minimum sub-professional or technician support, because a surplus of support can lead to inefficiencies. Of the professional staff, about half should be primarily researchers and about half primarily practitioners, with each having considerable background in the other area so as to promote effective communication.

The program of a center of competence would consist of 5 to 20 short courses (3 days to 2 weeks) per year, for which tuition charges would be modest. This would encourage attendance and expose the center to the profession. As the profession becomes more fully aware of the center's capabilities, there will be requests for assistance in practical applications. This type of assistance is absolutely essential to the success of an integrated program such as is suggested here, because experience thus gained keeps the center aware of current problems, provides examples for courses and manuals, and provides invaluable vehicles for testing and developing research results. The center should be free to pursue research that is considered to be most needed and interesting, although there would undoubtedly be many cases where outside organizations will wish to partially or wholly subsidize research of particular importance to those organizations.

Through an integrated program such as described here, a staff of competent individuals can be developed such that they can become leaders.
in the field. It is not at all necessary that individual experts be maintained for long periods of time (longer than 3 or 4 years). As a matter of fact, a moderate turn-over of technical personnel is desirable and, in fact, virtually inevitable. There should be a continuing demand for staff members to move to better positions outside, and there should be a continuing inflow of new talent and new ideas and perspectives if the organization is to remain dominant.

CENTER IMPLEMENTATION

For such a center to be possible, some organization interested in advancing a defined area of technology must provide for its establishment. While it is not within the interest of this paper to discuss the institutional aspects of this subject, it is important to point out that a research and development organization (center of competence) is only successful if its staff is vitally interested in the subject and mission and if it must derive part of its support from services rendered.

The decision to establish a center must be occasioned by a recognized need for improving some area of technology. Hopefully, termination of a center would result when demands for services diminish to the point where the mission of the center is no longer vital.

CONCLUSION

The concept of a center of competence organized and operated along the lines briefly described herein can be highly useful in transferring
technology from the researcher to the practitioner in a manner that is much more effective and efficient than are other existing mechanisms.
APPENDIX E

Paper

"Design of OWRT Annual Allotment Research for More Effective Technology Transfer"

by

L. Douglas James, Donna H. Falkenborg, C. Earl Israelsen, Frank W. Haws and Mardyne Matthews
ABSTRACT

A review of the 29 research projects completed in Utah over the last twelve years under the OWRT Annual Allotment program revealed a great deal of variety in the success achieved. Some projects produced results that have received wide application. Other results seemed to promise considerable contribution to more effective water management but were never really accepted. Still other projects were never able to deliver more than the most general contribution to knowledge.

From statistics collected on proposal characteristics and on the efforts in disseminating findings and from interviews with principal investigators on these projects, the obstacles to achieving promised objectives or to others using the results were listed and analyzed. Data on the quality of the research results and the effort made to disseminate them were then analyzed for significant associations. The results generated suggestions for improving project selection and study design so as to enhance the probability of usable results. The conclusions provide help that program administrators can use to help principal investigators from the time of proposal inception, to enhance productive researcher-user contacts, and to provide follow-through after report completion.
DESIGN OF OWRT ANNUAL ALLOTMENT RESEARCH FOR MORE EFFECTIVE TECHNOLOGY TRANSFER

By L. Douglas James, Donna H. Falkenborg, C. Earl Israelsen, Frank W. Haws, and Mardyne Matthews

Introduction

The general public and elected public officials frequently express dissatisfaction over the money and effort going into research projects only to produce reports that few can understand and whose limited copies largely gather dust in scattered personal libraries. The results, in their view, are not solving the problems that generated the political support required and promised to get the research program authorized and funded. Elected officials see regular requests for continuing funding, few solutions, and little public support.

Part of the problem is that research findings are not being applied. The ready recommendation is to do a better job of getting the findings to potential users through technology transfer or information dissemination programs. Simply adding this worthwhile component to the research program, however, fails to address the total problem. Research performance and the dissemination of the results should be highly interrelated.

1. Director, Utah Water Research Laboratory and Center for Water Resources Research, Utah State University, Logan, Utah.
2. Editor, Utah Water Research Laboratory, Utah State University, Logan, Utah.
3. Research Associate Professor, Utah Water Research Laboratory, Utah State University, Logan, Utah.
4. Research Engineer, Utah Water Research Laboratory, Utah State University, Logan, Utah.
5. Administrative Coordinator, Utah Center for Water Resources Research, Utah State University, Logan, Utah.
components of the total research program. Researchers need to plan and conduct their studies to produce results that will, when disseminated, help solve problems. They need to organize their presentations to overcome the obstacles to effectively communicating the results. Technology transfer agents need to organize to communicate not only research content but also related concepts in the total state of applicable knowledge.

Few are likely to quarrel with the potential value of integrating research performance with technology transfer. Objectors are more likely to note its idealism. Practically speaking, how can a research administrator know in advance which candidate projects will produce readily transferable results? How can he guide principal investigators of selected projects toward producing such results? The skeptic may doubt whether it is really possible to do either, but the possibility that that viewpoint may be right is no reason not to try. The purpose of this exercise is to search for empirical relationships that water research program administrators can use to 1) select projects with a higher probability of generating operational technology transfer to problem solvers and 2) help would-be principal investigators toward that end from the time of proposal inception. The data base is the set of 29 research projects completed under the OWRT Annual Allotment program in Utah over the last twelve years.

The Total Research Program

A user-oriented research program needs to 1) identify water management problems people believe important, 2) determine if deficiencies in knowledge on how to deal with that problem mean that research is required, 3) perform needed research, 4) express research results in a form that
can be used to solve the problem, 5) disseminate the results to those who need to apply them to get the problem solved, 6) monitor remaining problems, and 7) followup as needed. Water management problems may exist for the non-technical water user (particularly in an era of the nonstructural measure) uncertain as to how to cope with a water supply, storm water, or water quality problem; for the engineer or other professional who finds that he cannot provide his clients reliable advice for a resonable cost; or for the scientist unable to pursue his research objectives further when he encounters a deficiency in his tools or knowledge. Water research thus has popular, professional, and scientific audiences; and it would be unwise to say that research directed toward one is any more important than research directed toward the others without empirical evidence on what is most needed to solve the problems at hand. Each direction has times when it is more important than the others.

Once the water management problem is identified, the research program administrator must determine whether the information is available and only needs to be collected, organized, and distributed (perhaps because previous researchers did an inadequate job of information dissemination) or whether research is needed to probe the unknown.

Where research is needed and the problems have sufficiently high priority, studies should be performed as funds and personnel permit. Seldom, however, would a research report be sufficient for problem solving. It more properly presents previously unknown information contributing to the solution. The next step is to integrate the research findings with what was previously known into a form that can be applied, and the following step is to distribute the results. The appropriate process for organizing and disseminating the results depends on the audience who must
apply them. The greatest effort is needed where the results must be expressed in popular form for lay users for their personal implementation (e.g., flood proofing or irrigation practices) or to increase their knowledge for group decision making when water management problems reach the political arena. The effort of technology transfer to professionals is of a different sort involving such instruments as user manuals, short courses, and, to really be effective, direct personal contact for training. Information dissemination to scientific audiences usually requires little more than spreading awareness of research reports and making them more readily available. The important point to be made here is the gross inefficiency of attempting to disseminate all three kinds of products to all three audiences. A well-managed research program will match the technology transfer effort for a given body of research results to the audience that must apply those results for the problem to be solved. A very well-managed program will construct the total research effort from inception to dissemination to best meet the needs of the user.

Transfer Scenarios

The people who need to interact within a total research program may be classified as users (general public, professionals, or other researchers), transfer agents or researchers. They interact in six patterns:

1. U-T-R-T-U The user (U) may perceive a water management problem on which he feels a need for advice and communicate that fact to a transfer agent (T) who, if he determines that research is required, communicates the problem to a researcher (R). The researcher completes his study and communicates the results to the transfer agents to pass on to the universe of potential users. This model is most applicable to cases
where large numbers of users, particularly in the general public, and differences in technical background make direct communication between researchers and users difficult. The best example is the agricultural extension system.

2. U-T-U Some of the needs may be answerable through expertise already available to the transfer agent. He can then respond directly without needing to involve the researcher. One of the most valuable contributions the transfer agent makes within the total research program is this type of response which frees the researcher for his primary responsibility.

3. U-T-R-U On some occasions, the need the users communicate to a transfer agent and the transfer agent passes on to a researcher may be either so technical or involve so few people that the best approach is for the researchers to work directly with the users. Certainly, it would be a mistake for anyone to rate research of interest to only a few users with a specialized problem as automatically less important than a study whose results are distributed to many users. A few users can make research applications (e.g., a new treatment for a problem industrial waste) with many beneficiaries (all those downstream whose water becomes cleaner).

4. U-R-T-U On other occasions, the users may communicate their special problem to a researcher who when he solves it finds that, either because of the large numbers of people who can benefit or because of difficulty experienced in conveying the meaning of the results, he can best disseminate his findings through a transfer agent.

5. R-T-U Many projects originate in the mind of a researcher who perceives a problem or an opportunity that the users never realized or at least never vocalized and performs a study of general value. The
results may then be disseminated by transfer agents among users. Some
may feel this model to be less satisfactory than those originating with
user-expressed needs, but the probable fact is that much more has been
accomplished on researcher than on user initiative.

6. R-R The researcher originator may produce results that fol-
lowing researchers can use but that is not really directly applicable
by users. This model is made more frequent by research funding in units
too small to really address basic user problems. It is aggravated when
funding agencies become disillusioned when their limited funds fail to
solve one problem and then turn to the next topic to become politically
popular. Any research program must contain some basic studies that only
build information for other researchers; however, too many studies of
this type means too much money going into a program from which the public
sees too few results.

Role of the Technology Transfer Agent

These six scenarios show that the transfer agent has a dual role of
communicating problems to researchers and communicating solutions to
users. The first role is to ascertain user needs, respond directly to
those that can be solved within the current state-of-the-art in order
to conserve researcher time, and communicate defined research problems
for further study. The second role is to integrate research findings
into the body of applicable knowledge and convey the results to users
in a way that will lead to their applying the results to solve the ori-
ginal problems.

The transfer agent role is critical for dealing with the general
public, can significantly contribute to helping professionals, and may
well even detract in communicating to other researchers. Conversely, a
research program without a capable transfer agent can be expected to do quite well in adding to the body of knowledge available to other researchers, achieve moderate success in helping professionals, but do little to solve problems perceived by the general public, or more importantly, to develop a broad base of popular support. The logical hypothesis stemming from this line of reasoning is that the current nationwide water research program funded by OWRT is, through some combination of Federal expectations and university rewards that favor research over extension, directed into a prevailing R-R scenario. The concept so often expressed on university campuses of using the OWRT Allotment program as seed money to help researchers get large projects is essentially an R-R approach.

**Program Management Implications**

If the logic of the above analysis is correct, a program without an effective technology-transfer component will only be successful at the more scientifically oriented end of the user spectrum. A program that cannot afford technology transfer should address research problems of the more scientific sort because those are the only kind that it is likely to solve. If this research direction does not promise to solve the more critical water problems to those providing the funding, greater effort needs to be spent to technology transfer.

Second, the choice among the six scenarios listed depends on the nature of the problem, but the success of a given project within its optimal scenario depends on the quality of the research performed. Furthermore, quality should be judged on the bases of both scientific and transferability components.
Empirical Data

In order to examine the above hypothesis and to probe relationships to guide research program administrators toward selection of more successful projects, data were sought on each of the 29 OWRT Annual Allotment projects that have been completed in Utah. As it turned out, only the most recent 24 of the 29 projects provided useful information because the larger scope and longer duration of the earlier projects made their statistics quite different. The five early projects had a much less formal proposal development, review, and selection process and averaged many more reports and publications. The trend toward formalization of proposal review common to OWRT Allotment programs in nearly every state has undoubtedly improved the scientific quality of the selected projects (improved performance under the R-R scenario), but that does not mean that it has added to program responsiveness to non-research users.

The results of each project were reviewed first by the senior author of this paper and second independently by three of the other authors with respect to the degree to which the results would help Utah water managers. In addition, each principal investigator was asked whether he achieved the target objectives of his proposal. The three ratings are tabulated on the left side of Table 1. The projects were only rated with respect to these indices according to whether they were among the top third, the middle third, or the bottom third on the basis of reasoning that the method of rating does not justify greater precision. A higher number is a more favorable rating. Occasional rating ties cause variations from exactly eight projects in each rating third. Also, an overall rating was computed as the sum of these individual ratings.
Table 1. Summary of allotment project research results.

<table>
<thead>
<tr>
<th>Project</th>
<th>Result Ratings</th>
<th>Result Communication</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Author</td>
<td>Reviewer</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>13</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>14</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>16</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>17</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>18</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>19</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>20</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>21</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>22</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>23</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>24</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Legend: 1 = lowest third  
2 = middle third  
3 = highest third
Statistics on communicating research results to users were then compiled under the headings:

1. Number of resulting reports and papers other than those appearing in refereed journals as an index of the quantity of output. Actual numbers ranged from one to seven.

2. Number of resulting papers published in refereed journals as an index of the amount of high quality material produced and its reception by the scientific community. Actual numbers ranged from zero to four.

3. Number of presentations to user groups as an index of the effort spent in transferring results to potential users. Presentations ranged from zero to 40.

4. Number of orders to purchase completion reports as an index of interest in learning the results. Numbers ranged from zero to 125.

5. Number of contacts made with the principal investigator for information on project findings as an index of interest in applying the results. The range was from zero to 500.

Again the ratings were divided among thirds (right side of Table 1) and the five numbers were totaled as an overall rating.

These two overall ratings, one indexing quality of the research performed and the other indexing effort to communicate results to others, were then compared with the following attributes of the proposals and of how the results were used:

1. Length of the proposal as an index of the work put into developing a sound project.
2. Number of citations in the literature review as an index of the care taken to search out and build on the work of others.

3. Specificity of the proposed research procedure as an index of the effort put into developing a meaningful research strategy.

4. Ranking of the proposal given by the review committee at the time of project selection.

5. The predominate user group as judged by the nature of the findings: $U =$ public, $P =$ professionals, and $S =$ other researchers or the scientific community.

6. Whether (scored 2) or not (scored 1) the research results were used to stimulate followup funding to continue the work.

These six items and the two overall ratings for each project are shown on Table 2.

Analysis of Data for Significant Relationships

Table 3 shows how average proposal characteristics, use of the research to get followon funding, and research audience vary among proposals with different ratings. The only statistically significant relationship proved to be that the fewer literature citations quoted in the proposal, the more successful the project was likely to be. This may be an indication that the researcher already well versed in his field references only selected key articles and then goes on to do a good job while a researcher breaking new ground cites many references but has greater trouble producing. If this interpretation is correct, these results reinforce the expectation that experience generates superior performance. While the relationships did not prove significant with a linear regression model, the numbers on Table 3 also indicate slight
Table 2. Comparison of proposal characteristics with research results.

<table>
<thead>
<tr>
<th>Project</th>
<th>Length</th>
<th>Citations</th>
<th>Specificity</th>
<th>Ranking</th>
<th>Audience</th>
<th>Followon</th>
<th>Rating Sum</th>
<th>Communication Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>S</td>
<td>1</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>P</td>
<td>1</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>S</td>
<td>2</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>P</td>
<td>2</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>U</td>
<td>2</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>S</td>
<td>1</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>S</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>S</td>
<td>2</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>P</td>
<td>2</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>P</td>
<td>2</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>11</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>U</td>
<td>1</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>U</td>
<td>2</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>13</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>P</td>
<td>2</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>14</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>P</td>
<td>2</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>15</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>U</td>
<td>2</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>16</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>S</td>
<td>2</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>17</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>S</td>
<td>1</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>18</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>S</td>
<td>2</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>19</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>S</td>
<td>2</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>20</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>S</td>
<td>1</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>21</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>P</td>
<td>1</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>22</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>S</td>
<td>2</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>23</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>S</td>
<td>1</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>24</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>P</td>
<td>1</td>
<td>9</td>
<td>10</td>
</tr>
</tbody>
</table>

Legend: 1 = lowest third  
2 = middle third  
3 = highest third  
U = public  
P = professionals  
S = other researchers or scientists  

Note: Rating and communications sums are added from corresponding columns on Table 1.
trends toward better results from projects initially receiving a higher rating and toward the more productive projects being aimed at public or professional applications rather than other scientists. The lack of correlation of administrative proposal ranking at the time of research funding with research results emphasizes the difficulty the review process has in selecting the best projects (a situation that may or may not be possible to remedy by upgrading proposal review). A higher correlation, however, would hopefully have resulted if the data had included all proposals and not just relative rankings for those funded.

Table 4 shows how the same six variables vary with the communication score. The only statistically significant relationship here proved to a tendency for researchers who are more specific in expressing their methodology in their proposals to also do a better job (perhaps because of being more specific) in communicating their results to users.

The analyses in Tables 3 and 4 are based on grouped scores, and the possibility also exists of using individual scores or at least groups of fewer items. The data were inspected for this possibility without finding any trends adding important information. One could also argue that individual items are too subjective to be as good a measure as a composite scale.

Table 5 shows an absence of significant correlation between the quality of research performed and the effort to communicate results to others. This absence suggests a need to devote greater technology transfer effort to those projects producing important but undisseminated results and to reduce the effort in disseminating less important information. Such a shift can be accomplished by assigning priority items to a technology transfer agent but more difficult to administer
Table 3. Proposal characteristics by ranked ratings.

<table>
<thead>
<tr>
<th>Result Rating</th>
<th>Number</th>
<th>Average Proposal Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Length</td>
<td>Citations*</td>
</tr>
<tr>
<td>9</td>
<td>5</td>
<td>2.0</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>1.3</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>2.0</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>2.5</td>
</tr>
<tr>
<td>4 &amp; 5</td>
<td>5</td>
<td>2.0</td>
</tr>
</tbody>
</table>

*R² = 0.27, significant at 99.5 percent level. No other relationships statistically significant.

Table 4. Proposal characteristics by result communication score.

<table>
<thead>
<tr>
<th>Communication Score</th>
<th>Number</th>
<th>Average Proposal Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Length</td>
<td>Citations*</td>
</tr>
<tr>
<td>12-15</td>
<td>4</td>
<td>2.0</td>
</tr>
<tr>
<td>11</td>
<td>4</td>
<td>2.0</td>
</tr>
<tr>
<td>10</td>
<td>6</td>
<td>1.5</td>
</tr>
<tr>
<td>9</td>
<td>6</td>
<td>2.5</td>
</tr>
<tr>
<td>5-8</td>
<td>4</td>
<td>1.8</td>
</tr>
</tbody>
</table>

*R² = 0.07, significant at 90 percent level. No other relationships statistically significant.

Table 5. Ranked rating/communication score matrix.

<table>
<thead>
<tr>
<th>Score</th>
<th>12-15</th>
<th>11</th>
<th>10</th>
<th>9</th>
<th>5-8</th>
<th>Average Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>10.0</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>10.3</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>10.4</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>10.3</td>
</tr>
<tr>
<td>4 &amp; 5</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>8.2</td>
</tr>
</tbody>
</table>

Average Rating  

\[ \begin{align*} \text{Rating} & : 7.3 \quad 6.5 \quad 7.8 \quad 6.5 \quad 6.3 \\ \chi^2 = 14.44 \quad \chi^2_{75} = 19.37 \end{align*} \]
would be in a system relying primarily on the efforts of the researcher to communicate his results. The priority technology transfer role would be in assisting researchers who are better at producing than communicating.

Table 6 lists the items checked by the researchers as making their job more difficult or preventing achievement of their research objectives. The primary difficulty proved to be failures to anticipate and consequent inability to overcome problems in obtaining necessary data, executing the proposed methodology, and securing inputs from others on an interdisciplinary team. These factors reinforce the significant relationship in Table 3 in that a more specific proposal suggests more careful research planning and a reduced chance of becoming hurt by unforeseen difficulties.

Table 7 lists the items those who reviewed the project completion reports checked as likely to inhibit users from applying the results. Here, the primary problem, that the explanation was insufficient for the reader to make direct application, suggests a role for a technology transfer specialist in reviewing and helping improve completion reports before they are printed.

Conclusion

The qualitative analysis of the role of technology transfer in the total water resources research program in the first part of this paper concluded that the current system of providing minimal technology transfer funding is biasing program content toward research of primary interest to other researchers and eroding the program political support base. The data collected on 24 Utah projects showed a definite time trend toward the more recent projects being more oriented toward other researchers. The analysis suggested that program administrators can
Table 6. Items which researcher felt made more difficult or prevented achieving objectives.

<table>
<thead>
<tr>
<th>Item</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not able to obtain needed data</td>
<td>8</td>
</tr>
<tr>
<td>Unforeseen difficulties could not be overcome with available time and money</td>
<td>5</td>
</tr>
<tr>
<td>Objectives proved unrealistic after getting into study</td>
<td>4</td>
</tr>
<tr>
<td>Difficulty in obtaining necessary support from USU and UWRL colleagues</td>
<td>3</td>
</tr>
<tr>
<td>Other work assignments became too demanding</td>
<td>2</td>
</tr>
<tr>
<td>Not able to obtain sufficient cooperation from people outside USU</td>
<td>1</td>
</tr>
<tr>
<td>Could not find necessary student help</td>
<td>1</td>
</tr>
<tr>
<td>Needed equipment was not available</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 7. Items which reviewer felt would inhibit potential users from applying research.

<table>
<thead>
<tr>
<th>Item</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research application requires supplemental explanation not easily acquired from report</td>
<td>14</td>
</tr>
<tr>
<td>Research application is so complicated that a busy user would not normally have time to develop an understanding of the results sufficient for application</td>
<td>7</td>
</tr>
<tr>
<td>Project did not really accomplish anything sufficiently worthwhile for application</td>
<td>5</td>
</tr>
<tr>
<td>Research of a theoretical nature and not of much value in solving real problems</td>
<td>4</td>
</tr>
<tr>
<td>Research of value in solving real problems but presented too abstractly to communicate to users</td>
<td>1</td>
</tr>
</tbody>
</table>
use researcher experience as the key to good results and performance in organizing a specific research methodology in the proposal as the key to success in passing results on to others. The logical conclusion is that the greatest need for additional technology transfer effort is in helping experienced researchers who do not propose a well-organized research methodology and consequently are unlikely to present well-organized results. The consequence would be a movement of research effort back toward greater concentration on problems of interest to professionals and the public.