Open File Report
Number 204

STATEMENT PRESENTED BEFORE THE INTERIOR AND RELATED AGENCIES SUBCOMMITTEE OF THE APPROPRIATIONS COMMITTEE

U. S. HOUSE OF REPRESENTATIVES
APRIL 10, 1974

by

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It certainly is a great pleasure for me to have the opportunity to appear here today and share with you my views of the role of research in water resources planning and management. And further, to discuss with you what I believe to be an error in judgment on the part of the Administration as to the relative value of the program of research supported through the USDI Office of Water Resources Research. The suggestion that the level of support should be reduced, in the face of repeated Congressional efforts to increase it substantially, clearly indicates a major difference of opinion. I believe it shows a lack of appreciation for the role of research--especially of how the OWRR program ties the various Federal efforts together.

As a Director of one of the 51 existing Institutes funded through Title I, Section 100 of the Water Resources Research Act of 1964 (as amended) my presentation should quite correctly be suspect. My Institute obviously is vitally concerned and will benefit or not, depending upon the actions taken. I accept this, and would not want it otherwise. My comments, as a result, are presented as objectively as I can, my one goal being to present this committee with what I believe to be the facts. They are based upon many years of experience in applied research, both as a researcher and an administrator. I had an opportunity to tie many of these ideas together when I worked on the staff of the U.S. National Water Commission and had as one of my assignments the task to develop a background analysis of the role of research as it applies to water resources. Lest I claim too much, let me quickly add that what was finally published in that Commission's report bears almost no resemblance to anything I suggested-a point in which I take great pride since I feel strongly that in at

least that aspect the National Water Commission was greatly in error. The concept of an Office of Water Technology was counter to my suggestion, and I have yet to hear any arguments that would convince me otherwise.

A Philosophy of Federal Research Support

The Federal Government has always supported research as much (if not more) because science is useful as because it has been decided that the culture of science should be left to future generations. There is no doubt that the support has been and continues to be substantial. However, the support of science has not been the result of a systematically planned program of action on the part of the Federal Government. Rather, it represents a conglomeration of many lesser decisions made within the White House, numberous Federal agencies, and Congressional committees which have legislative and fiscal oversight responsibilities for those agencies.

The individual decisions that have led to the great increase in R & D spending have likewise created a mixed economy in the research industry. The Federal Government supplies more than one-half of the funds used for R & D in this Nation. The bulk of the research and development (principally at the development end) is executed by industry and, to a much smaller extent, by universities and by nonprofit research organizations. With most of our public and a large portion of our private R & D financed by Federal funds, the pace of scientific advance, the areas of advance, and the objectives of the Nation R & D effort have for obvious reasons become greatly influenced by the Federal Government. Research and development activities have been sponsored and supported largely by the Federal Government because it has been the principal customer.

Most National goals involve some environmental constraints. Protecting the integrity and proper use of the environment and its resources are traditional concerns of governments. There has been an increasing recognition of Federal responsibility in this area. And there is a need to assure that the necessary studies and actions continue to be undertaken, if not by the private sector, then through incentives of the Federal Government itself. Such studies will permit knowledgeable innovative processes to be pursued in the expansion of a better quality of life.

The water resource is clearly one of our natural resources which has and always will maintain a pervasive public interest. In one way or another this basic resource serves (and is too often abused by) the entire Nation. Even though most water problems are commonly regional or local, they are not necessarily independent. The manner in which water problems are handled in one area can significantly affect the resources of other regions or localitites, and the National interest itself. Research efforts directed to even the more local problems benefit by a limited central overview and funding mechanism.

All sectors of society are touched by major water-related activities such as water supply, flood control, navigation, and recreation. Facilities for water use and control presently require expenditures (Federal, state, and local) in the billions of dollars every year. Based on trends and expressed interest by society generally in environmental protection and enhancement, the rate of expenditures for these activities will certainly continue to increase.

It has always been a major objective in an implicit National water policy that because of the pervasive public interest in water, research of Nation significance that others are unable to perform becomes a responsibility of the Federal Government. As I noted earlier, the water resources field has been divided among many different Federal agencies, each of which has been given statutory responsibilities and objectives that require them to conduct water-related research. There is, unfortunately, no overall pattern of consistency for Federal water-related research programs. Therefore, primary Federal responsibility should be to develop and maintain a system to keep overall objectives of water resources research in view, to maintain and strengthen the coordination of the Federal efforts so that research programs may be properly fitted together, and to relate water resources research to the total R & D program. The funds needed for water-related research will continue to be large. Although the Committee on Water Resources Research of the Federal Council for Science and Technology fills and important role along these lines, it comes nowhere near doing what needs to be done.

Because research activities are of uncertain scope and reward, there is justification for shared National support, beyond that supported by strictly mission-oriented Federal agencies. The Federal Government, it would seem, must continue to take upon itself the responsibility to fill the gaps in those areas where market or mission forces are inadequate to the task. This has always been a very vital role of OWRR in the field of water resources.

Impacts of Federal R & D Investments

Federal R & D programs can make their impacts on specific areas in several ways: through Federally-owned or operated research and

development installations; through research and development contracts between Federal agencies and private industry or nonprofit research groups; and through the expenditure of funds for basic and applied research at colleges and universities. There is often an impact on the locale which is far different from that resulting from the spending of Federal in other types of activities. Included here is the phenomenon of university, and in particular of their graduate program, development. Another is the occasional phenomenon of certain types of research and development related industries that have tended to grow up around those universities which have been heavily supported by Federal R & D grants and contracts.

The Federal Government must continue to accept the responsibility for effective support of graduate education and the related basic and applied research. This reasoning is quite pragmatic in nature, for Government must do these things because by the very size and nature of the problem no other group can. The argument that we don't need training programs seems incredible in the face of expanding programs in the fields of energy and environment. Worse yet is an apparent refusal to even study the problem of training and education. But the Federal Government should not act alone, allowing the rest of society to stand aside. Private and state funds must be sought; in fact, this will be an important safeguard against undue Govenment influence.

However, it is evident that increasing support and utilization of R & D by the Federal Government has in general not been paralleled by a corresponding trend in state and local governments. Generally speaking, state legislatures have tended to be conservative, for example, in the support of basic research. In water resources

research the reaction has been strikingly different. Many states, for example, have offered direct support to the OWRR institutes, and all have found it desirable to participate through those institutes in research on a matching basis. The Matching Grant program of the Water Resources Research Act of 1964 (as administered by OWRR), for example, has had considerable more requests--evidence of solid local monetary support--than were even remotely possible to fund with current levels of program funding. It is evident that under Title I a considerable interest has been stirred in developing local funds to add to the Federal funds available. Many of the research projects have had regional and local emphasis; however, in response to the priorities established for the Title II funds and through programmed coordination efforts considerable National significance is to be evidenced even with the Title I program.

Although Government expenditure unquestionably is the principal financial influence in scientific exploration of the United States, Federal money and programs for research will not, by themselves, create centers of excellence, or solve all of the problems that our society will encounter. It seems clear that the total amount of money which will be made available from Federal sources will not be sufficient to support social and technological innovation at a sufficiently high level. Increased state, local, and private investments will be essential if the urban and environmental problems of the present and future are to be solved. But even more important, it points to the need for rational coordinated research plans--another major point stressed by OWRR.

The field of water resources research in particular requires a rapid growth as part of a total environment research program.

The identification of the specific fields is a job for scientists, engineers, industry, universities, and all levels of governments . . . all working together. But because the National interest is particularly involved, responsibility for support and direction will inevitably rest largely on the Federal Government. Federal support, however, has not and should not necessarily imply Federal operation.

Why Start Again?

Whatever the criticisms that have been leveled at the present Federal R & D establishment, it has been the most productive and most innovative of any in the world. This is as true today as it was a decade ago. It is particularly true of water resources.

It is an interesting paradox that we often presume that problems which have been caused or aggravated by technology can be solved by technology. Many of the solutions, however, involve political, social, environmental, and economic skills in which new technical devices may in reality offer but a minor contribution to the solution. This requires capabilities for coordinating and implementing broad programs.

Many of these skills already exist in Federal laboratories concerned with individual mission responsibilities and in non-Federal Institutes throughout the country. Therefore, the programs of existing laboratory and institute capabilities can be redirected in response to emerging National problems. In fact, engineers and scientists are deeply concerned with social problems, and it is not difficult to find highly motivated individuals willing to explore these new areas--when mechanisms for their coordination are available.

To be effective an analytical institution must not only be creative but also objective and relatively independent. Without

these qualities there would be great difficulty in attracting and retaining the talent that is necessary to deal with difficult social and environmental problems.

One way to assure a degree of independence is to maintain a balance between Governmental and non-Governmental support. Where this is not practical the support from Government might come from a number of different agencies. This would allow the institute to refuse requests that in its opinion were inappropriate without fear that its major source of funding would be threatened. This is not always possible, yet some freedom is always desirable.

Conditions conducive to the best productivity are characterized by internal freedom under strong leadership. Success in inter-disciplinary research, for example, is seldom achieved by strong-handed management methods. This is accomplished by internal discussions and arguments conducted in an atmosphere of mutual intellectual respect between management and the scientists. The lines of internal scientific communication must be as short as possible.

The problems of laboratory and institute management have been with us for years. In fact, for Federal laboratories the Bell Report of 1962 recommended:[1]

> "--delegating to research laboratory directors more authority to make program and personnel decisions, to control funds, and otherwise to command the resources which are necessary to carry out the mission of the installation.
>
> --providing the research laboratory director a discretionary allotment of funds, to be available for projects of his

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[1] U.S. Congress, House, Committee on Science and Astronautics (1968), p. 363.

choosing, and for the results of which he is to be responsible;

--eliminating where possible excess layers or echelons of supervisory management, and insuring that technical, administrative, and fiscal reviews be conducted concurrently and in coordinated fashion; and

--making laboratory research assignments in the form of a few major items with a reasonable degree of continuity rather than a multiplicity of small narrowly specified tasks; this will put responsibility for detailed definition of the work to be done at the laboratory level where it belongs."

It is of course, more difficult for Government laboratories to operate with flexibility than those of the private sector. It is, therefore, sometimes simpler and more desirable to do certain things externally. Those outside laboratories, however, are often more expensive to operate and more difficult to control; thus, there is a challenge to Government to overcome its procedural weaknesses so that it can carry out its research with satisfactory flexibility.

Now, clearly laboratories or institutes are not normally funded to do research for their own satisfaction. Their task is to produce those ideas on which the next generation of the parent agency's policies and activities will be based. As such, they need to operate as a system and not as a collection of disjointed parts. Their productivity is measured by their effect on public and private programs, difficult as this may be. But because those programs usually involve expenditures many times greater than those involved in an institute's direct operations, the "multiplier effect" is important.

The hardest management problem is to decide what the water resource problems really are and how they should be approached. In many cases the general concept of problems can be defined at the agency level, but whether real progress is to be made depends on picking the right problems, those that are ripe for solving at the time. This requires more than a single agency approach. It also must be approached with extreme caution, for the research planners who try to go to the level of research "projects" will have eliminated from consideration those very ideas which so often turn out to be more important. OWRR has always tried for a good balance on research planning.

Many strong water resources research institutes are desirable so that each will be able to deal, in general, with specific types of problems. However, pluralism also offers the opportunity for having competition among institutes whose subject matters and research projects overlap reasonably. Diversity and competition are unlikely to evolve when excess direction is required from the Federal or any other point of view.

I should add at this point that it was my conclusion to the National Water Commission that the water resources research institutes established by the Office of Water Resources Research were the logical location for an expanded Federal-university program of multi-disciplinary programs presently underway at those institutes, which already comprise an important National resource. These institutions, essentially outside the government, have advantages of flexibility and minimum bureaucratic constraints. If properly initiated, the program should encourage a free interchange of research staff and information between the institutes (and their respective universities) and various

governmental agencies. Finally, they would not represent yet another proposed laboratory system, but rather an extension of a program proven to be successful on a smaller scale. I, furthermore, see no reason why these institutes cannot be used in expanding programs of research on land-use and the environment. The mechanisms are there, all is needed is to provide the wherewithall by which the realm of research can be expanded.

Multiple Capabilities are Important

An issue of continuing concern has been the geographical distribution of scientific capabilities and of the related Federal support. This is related to two National objectives; the provision of educational opportunities to all segments of the population, and the equal opportunity for regional development. With respect to these two objectives, there has been a growing realization that the presence of high-level scientific research and of quality graduate education will raise the educational and the cultural level of a region in its entirety. There is also a wide belief that a direct relationship exists between the quality of science and education and the economic growth of a region. With the growing acceptance of these relationships has come pressure to distribute Federal scientific resources more widely and uniformly geographically. Excessive concentration in a few areas, it has been argued, denies equal participation in activities involving science and technology.

There are two problems, however, with excessive efforts to equalize geographic distribution. First, it may deny the benefits of "economies of scale" that can result from the concentration of technical and educational capabilities in a single area. Second,

there is the obvious hazard of lowering the quality of the existing successful science centers. Again I point to the programs of OWRR as combining both the geographical distribution and competitive aspects -- combined extremely effectively.

It is worth re-emphasizing at this time that Federal scientific support programs have gained for the United State a position of unquestioned world leadership in research. It is difficult, therefore, to conclude that issue should be taken with the present system of funding science because in some cases it may concentrate the educational (and perhaps economic) benefits in a limited number of institutions and areas.

It may well be asked, therefore, that if things are going so well, would not the best course of action be to continue doing what has been successful? Many scientists feel precisely this way. But change is already occurring, particularly in water resources research because of the success and growth of many new, strong centers of scholarship and research. These centers have been encouraged by the Administration and the Congressional leadership of both parties, and for nearly ten years now have been upgrading their scientific and technological capabilities.

It must be emphasized that the primary purpose of the Federal funds is for the advancement of the science and technology of water resources in the National interest. Because of the relationships that exist between university research and graduate education they also have an influence on educational programs. It is recognized that a high-quality university is a regional asset in that it attracts and holds intellectual and other leaders to the region. The planning and the drive for their development, however, must come from the

campuses. Although not fully appreciated by many, it nevertheless is true that Federal money cannot buy or create excellence. It can only assist those institutions where excellence is evident, or those with evidence of sound plans aiming toward excellence.

The answer to the question of Federal backing, however, does not lie in a policy that concentrates on support to water resources research institutes to the point of elimination of individual project research support, for there is clearly too beneficial a secondary effect that results from the direct support of individuals. The exclusive support of institutions at the expense of directly funding individual investigators could do extensive damage to a system of quality-competitiveness which has given this Nation high standards for scientific research and for science education.

On the other hand, it seems quite clear that the project approach has caused a concentration of Federal research backing in relatively few universities. This is not unexpected, for the universities best equipped to undertake research are also those established ones with the faculty and facilities to provide for strong graduate programs. It is natural for a research administrator to want to have his extramural research done by the best scientific minds he can find. The concentration of Federal funds has undoubtedly been extremely beneficial to those few universities and improved the quality of faculties and facilities of those already in the lead. In fact, however, it has the tendency to widen the gap between those selected few and the remaining second and third rank schools.

I believe the program of OWRR stands as a good example to all of the Federal agencies. In its various categories of grants and

contracts it combines geographic distribution with individual initiative -- resulting in an extremely well balanced operation.

Federal Research at Universities

The fact that colleges and universities have important public-service functions is clear. Traditionally and increasingly they have accepted the obligation to make their faculties and facilities available for the solution of problems. The Nation has regularly called on their services where the work could not be done as effectively elsewhere. This relationship between the Federal Government and the universities has proved valuable for the universities, for the government, for science, and for the Nation as a whole.

In general, methodologies and objectives of research conducted at universities are not much different from those of research performed in many non-profit institutes, in municipal, state, and Federal laboratories, or in industrial laboratories. However, the association of the research endeavor with universities, with the resulting effects upon higher education, creates problems and opportunities which must be of particular concern to the Federal Government.

These effects are at least threefold: first, research is essential in the training of graduate students; second, research permits teaching faculties to keep abreast of the latest scientific developments; and third, the advancement of knowledge is a fundamental part of the mission of the university. Each of these is essential to the other, and their positive interaction is clearly in the National interest. In fact, first-rate universities cannot stay first-rate without a healthy research program. The product -- the graduate -- represents the basic form of information transfer.

Furthermore, when the research program has been planned, the new graduate will have intimate knowledge of an area specifically identified as needing more work. We are therefore clearly training people who are needed, and the statistics bear this out.

It is my feeling that in general the Federal support which has made possible so much of the academic research has been of great benefit. But there have been criticisms of some of the effects such support has had. For although much of the specific research effort has been left to the initiative of the scientific community outside the Government, the fact that a great deal of the financing has been associated with mission needs has definitely influenced the character and nature of efforts undertaken. Although more Federal money has been made available to support university scientific investigation, some feel that it has been taken at a high price. For one thing this research money has been, to a large extent, for work specified by the Government, meaning that the usual range of academic freedom can be limited. With the project to be undertaken defined by the Government, a university's choice has been to accept or reject. Experience indicates that if one university rejects the grant because it wishes to select the question to explore, another will invariably be willing to accept it. Although on the face of it this seems innocuous enough, I feel that from the academic point of view, if carried too far, it must inevitably lead to a lowering of standards. Again I point to the OWRR program as one of balance . . . a successful balance between designated and undesignated research.

Another problem has been the occasional difficulties that arise from having a substantial portion of the university research effort supported by mission-oriented agencies. There is always the

danger that changing mission-oriented agency priorities will not permit the support of all of the important fields of science; and there is also the perennial danger that large research budgets will put undue emphasis on research as compared to teaching. Even when all of these potential problems are well in hand, there is always the danger of fluctuating support depending upon the needs of the Federal agencies. Clearly, this is not to imply that universities do not want or should be advised not to accept research grants from mission-oriented agencies, but rather that it is a problem of balance, of continuity and of integration of the efforts of the various agencies into the university objectives. All of these problems are reduced through the OWRR program, wherein the entire university faculties in effect become Institute staff when called upon.

On the other hand, from the agency point of view there is a tendency to believe that by providing concentrated support for a single very detailed project the opportunity for finding the best solution to a problem is being maximized. In fact, however, less detailed ties will often permit more effective research to be undertaken. Universities particularly can often find specific project support particularly cumbersome and awkward. Attempts to involve graduate students in this research are often extremely difficult. It thus appears desirable for agencies to carefully consider a move toward the use of more grants to support broader programs, or to support a singular mechanism of research project support.

Short term mission-oriented research is, nevertheless, appropriately conducted at universities. In some universities, however, contract research has become a major activity. Careful consideration

should be given to the fact that it may be displacing the science-directed, innovative investigations that universities should be able to provide. It is important that this not be permitted to happen, and that the universities maintain instead a healthy mix of internally generated, science-oriented research as an extremely important part of their general educational function. The question the Federal Government must now face is the means by which its investments in university research/graduate programs can be best made to support universities in their dual roles of producer of scientific knowledge and of trained manpower.

It seems evident, then, that the Nation must recognize that we need to develop basic knowledge; and equally important, to develop better ways of applying it to the needs of society. But, this is not an automatic process and among the mechanisms there must be those for interesting university people in working on those water resource problems which are important to society. This can be, but is not necessarily limited to applied problems, for it is possible to do very basic research in things like ecology, for example. The OWRR program is, I believe, serving a vital function in this respect. The Institutes, with OWRR, form a very real team effort. Each member of this team is an important part.

In view of the importance of universities and their graduate research/education efforts, it is in the National interest that (1) the universities be financially solvent, (2) that they retain sufficient control over their activities in order to be able to generate new programs in addition to strengthening or deleting existing ones, and (3) that their financial stability be sufficient to permit them to plan rationally for the future.

Responsibility for seeing that R & D financed at universities does not weaken or distort the functions of these institutions must be shared by Government agencies. In this respect, where the Government does not need to exercise close control over the objectives and direction of university research, the use of grants has proved to be a simpler and mutually more desirable mechanism for Federal financing. All relevant Government agencies are now authorized to use the grant procedure instead of contracts in supporting basic research. I believe greater use of this power should be encouraged. The OWRR Allotment and Matching Grant programs are "grants" but not "gifts". Through direct and indirect actions the 51 institute research efforts are very effectively coordinated. And yet with all of that, the institutes still maintain a great deal of flexibility.

Why Should OWRR Continue?

You might logically ask, then, "why don't the states fund this program if it's so good?" The answer can only be, of course, that they should. And in fact, indirectly on a project-by-project basis they do. My university has also been extremely good about adding its own funds to the basic OWRR Allotment Grant -- as has every university where these Institutes are located.

But that begs the question. Most of our work has had, and will continue to have, much greater implications than simply those of the state. There is a very real National purpose involved, one in which the Nation as a whole -- the Federal Government -- should participate. I believe our people have come to expect their Federal Government to do those things which in the absence of that

kind of help should but would not be done. It is not a matter of asking for a "handout" but simply one of looking to the proper level and proper mechanism for certain kinds of support. I do not believe it is equitable to expect universities to shoulder the responsibility -- by themselves -- for maintaining the kind of capability required for the solution of these types of problems.

No matter how we look at it, the problems related to this Nation's water resources are going to increase -- not decrease. And contrary to what we might infer from what we can all see in the Administration's mind, the problems have certainly not disappeared. With the growing population and industrial activity we have increasing needs for water. At the same time we have increasing calls for higher quality water. Laws are passed which no one has any real physical basis for understanding how they can be implemented logically. And, furthermore, in many cases we do a lot of planning and law-passing only to find that nobody appears to want what we've done. The easy answer is to say that all we need is to get better people in charge. But my experience is that "better" people seem to be those that speak in an authoritative manner -- but when you get right down to it they suffer from the same problem everyone else suffers from in these complicated areas . . . they simply don't know. And furthermore, they many times don't know why they don't know, or even what they don't know.

What does the OWRR program do that makes me believe it is so valuable?

1. It provides for flexibility in both the conduct of research and in the ability to identify and establish priorities;

2. It assures reasonable stability and support in the pursuit of the designated objectives;
3. It established a program of moderate centralization of water resources research, including a strong program of coordination;
4. It emphasizes the need and encourages a well coordinated and efficient means of communicating and transferring the results of publicly funded research to the interested Federal and non-Federal groups with a minimum delay;
5. It successfully encourages the participation in water resources research by non-Federal entities;
6. It has established the mechanism by which non-Federal interests in the establishment of priorities in water resources research can be effectively incorporated into the program;
7. It aids in the continued development of geographically distributed water resources institutes to provide focus for both water resources research and manpower training;
8. It establishes by example the value of a balanced program of basic and applied research that could well be followed by other Federal agencies;
9. It strongly influences, but does not impose, the direction of water resources research at universities such that they might continue to improve their capacity to provide the climate for creativity and meaningfully contribute to a National program; and

10. It encourages free and open discusssion and criticism of scientific and technologic issues, and provides mechanisms by which this can be facilitated.

The result has been an unquestioned quantum jump in the level of many aspects of water resources planning and management.

What would happen if the OWRR program were allowed to die? This is a very difficult question to answer -- but it seems to be one that is of more than theoretical interest. It takes no great sage to see the implications of the President's budget request. I might ask, what would fill the place of these Institutes? And I think the answer is that there will probably be no replacement, for their success depends upon the continuing level of dependable support.

Certainly, research will continue. But it will revert to the piecemeal uncoordinated efforts government leaders claim to despise. The capability for sustained major efforts of a multidisciplinary nature will soon be lost.

And what will we lose as a result? Who can say? How much has this Nation or my region gained because my Institute was a leader in developing rational bases for assessing Wild and Scenic Rivers . . . or of determining the ecological costs of fluctuating rivers to maximize hydroelectric energy production . . or of developing operational ground water models that planners have had confidence in using . . or of developing systems for classifying recreational water bodies . . . or any other of a number of equally varied subjects. Some might and do say . . . perhaps not very much. But I believe this Nation's water resources are a

lot closer to where we want them to be because of the OWRR program. And a great deal of work remains to be done . . . important work that cannot simply be ignored.

Rather than reduce the scope of the program, I recommend that the members of Congress tell the President and OMB -- for the third time -- that you disagree with them. I recommend further, that you do this by increasing the appropriation level to the full authorization level of $250,000 per institute per year. And I finally recommend that when the statutory limit on the Title II program comes to a close, that you act to reinstate it at its full level of authority.

I thank you for the opportunity to share my thoughts with you today.

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