PROCEEDINGS—

FIFTH NATIONAL CONFERENCE

WATER RESOURCES DIVISION

San Diego Bay

NOVEMBER 17-21, 1985
SAN DIEGO, CALIFORNIA

U.S. GEOLOGICAL SURVEY
OPEN-FILE REPORT 86-540

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FIFTH NATIONAL CONFERENCE

Water Resources Division

Jack H. Green, John E. Moore, and Andrew W. Spieker, *Editors*

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UNITED STATES DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, *Secretary*

U.S. GEOLOGICAL SURVEY
Dallas L. Peck, *Director*

For additional information:

Chief Hydrologist
U.S. Geological Survey
409 National Center
Reston, VA 22092

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OPENING REMARKS

T. J. CONOMOS, Regional Hydrologist, Western Region

On behalf of the California District, I welcome you to the Fifth National Meeting of the Geological Survey's Water Resources Division. Welcome also to San Diego, the queen city of southernmost California, traditionally known for its sunshine, naval base, and zoo.

There is, however, a new emerging San Diego—one that is gaining a reputation as a leading center for research into genetics, medical diagnostics, and oceanographics. By the year 2000, when San Diego's population expands by 47 percent, hopefully you will hear that it is also a leading research center for hydrology—much of it done by our District project staff.

The coming years will be a worrisome but exciting and challenging time for our Division. Our national environmental issues must be addressed promptly and adequately with static budgets, increased operating costs, and lower manpower ceilings. But they must also be attacked with our continued optimism, dedication, diligence, and ingenuity.

This conference has been planned to address these challenges, and to define our goals for the next 15 years, hence the theme: "WRD in the Year 2000". How have we decided to do this? Through a carefully structured meeting that includes:

1. News and views from our leaders in the Department, Bureau, and Division;
2. Scientific forecast of research, investigations, and data collection;
3. Panel discussions by Division hydrologists who will address personnel resources, programming, and perspectives of WRD's role in the future;
4. Direct involvement in work groups that will allow us to share our views on a wide variety of critical administrative issues;
5. Exposure to new technical knowledge by using seminars, presentations, and displays to help us deal with a future of increasingly complex techniques for conducting research;
6. Communication through getting to know each other better during the week's social and professional activities.

To summarize, I would like to repeat Hal Langford's declaration in Ocean City, as it applies here, "Each participant in this meeting has been at work preparing for his or her particular 'piece of the action'. For this is a meeting of participants, not just attendees. I urge each of you to do just that—participate!"

WELCOME ADDRESS

Introduction of J. H. SNYDER by T. J. CONOMOS

It is an honor to have with us Professor J. Herbert Snyder, Director of the Water Resources Center (WRC) of the University of California. Herb is a distinguished agricultural economist, earned his Bachelor of Science degree in Soil Science at the University of California at Berkeley, and received his Doctor of Philosophy degree in Agricultural Economics at that same institution soon after.

Herb then moved to the Davis campus where he accepted an academic faculty position. He progressed rapidly through this fine institution, studying, lecturing, and publishing in the fields of natural-resource economics, regional planning, and economic development. Herb also progressed up the research administrative ladder, becoming Department Chairman, Division Chairman, and Assistant Dean. In 1972, he assumed his current position as Director of the University of California Water Resources Center.

This center is one of the largest and oldest, and consists of 45 projects on seven separate campuses, with a budget of more than a million dollars. During this time when the WRC program is receiving a great deal of interest and attention in the Division and in the Nation, it is a pleasure to look forward to increased interaction with Herb and the Center.

J. H. SNYDER, Director,
Water Resources Center, University of California

I appreciate the opportunity to welcome you to California and to San Diego, for two reasons: First, I am one of those rare native Californians, and so the Chamber of Commerce loyalty oath requires that I smile and say that California is the greatest State in the Union. Those of you from other areas may have different opinions. Nonetheless, I hope that your stay here will be pleasant and profitable as you consider the future and the challenges for the Water Resources Division.

Second, it is a pleasure to welcome you here because you have welcomed us, the Water Resources Research Institutes. Over the last 5 years the Institutes have had a bouncy ride in the search for a home in the Federal government. As the result of our last legislative authorization, and some serious efforts by some of you and others throughout the country, an arrangement was made that provided a home for us in the U.S. Geological Survey. We have received a grand welcome from Dallas Peck and from everyone throughout the organization. So, it is truly a pleasure to reciprocate. I hope that you will feel as welcome here as the Institute Directors feel in the U.S. Geological Survey.

With those words of welcome, I would like to consider some similarities between California and the Water Resources Division. Water is essential to both. I would like you to think along with me regarding the challenges that face you in the discharge of your responsibilities. Because water is essential to both our beings and continued existence and prosperity, it behooves us to think about some new directions and some different philosophies.

The importance of water to an efficient and productive California economy can not be overstated. Before the introduction of tilled crops and controlled grazing by Spanish and Mexican settlers, the Indian populations of the region depended on the productivity of the landscape that was nurtured by natural precipitation. The native plants produced grains, grasses, bulbs, roots, fruit, and leaves. These, along with fish in the streams, contributed to the diet of the Indians and also supported a very large native animal and bird population.

These elemental food sources depended on seasonal and geographic features that are still characteristic of certain aspects of California agriculture. Although California has abundant water of quality suitable for most purposes within its borders, the supply has unique aspects of seasonality and location. As use has been made of this resource over time, some of its quality aspects have deteriorated and created an additional set of problems.

In addition, as California's population has grown, we have come to a situation where people and institutions have created a unique set of challenges for water development, management, and use in the future.

I would like to look briefly at three aspects of water in California. I invite you to think along with me in terms of how these thoughts apply to some of the specific responsibilities and locational aspects that you must face.

At the current level of development in California, available water supplies generally are sufficient to meet our needs, although there are extensive areas of ground-water overdraft. But various laws, administrative actions, environmental concerns, public opinion, and cost considerations of the past two decades have combined to limit new water development in this State. The result has been increased attention to nonstructural solutions and a virtual moratorium on the structural approach to water-supply problems.

Continued urban and agricultural growth, and the demand for greater attention to instream flow requirements, are intensifying the competition for California's water resources. If this trend continues, most pundits predict that by the year 2000 availability will not match the demand for water. Thus, the next 15 years for California are going to be very challenging in the same way that the next 15 years for the Water Resources Division will be stimulating and challenging.

We have sufficient water supplies to take care of most needs in the various locations of the State. However, we have a regional imbalance in that more than half of our natural water supply is produced in the northern one-third of the State, whereas more than half of the water use is in the southern half of the State. We also have seasonal maldistribution. Following Mediterranean climatic characteristics, about 75 percent of our water is available in the winter, but about 75 percent of our seasonal demand is in the summer.

Therefore, at the heart of our basic water-quantity management problems is the challenge of moving water, both in time and space, to provide the water that is demanded and used. For example, California's agricultural industry is the largest in the Nation, with an annual value of more than $15 billion. We export well over $4 billion in agricultural commodities to foreign countries each year. The bulk of the value of this agricultural production is based on water that has been moved in either time or space.

In the late 1800's, the introduction of centrifugal pumps, and later the development of deep-well turbines, opened up ground-water development, which is another aspect of the water supply in the State. Well over 25 percent of our agricultural industry depends on ground-water development. Most of our urban and commercial populations had their first upward development spiral based on ground water. When those ground-water supplies became nearly exhausted, the cities began to look to the importation of water from other areas. Owens Valley and Mono Lake are familiar examples of how urban populations have moved to remote areas to develop and import water. In this process many institutional, political, and legal problems have been created.

Subsequently, the Federal government became involved in the California water picture and the era of massive water developments began. The Central Valley Project, which California had originally planned but was unable to develop because of financial limitations of the Great Depression of the 1930's, initiated this era. This began a partnership—often a reluctant one—but nonetheless an operating partnership between Federal and State water institutions in developing, transporting, and delivering water supplies. Agriculture was the primary beneficiary of the partnership and a tremendous agricultural industry was created as a result.

There were however, some additional aspects which were not foreseen at the time—the impacts on water quality. We have always taken the quality of water as a given in terms of our natural resource base. But the human tendency for using this resource base has frequently been to introduce pollutants or contaminants.

Part of this activity is natural. When water falls as precipitation, it goes through the soil and picks up salt. But, imported irrigation water also goes through the soil, picks up salt, increases the salinity, and further degrades the quality.

As we developed our industries and our commercial activities, and as our urban centers have developed, water has been recycled. Each time it is used and cycled, it picks up contamination and pollution substances.

Historically, given our abundance of resources the old saw, "The solution to pollution is dilution", became our philosophy. But as population pressures came to bear on our various resource bases, we no longer had the luxury of unlimited resources. We no longer had the luxury of using that old saw and singing that particular song.

We now find ourselves in a situation where, because of the very productivity of our agricultural and industrial base, we have created a problem with respect to water quality. We look solely at the movement of volumes or masses of water with their attendant political, institutional, and legal problems. We must now include a second element—a concern for quality of surface water and ground water.

The management, development, and use of our water resources requires that we have a greater concern over the *how* of water use, not just the fact of water use. One of the great things that the Geological Survey and the Water Resources Division have done over past years is to provide valuable information to those who are charged with the development and use of water resources.

Over the coming years, certainly between now and the year 2000, we face an increasing condition that I sometimes call "steady-state management" with respect to our water resources. The information gathering and conversion to easily understood information must consider the *how* of water use. This information must recognize the institutions of water use and management where the information is to be applied. This will require greater concern, understanding, and awareness of the water laws.

California is the only State I know of that has two absolutely conflicting water-rights doctrines that meet head-on day after day. The original land settlers, under the Spanish Crown Grants and Mexican Land Grants in what is now California, brought with them the Riparian common laws of Europe. Then the 49'ers brought the appropriation doctrine. The Riparian doctrine says that you have the right to use that water flowing freely next to the stream in the area where the stream is located, and you have absolute rights to undiminished flow of that water. The appropriation doctrine says you may go to a source of water and move it to where you want to use it. This head-on conflict illustrates the importance of remembering the institutional and legal settings in which these water events take place.

We must be aware of the water-quality relation, and we must provide that information; we also must be aware of how to detect them. A recent study emphasizes three objectives: detection, correction, and prevention. I think those are three beautiful key words to keep in mind in terms of our concern for the future with respect to water-management strategies.

First, in the quantity area, I like to remember that the term "steady-state management" is going to create many headaches. However, much of the research that we promote and conduct

through the Water Resources Center at the University of California is concerned with how to manage our water resources efficiently under this steady-state concept. I believe that in the future there will be less new project water development because the various political, institutional, and environmental issues make additional physical development nearly impossible in most areas.

Second, we must be concerned for detection, correction, and prevention of water contamination and water-pollution problems.

Third, we should all be aware of the institutional setting and the political and the legal bases within which water resource use and development decisions are made. Do not be content merely with developing information, but also anticipate how that information is likely to be used, so that the character and quality of that information is the best that can be developed. Remember always, the final decisions made with respect to water are usually based on the attitudes of the local citizens which are most vitally concerned and affected.

Attitudes with respect to water change over time. So it behooves all of us to keep in close contact with the attitudes of those who make decisions concerning water use and development.

I would like to close with a little anecdote that illustrates an attitude that prevailed amongst a rather important segment of our Nation, at a point in our history. It is illustrative and may very well be accurate. The title of this little anecdote is "Water Conservation in the Early Days of the Republic".

"The USS Constitution, better known as Old Ironsides, was a combat vessel. She carried 48,600 gallons of fresh water for a crew of 475. This was sufficient to last through 6 months of sustained operation. Total evaporators installed: none."

"On August 23, 1779, the Constitution set sail from Boston. She carried 475 officers and men, 48,600 gallons of fresh water, 7,410 pounds of shot, 11,600 pounds of black powder, and 79,000 gallons of rum.

"Her mission was to harass and destroy English ships. Making Jamaica on October 6, she took on 620 pounds of flour and 68,300 gallons of rum."

"Then she headed for the Azores, arriving there on November 12. She provisioned with 550 pounds of beef and 4,300 gallons of fine Portugese wine. On November 18, she set sail for England. In the ensuing days, she defeated five British men-of-war, captured and scuttled twelve English merchant ships, salvaging only the rum. By January 27, her powder and shot were exhausted. Unarmed, she made a night raid at the Firth of Clyde. Landing parties secured 2,000 pounds of black powder, 1,500 cannon shot, and captured the local distillery, transferring 30,000 gallons of whiskey to Old Ironsides before dawn."

"On the route back to her home port of Boston, she continued to harass British ships. The USS Constitution arrived in Boston in late February 1800, with no cannon shot, no food, no powder, no rum, no whiskey, no wine—and 43,500 gallons of very stagnant water."

I hope you enjoy your stay in California. I hope you find it productive. Welcome and have an excellent week.

KEYNOTE ADDRESS

Introduction of ABEL WOLMAN by PHILIP COHEN

I have the pleasure to introduce our keynote speaker. He is Emeritus Professor of the Johns Hopkins University, Baltimore, Maryland, School of Engineering, Hygiene, and Public Health, Dr. Abel Wolman. Dr. Wolman has spent some three-quarters of a century as a regulatory official, educator, and consultant on a wide spectrum of environmental issues. His activities cover problems in water resources and their development, wastewater, pollution, management, and finance.

He has been a consultant to numerous American city, State, and Federal agencies; and his global activities encompass advisory and investigative services for more than 50 foreign countries. He has received five honorary degrees and numerous awards, including the U.S. National Medal of Science, the Tyler Ecology Award, and a Public Health award. He is the author of several books, including "Water, Health, and Society", and has published more than 300 articles in scientific journals. He is a member of the National Academy of Sciences, the National Academy of Engineering, and an honorary member of the American Society of Civil Engineers. He also has been president of the American Public Health Association and of the American Water Works Association.

ABEL WOLMAN, Emeritus Professor, Johns Hopkins University

I have two speeches. One of them I gave to the equivalent of this group—much younger than most of you here—just 30 years ago. I have that one with me, but decided it would be an imposition if any you heard me in 1951.

So, I choose to give another one, which I prepared only a few weeks ago at the request of Mr. Cohen. I choose the title, "Then, Now, and Tomorrow". This is my effort to look backwards and, on the basis of looking backwards, to determine where we may be in the future.

I borrow two observations from the 1951 speech, because they are appropriate for today, and even for tomorrow. One is from Chief Judge Learned Hand of the Federal Court of Appeals for the New York area in which he said, "The spur of constant stress is necessary to counteract an inevitable disposition to let well enough alone." It is part of one of my messages to you this morning. And the other is from a private individual who, at the age of 88, was still the chief executive for the United States Fidelity and Guaranty Company, an international corporation. He said, "If you've been doing things the same way for 10 years, you undoubtedly need a change."

These two precepts are part of what I would like to discuss. Let me say a few words first about looking backwards. Here I have two concepts that I want to rehearse with some degree of brevity. One is the search for the utopia of a national water policy. I am sure it is familiar to most of you. I call it a utopia because we are eternally searching for wisdom and logic in public decision making.

I spent a great deal of my early life in that particular endeavor. I was chairman of a committee on national water policy. I participated on one that was under the aegis of the National Council of Engineers, and they likewise spent 10 more years in that particular endeavor. I finally gave it up because I was convinced that if there was one thing that Congress did not want, it was a defined national water policy. They wanted no one to indicate to them how their actions should be guided by an overall policy.

It is interesting to me that in 1985, there is a new push toward the establishment of a national water policy. I look at it with some degree of misgivings and a bit of a jaundiced eye. I do not believe that the attitude of Congress has changed in any fundamental direction. I have a little bit of assistance from a Brookings Institute research project on decision making at the top level, which says that logic and wisdom are in low supply. They are not major guiding principles under which one functions.

The second item that I want to talk about, in which I was a personal contributor in my earlier years, was the desire for na-

tional planning. Assuming you have a national water policy, you should have a national planning agency. I headed one, which many of you may not remember, for about 11 years in the middle 1930's. I chaired the National Water Resources Planning Board at that time; and it had jurisdiction over all of the national water projects.

This was a fascinating undertaking and I could summarize it with a great deal of simplicity: Nobody wanted it, including Congress, and no single governmental agency was very happy with it. President Roosevelt told me that we had $550 million for all the water projects of the Federal government. Every one of the agencies that came to our hearings over the 11 years wanted the $550 million for itself. There was no disagreement—that is what everybody wanted. I will summarize my experience with that particular issue in the 1930's by saying that aside from the Public Works Directorate, I made more enemies per hour than in all of my subsequent career.

I did, however, institute a university course in global national planning, at the request of the faculty. Then and now, there is always a desire to have that kind of substantial wisdom, and planning would be done. My group of distinguished students came because it was one of the few places in the world that kind of a course was given. It was directed primarily toward health planning on a national basis, and we had the top level people from approximately 28 countries. I used the case method of disclosure. I would pick two of the planners from sovereign countries and put them together to look at a case history.

I tell you this because I think you would be interested in the attitudes that prevailed in many of the countries. I put together, with a bit of malice aforethought, the chief planner of India and the chief planner of the USSR. One was a democratic institutional structure, and the other was the panacea for all planning. Namely, you plan and everybody follows, and you have no problem of disadvantage or disappointment or contest.

I pursued the malice by saying, "Your case history will be to take a couple weeks to look at the national planning in the United States." I remind you that I have had 11 years of that direct contact. As I suspected, in about 48 hours, they were back in my office and saying, "We can't find the book on the United States." I looked across very innocently and said, "What book?" And they said, "The book that shows the national health planning in the United States."

So, I thought and I said, "I guess that's so. There are a lot of books and my suggestion for your reporting is to go back and find those books and determine how one plans on a national basis in the United States."

The deputy director of Gass Plan in the USSR was a young, humorless, intelligent individual who could not understand why he was greeted with a degree of laughter when he reported on planning in the USSR. I had then been twice in the USSR, and I had an indication how one plans there. And I share that with you, even at the risk of using much of my remaining time.

In my dealing with the city engineer of Moscow at the time, he said, "We have six million people. We don't have enough water. We are being surrounded by waste water and we don't have any way of handling it properly. So we just issued a directive: There are to be no more people in Moscow."

When I went back to the USSR three or four years later, I asked the city engineer, "How many people are in Moscow?" He did not think very long and answered "Seven point one million people."

I looked at him and asked, "There weren't to be any more than six million. What happened?" "Well," he answered, "We issued the order and it was national and everybody knew about it. Then the trucks come in from the rural areas with the aunts and uncles and the children and the friends, with such possessions that could be transported; and they moved in with you and me, where there wasn't any room to begin with, and this still isn't somewhat better." "Well," I asked, "What did you do? Did you put them back on the trucks and send them back?" He answered, "We couldn't do it. We gained a million people in about four or five years."

I want to depart from that because I want to talk about what is new. What did the last 40 years disclose? I want to say a word about that, because Mr. Snyder commented on both of these. Every time I pick up a "New York Times", "Time Magazine", and sometimes "Playboy" there is an indication that we are running out of water in the United States and the world. I want to dispose of that idea. Almost 20 years ago the Russians made one of the first studies of global availability of water, and there have been many similar efforts in our own country. His answer was simply, "We're not running out of water." As far as he could look—and I think he looked at the year 2050—there was enough water to go around.

The real check is the one you emphasized, pollution. If you do your job well in meeting the contaminant levels, then you are assured of availability. That is true, incidentally, in our own country.

It is not always where you want it; the distances are greater and the cost may be higher. Once I was almost executed in Canada after saying that "Canadian water is great, plentiful, accessible, and I'm quite sure the United States will be using some of it at a price."

Their editorials said, "Who is that s.o.b. Abel Wolman who wants to take the Canadian waters?" I have lived it down. As is often the case, one says, "Some of my best friends are Canadians."

This is my answer. Just about a week before I came here, I had a delegation from the University of Peking. The group arrived in my office to discuss the same problems we are talking about here today. And I said, "Well, what's on your mind?" They said, "We have a water problem."

I said, "What kind of a water problem do you have in mainland China, prodigious river sizes and the like?" And they rehearsed for me these three components, which again are familiar to you: first, the impact on the total water ecosystem. The second was the impact of conservation. Could you really stretch your water availability. And lastly, the whole question of the control of industrial and irrigation water. Again, Mr. Snyder covered those in great detail.

I indicated to them that that is the dilemma also of this country and of the other countries where I have been working more than 40 years. They are all about the same. They all demand availability of sound data and additionally, the most exciting of all, the implementation. Easy to say, difficult to do.

Now let me ask again about tomorrow. I use a catch phrase the Chinese offered—we move from simplicity to complexity. Let us look at standards of water quality. One I find biblically and I like very much today, for the simple reason that everybody understands it. It had three parts biblically, and I mean biblically. Several thousand years ago people wanted water that was clear, did not taste too salty, and that fish could live in. Not bad even for today.

I was party to a paper written in 1918 on whether it was practicable to develop standards of quality in the United States. That is of great interest to me and I hope it is to you—not what are they, but is it possible to establish them. Then in 1924, I found myself as the chairman of a national group in the United States to develop standards. We struggled, and we established bacteriological standards for the first time for drinking water and then a few of the chemical and biological ones. I think they totaled seven.

I have a list to indicate why I say we have moved from simplicity to complexity. I can not guarantee that it is true today, because it is a list of yesterday and it will be added to, but yesterday it was 129. And the 129 have also come from Europe about 10 days ago—announced by the overall European group, 129.

This is why I say we have moved from simplicity to com-

plexity. I must say a word therefore concerning the passage toward the chemical era in this country and in the 50 other countries where I have worked. They share and they borrow, and they are upset if we indicate they should not borrow too heavily from the Western industrial world. They feel that if they do not, they are being treated as lesser members of society. Therefore, they move toward the 129 as well.

The chemical era poses an obligation that you will be unable to escape and one in which you are going to have tremendous problems. Secondly, sediment fills your impoundments and drowns a variety of things. We now realize the sediment has two important and exciting aspects. One, it erodes the countryside. It also gets deposited where you do not like to have it. But much more important, it comes up again and brings with it things such as phosphorus and nitrogen that you thought you had disposed of. This turned up in the Great Lakes, for example, to the amazement of everybody who thought everything had been eliminated.

Werner Stumm, for example, in the last "Environmental Science and Technology Journal" has the invited editorial in which he simply says, "Every State in the U.S. should ban phosphates." They should ban the familiar household chemical that everybody uses. If you did that, you would be free of most of the complications with algae and inorganic materials and the like.

Stumm is an old friend and student of mine. He is also an instrumentation man. We owe it to him that we can now measure not only complexity, but we moved from gross determination to the determination of the infinitesimal. He told me, sitting in my office, that he now can measure parts per quadrillion. Fascinating and true, because we do it now in our own laboratories and I am sure you will, or do. So, I asked him, "What in the world do you want me to do with that?" And he answered, "It's not my problem, it's yours." He is right, he is the instrumentation man.

We now use parts per quadrillion in industrial control, to my utter astonishment. And we do it in a very curious way and exciting way. We have a problem because we do not understand the health impact of the parts per quadrillion of the 129 ingredients. One of my physiological medical officers tells me that what we create today by way of water, vegetables, and food may not have a manifestation until as long as 60 years from now. This led me to say in the United States about 3 years ago, "In view of the genetic potential, the somatic one long deferred, I have three suggestions. Starting first with industry, I would like a closed cycle of production." Many of the major companies are already doing some of that.

Secondly, I borrowed a British phase: "If you have any residuals, keep them in situ." I do not want them. There will be some. You release that some, it goes to our next set of friends, the waste water handlers. I say, "You take out the rest." And again I realize you are going to have some residuals. And then I say to the potable-water people, "You take out what is left" and it should be, of course, less and less and less. When I made that speech in Atlanta not quite 3 years ago, all three groups were ready to shoot me. Why? First, we cannot do it; secondly, it is going to be very costly. We may have to multiply all costs of everything threefold, fourfold, fivefold.

Thirdly, there is the technology to do all this. As a matter of fact, the technology in waste water and in potable water is old technology. Matter of fact, in Southern California your newer plants are doing it very well.

One of the reasons I say it is old is that it has been abandoned already in the United States. The other reason is that it has been practiced in Western Europe for many, many years—20 or 25 years—simply because they had to do so. One characteristic of the Western industrial world in Europe is they do not have a Mississippi. They have rivers like the Rhine which was dealt with 25 years ago and not yesterday. So, that mechanism is there.

I have been a continuing critic of research of USGS and others in my own country and elsewhere. One of the major criticisms deals with major rivers or estuaries. Chesapeake Bay, in which productivity has gone down completely over the last 50 years, is where everybody's rushing toward correctives. Hundreds of millions of dollars have been spent on individual bays.

Research is prodigious. You are looking, incidentally, at a regular bay in my early existence for 24 years; so that I speak feelingly about the problem. I will merely indicate to you one of the difficulties with any bay. They are prodigious in number, in size, and they have that major concern.

The difficulties are primarily intelligent public policy, which nobody has the courage to pass through Congress. That means a conflict between private and public operation of a farm. As I pointed out to the legislators, "If anybody ran a farm that was not submerged in water the way we run the Chesapeake Bay, he would not be in business very long."

I want to come back to the research aspect of all of this. On the Potomac, actual sampling began in 1915. *You have a shelf of reports with accumulated wisdom and with less than successful implementation, and partial, never complete. My criticism is, you never put it together for me.* The Director talked to our seminar once, on San Francisco Bay. It was very fascinating to hear him say, "It's all very, very exciting; but nowhere can I find what it is that you put together and what it is you want me to do." This is a missing link for you. I apologize for even suggesting that you still have that obligation.

A gentleman with whom I was traveling on one of my trips in the USSR was a remarkable individual from an African country, tribal in origin, a medical officer with superb training. He had collapsed and they had hauled him into the hospital in Moscow. When he got out, I had dinner with him, and asked, "What did they do with you?"

"Well," he said, "The first thing that happened, a lady in a white coat came in and told me to undress". And in his particular tribal experience, that does not happen, and he was hesitant. And she said to him, "Don't be so hesitant . . . I see a lot of males." And she finally persuaded him to undress.

And then he said, "I was in bed, and for several days, ladies after ladies came." They had lost most of their men, so that most of the doctors are women. And incidentally, very capable ones. And one came in and examined him and made notes. And then another one did the same. And he said, "Over a period of 2 days, they had covered what would be the total human region of the individual. And then about 3 or 4 days later, a lady in a white coat came in and said, 'Get up and dress. You can go home.'" And that is when I met him, later in that afternoon, and he told me this story. And then he added, "You know, it's very interesting to me, because each one came in and filled out this sheet and so on." He said, "The fascinating thing to me was nobody ever put me together." And that is my criticism of the Potomac, of the Mississippi, of the Sacramento, and so on.

One last word—I really should not put it last; I should put it first. One of the major phenomena in my own country, and now penetrating every other country, is public perspective. And you refer to the same aspect. My comment on it is very simple. I always have to deal with the public. But I deal with the public in a different kind of a situation today. I deal today with a public that has fear, no small degree of hysteria, a passion for control and for guarantee for the zero risk. They do not accept any calculation of risk. And secondly, of even greater importance, they do not believe a word I say.

Not because they do not like my looks or whatever it may be, but it is just characteristic. The reason is that in the last 10 to 12 years, beginning with a place called Love Canal, they distrust officialdom. They distrust the President of the United States who

landed there in a helicopter, and in 42 minutes indicated, "Move out of all of those houses. We'll take care of you; we'll put you in the church, and we'll feed you" and the like. In 42 minutes, he was gone, and they never heard another word from him.

And when I say to them, "Based on the risk calculation of what is in that water, in parts per quadrillion, there is one probability of one additional carcinoma case in 100,000 people." They say, "It might be my newborn child." That is hard to answer. I leave that unanswered question, with a few others.

WELCOME

Introduction of BILL MENARD by PHILIP COHEN

This is a very personal pleasure. We have a distinguished guest I would like to acknowledge: Bill Menard, the 10th Director of the Geological Survey, and Bill has agreed to be kind enough to come up here and say "hello" to you and give you a few words of welcome.

BILL MENARD, Former Director, U.S. Geological Survey

I am going to be even kinder than that. I am going to say very few words.

It is a pleasure to be here and to welcome all of you to San Diego. While everybody in the Geological Survey was very kind to us during my tenure as Director, nonetheless it did seem to me, and my wife felt the same way, that the hospitality of the Water Resources Division was really outstanding. Wherever we went—from throughout the contiguous States, and onto Alaska and out to Hawaii, there were always Water Resources Division people who helped us and greeted us, and took good care of us.

So, as I say, It is a pleasure to welcome you personally to San Diego. I am pleased, I must say, on the occasion of this meeting that management is still smart enough to pick a place like San Diego to have a meeting at the time when it is snowing and raining all over the rest of the country. I see that you are in very good hands, and I congratulate you. It is a pleasure to see you.

ADMINISTRATION'S GOALS

Introduction of NANCY LOPEZ by PHILIP COHEN

Our next speaker was to be Bob Broadbent, the Assistant Secretary for Water and Science. But as I said earlier, Bob is ill. I would have introduced the next speaker as being the newest staff member of the Office of the Assistant Secretary for Water and Science, but that no longer is correct. In fact, Nancy is a veteran compared to our newest Deputy Assistant Secretary. So, it gives me a great deal of pleasure to present our colleague and friend and member of the staff of the Assistant Secretary of Water and Science—Nancy Lopez.

NANCY LOPEZ, Staff Assistant to Assistant Secretary for Water and Science, Department of the Interior

When the Office of the Assistant Secretary for Water and Science was organized, our biggest challenge was to form a strong working relationship between the three agencies under the direction of that office—the Bureau of Mines, Bureau of Reclamation, and USGS. Even though the Survey had given birth to both the Bureau of Mines and the Bureau of Reclamation, they had not worked closely together for the past few years.

At the same time, we were also defining the appropriate role of Water and Science in dealing with the Department and other Federal agencies. As those of you who have watched this process know, we decided on an activist posture. As our various roles and responsibilities became more clearly defined, it became apparent that one of the major roles of the Office of Water and Science would be coordination of scientific research and development.

Our second major role lies in developing policy based on the results of that research. As Mr. Broadbent reviewed the many different areas where we are currently involved—it became apparent that water quality is our central area of concern. Because no one is better qualified to deal with the complex questions of water quality and the related issue of water supply than the Survey, all of you are going to continue to be busy. From what we already know, that will not come as any surprise. But it is important that you understand some of the organizational changes that have been brought about in the Department, and the way that they relate to your work as we begin our new era of emphasis on water quality.

Most of you remember that the Survey formerly reported to the Assistant Secretary of Energy and Minerals, a position which no longer exists. Although some major water-related projects began under that organizational structure (specifically, the "National Water Summary"), Mr. Broadbent does not believe your work was really getting its due. He was Commissioner of Reclamation for three years before becoming the Assistant Secretary for Water and Science, and he was barely aware that the Survey had a Water Resources Division.

In the past, most of the talking about water was done by the Assistant Secretary for Land and Water, who represented the Bureau of Reclamation. What the Department said about water was mostly focused on Western water development and not on the broader issues that faced the entire Nation. Now that Water and Science is in charge of both development and research, the Department is in a much better position to assert itself and to ensure that the work of the Survey receives deserved attention.

As we consider the views of the Department, there are a few things to keep in mind. First and foremost, the Assistant Secretary is a politician. He is not a scientist. He is also the person who explains our budget and program to the Office of Management and Budget (OMB) and Congress. In practical terms, he must be thoroughly convinced that the research programs we develop will provide the answers to relevant policy questions. No matter how interesting a given issue is, unless it has some direct relation to a larger question, it is not going to get first priority.

He does not intend for that definition to be overly restrictive. As you are well aware, we have determined that Federal research should include basic work having long-term payoffs. That is a good definition of the kind of work that the Survey does as part of its basic mission.

You need to understand, however, that in the more

controversial cases, the administration and Congress look for research that is going to help them answer tough policy questions. It has been the Reagan administration's position that we need to know more about acid rain before we take costly action. That same position could be applied to almost any current water-quality question. The White House views the Survey as the group to provide the answers to those questions.

One of the areas where we are already seeing the advantage of our more aggressive posture is with ground water. The Department was a major player in developing the Environmental Protection Agency (EPA) ground-water protection strategy for two reasons. Initially, we have concerns for State's rights, and later, to ensure that the Survey's highly successful cooperative program was specifically integrated into the ground-water protection strategy.

After a good deal of negotiation, we had a workable Memorandum of Understanding (MOU) between the two agencies that spells out each of our areas of responsibility. This process attracted the attention of Congress, which has complimented our cooperative approach.

While the MOU was being developed, HR-71, the Groundwater Recharge Demonstration Program Act, passed the Congress. Because of specific legislative concerns, EPA was a party to the Act as well. We added the necessary agreements between Reclamation, the Survey, and EPA onto the ground-water protection MOU. Last month, Reclamation cosponsored a seminar on the groundwater recharge project for all of the pertinent employees and the States. The seminar was successful in getting the program on track, but it was even more successful in ensuring early and beneficial cooperation between EPA, the Survey, and Reclamation.

In the past, Reclamation usually did all of its work, only rarely consulting the Survey. And sometimes EPA stepped in, once the project was nearly complete, to voice one objection or another. We have changed that for ground water at least. That fact should be of great benefit to the future of our ground-water programs, not only in the Department of the Interior but also in EPA.

The most visible area of cooperation among Federal agencies is our research program in the San Joaquin Valley in California, and the related work on other irrigation-drainage situations. Irrigation water quality is the area that I have focused most of my time on in the Office of Water and Science.

Without the technical expertise of the Survey, the Department would be encountering significantly greater problems than we already face in dealing with this issue. It is important to remember there are a number of economic and political considerations in every decision made on the San Joaquin Valley. Still, good science is a vital part of the ongoing process.

In response to the recommendations of the National Academy of Sciences, Congress, and our own administrative concerns, we have developed an organizational plan to deal with the lack of central coordination and management for the Kesterson study. The basic organizational plan consists of a Washington-based coordinator who will be accountable both to Assistant Secretary Broadbent and Bill Horn, the Assistant Secretary for Fish, Wildlife and Parks.

The organizational plan also includes a field-level manager for the San Joaquin Valley Drainage Program with the authority needed to get things done. The field-level manager will oversee the work of the three agencies, and keep them on track. Because the project manager will be independent, the potential for agency partiality will be smaller. In fact, many of the people involved in trying to coordinate and manage these issues—both at the Department level and at Kesterson specifically—have indicated that they felt the best solution for an independent manager was a Geological Survey person. So, there has been a lot of support and a recognition that, because of the third party status of the Geological Survey, they can be very beneficial in leading these types of interagency efforts.

We are working on agricultural drainage in other areas that might present future water-quality problems. Our organizational plan allows for the addition of new on-site project managers in other areas.

Mr. Broadbent was pleased to see that discussions of the proposed National Water Quality Assessment program formed part of your agenda here in San Diego. One of the issues that is repeatedly discussed in the administration and in Congress is the net effect of our environmental requirements and protection efforts. We have never been able to provide satisfactory answers, yet we have spent tens of billions of dollars. It is Mr. Broadbent's hope that this proposed assessment will begin to provide us with the information needed to make the value judgments necessary for future policy decisions.

The Survey's appropriation bill has not received final approval. It is difficult to predict what the Senate will do with the additional $5 million that Representative Yates wrote into the USGS budget request to begin the National Water Quality Assessment program. However, even if it is not funded by Congress this fiscal year, the Secretary has requested start-up funding for 1987.

The national assessment information will find wide use in and out of the Federal government. It is obviously going to be important to EPA and the Department of Agriculture. We already have been in contact with both agencies. We currently hope for financial assistance from both of those agencies. We are exploring possibilities with other agencies that may have an interest in becoming involved in the National Water Quality Assessment.

Mr. Broadbent fully realizes the concerns that you face as the Department and other Federal agencies place more focus on U.S. Geological Survey water-resources programs. But he has long maintained that if you want to be part of the solution, you need to be part of the action.

First, he wants me to assure you that we do not intend to have the Survey make policy. We intend to maintain the reputation of the Geological Survey as a high-quality scientific, third party, unbiased agency. There will be occasions when we will need information in a time frame that may not reflect the most ideal circumstances for research. This means basically that we will need to know the qualifications you place on the numbers; but we will still need the best numbers you can provide.

He is also aware of your most critical concerns. While we are sometimes providing new money for your programs, we are not always providing you with higher personnel ceilings. That is a concern government-wide, but particularly for an agency with growing responsibilities. Because the available pool of water resources experts is not large, even if we can provide the positions necessary, qualified individuals may be difficult to find.

In the future, things are going to be different. They are not necessarily going to be better or worse, but it looks like they will be different. We all need to figure out how we can best prepare the Geological Survey to meet the Nation's need for water-resource information.

U.S. GEOLOGICAL SURVEY IN THE NEXT 15 YEARS

Introduction of DALLAS PECK by PHILIP COHEN

I now have the pleasure of introducing our boss, Dallas Peck, the 11th Director of the Geological Survey. In all likelihood—I have heard many of his presentations—he is going to tell you a few things. I am going to scoop him, because he normally scoops me.

He is going to tell you he is a petrologist, he is going to tell you he is an igneous petrologist, and volcanologist, and he might tell you something about the Sierra Nevada, and perhaps a little bit about the Hawaii Volcano Observatory.

But I need to tell you something about his stream gaging prowess. He is a stream gager, and within the next 3 or 4 months, he is going to be up to speed on matching with the Theis Curve. So, I now introduce to you our igneous petrologist-hydrologist-Director, Dallas Peck.

D. L. PECK, Director, U.S. Geological Survey

I was impressed recently with my first experience in stream gaging. It was out in the Mid-Atlantic District, on a nice, sunny day—the water level was low. And what kept going on through my mind was, "We pay people to do this?" I presume that in the floods in West Virginia a little while ago, it was not much fun.

The title that the guy who runs this meeting laid on me was, "The USGS in the Next 15 Years," and of course, it is in the theme of WRD in the year 2000. So, I thought it would be fun to take a little time and look forward the next 15 years, and the best way to begin is to look back.

I think we have a good chance of surviving the next 15 years as an organization. We have survived 106, and I expect we will make it to 121. That is from having good leadership and the broad recognition of quality within the organization, as well as the production of earth-science information needed by the Nation.

To look ahead 15 years, it is fun to look back at the interplay of factors that changed in what we do and how we are organized. It was helpful to read Mary Rabbitt's first two volumes, the history leading up to the establishment of the Survey, and the first 25 years or so of the Survey. Also, she circulated an abstract of the next 25 years. The Survey grew in an environment buffeted by technological change, political change, domestic and foreign events—all of which had some effects. The same thing was true of the last 15 years, and I expect it will be true of the next 15 years.

Advances in technology and in scientific understanding have significantly influenced the organization over time, and these factors may be a more important influence today. Digital computers were a big factor in all of this. It is remarkable, the increased capability of digital computers and their effect on almost everything we do.

During the last 15 years, there has been a great improvement in instrumentation, from mass spectometers to ion microprobes, laser geodometers, and sonar devices for sea-floor mapping. There also has been much greater use of satellites. You will recall that the first LANDSAT (ERTS) was launched only in 1972. Now we use data from satellites for everything from topographic mapping to mineral exploration and water-use estimates.

Increases in scientific understanding have been considerable in the last 15 years; a major one is application of the understanding of the science of plate tectonics. In the early 1970's, that concept was not widely accepted. Over the last 15 years, there has been a great increase in knowledge of the nature of other planets—due to many National Aeronautics and Space Administration programs—and hence, of the early history of the earth.

Also in the last 15 years, there has been an explosion of knowledge about the ocean floor, particularly through the deep sea drilling programs. This includes such phenomena as spreading centers and hot, sulfide-rich ridge vents with their associated biota.

There has been considerable progress in the last 15 years on a better understanding of earthquakes and volcanic eruptions. We developed the concept of seismic gaps, for example, and have learned a fair bit during the eruptions of Mount St. Helens on how to predict eruptions. All this has led to increased capability in the Survey, and an increased emphasis on computers and other instruments and on their application.

Other factors have affected the Survey in the last 15 years. Those include both natural events and human effects on the environment. The San Fernando earthquake in 1971 had a great influence on our earthquake studies. That was a contributing factor to the move of the earthquake program from the National Oceanic and Atmospheric Administration (NOAA) to the USGS. The Mount St. Helens eruption of 1980 resulted in a dramatic increase in our volcano-hazards program, and in the capabilities of that program. And it also resulted in the birth of volcano hydrology in the USGS, as your Division Chief has emphasized repeatedly.

The drought in the mid-1970's resulted in increased emphasis on ground-water studies, and led to the birth of the Regional Aquifer System Analysis (RASA) program. Dying fish in New York and Scandinavia and Pennsylvania and dying trees in the Black Forest and along the tops of the Blue Ridge resulted in concern about acid rain, and a growth of that program. Contaminated ground and surface water, PCB's in the Hudson, kepone in the James River, selenium in Kesterson, the Love Canal and Valley of the Drums led to a heightened public concern about the quality of both ground and surface waters.

National and international societal and political events also affected the Survey. For example, the oil embargo in the 1970's resulted in increased programs in energy resources and energy hydrology and marine geology. Increased oil prices also led to increased prominence of royalty income and concern about royalty collections and about theft of oil. The more recent so-called glut of oil and decreased prices has led to a deemphasis on energy programs, including energy hydrology. It resulted in a decreased cash flow in the Saudi Arabian government with a marked decrease in our programs there.

Finally, national concerns and political events have had large effects in the last 15 years, partly in concert with other happenings. National environmental concerns led to the National Environmental Policy Act, the National Stream Quality Accounting Network, and emphasis on water-quality programs. National elections led to major changes in priorities and programs, from the environmental emphasis of President Carter to fiscal conservatism and emphasis on State rather than Federal action by President Reagan.

There also were changes in leadership in the Department of the Interior, for example from Secretary Andrus to Secretary Watt, each of whom had his own priorities and management style. This also led to some changes in USGS leadership, as for example from Vince McKelvey to Bill Menard to Dallas Peck. And even we have had our own peculiarities and areas of emphasis.

It is largely due to political factors that we can ascribe, for example, the establishment of NOAA as a semi-independent agency in Commerce rather than in Interior. That was wholly because Secretary Hickel did not behave. The transfer out of the Conserva-

tion Division to form the Minerals Management Service was largely a response to a political problem by Secretary Watt. The abolishment of the Office of Water Research and Technology and the transfer of the Water Resources Research Institutes and the grants programs of the U.S. Geological Survey was again a response to the perception of a situation by Secretary Watt.

Some changes are a result of priorities as perceived by the Survey leadership. For example, the reorganization of Topographic Division, Publications Division, and most of the Land Information and Analysis work into the National Mapping Division was an in ternally generated decision. The attempt to balance research and other activities in the Water Resources Division has been internally generated, going back to Luna Leopold.

The administration's approach to the budget and the Federal government's role has resulted in constrained budgets and ceilings over the last four years. So, what do we see for in the next 15 years? One thing we can bet on is that there are going to be very tight budgets in the next couple of years. Concern about the deficit, the Gramm-Rudman bill, all going on at the time when OMB is deciding on our 1987 budget ceiling. I think you can predict that both 1987 and 1988, and perhaps 1989 are going to have tight budgets. We will be doing extremely well to maintain a level budget, and it may go down a little bit.

In spite of that, we are going to pursue new programs. In the next 15 years, we can be sure the computer-based technology revolution in cartography will lead to enormous changes in the National Mapping Division, hastened by a very large Department of Defense investment in that activity.

I was fortunate to have a summary last Friday, of the Mark II program of the National Mapping Division. They have done a lot of work in planning what the Division will be like by the year 2000. I was very impressed with their thorough job. Elements of that plan include finishing the 1:100,000-scale digital cartographic data base of the 48 States for the Census Bureau by 1987, completion of primary mapping by 1989, completely bringing the revision up to date and putting it on a 5-to-10 year cycle by the year 2000, a switch to largely automated digital revisions by that time, and more emphasis on the use of satellite data. By the year 2000, the goal is to build the national digital cartographic data base on a scale of 1:24,000. They will produce maps, and more consistently up-to-date maps. But as we move to the year 2000, much more of the emphasis will be on the digital cartographic data bases, because those are good bases for expanded geographic information system application. We can foresee many new uses of digital data. For example, auto manufacturers will use the data for instant maps in our cars, and governmental units will use them for transportation, planning, and numerous other activities.

Computer technology changes will have a large effect on the other Divisions—not only through the increased capability to simulate large hydrologic systems with many variables and to deal better with the solid transport problem, but also the use of multilayered geographic information systems.

Increased capability is also going to lead to structural changes, as we have already seen. For example, we will see the continued growth of the capability of districts and subdistrict offices through the distribution of the water data bases and their increased capability to manipulate those data bases.

Natural events also may cause some changes in emphasis. Almost surely, we are entering the period of magnitude-six earthquakes in California. I think that over the next 15 years, we will continue to have some magnitude-six or maybe even magnitude-seven earthquakes, and even some chance of a very major earthquake in California. That is going to lead to continued and larger emphasis on our earthquake program and our attempts to develop earthquake-prediction capability.

I think there is an appreciable chance of a drought before the year 2000. Certainly, there will be more extremes of greater and lesser rainfall. Combine that with continued depletion of some of the aquifers and it may result in increased emphasis on water quantity and nonstructural solutions to local water-supply problems. This in turn is going to place greater emphasis on modeling of surface-water systems and conjunctive use of ground and surface water.

One thing for sure will happen in the next 15 years. That is we are going to have an International Geological Congress in Washington, D.C., in 1989, and Bruce Hanshaw is the Secretary General.

Some current trends that we have seen in the last few years surely are going to continue over the next 10 or 15 years. One certainly is concern about ground- and surface-water quality, with pressures to clean up waste sites. That interest will grow. Hopefully, by the year 2000 we will have faced the problem of selecting good waste-disposal sites. There will be a continued concern about radioactive waste disposal. Geologic and hydrologic studies at the current sites, like the Nevada Test Site, may shift to a lower level over the next 15 years as we complete some of the tasks. But attention then may be focused on additional sites.

We can depend in the next 15 years on the continuing use of new technology, ranging from new analytical techniques to use of new sensors and satellites. With extreme luck, we may have the Adaptable Hydrologic Data Acquisition System (AHDAS) in place by the year 2000.

Emphasis in the geologic community will be on such areas as exploration of the sea floor and knowledge of the structures and composition of the continental crust. This is an expansion of a current program, using such techniques as deep seismic reflection and the beginning of deep drilling on the continent for scientific purposes. I think we can see an expansion of those programs around the world and in the United States in the next 15 years.

Hopefully, we will progress in the next 15 years with such things as the movements of fluids through the unsaturated zone, solid-transport models, particularly of nonconservative components, and the effect of bacteria on toxic wastes.

I also see a continued increase in the pressure to communicate our results more fully, not only to policy makers but to the interested laymen, and continued pressure to do what Dr. Wolman has said repeatedly to us. That is, to look at the whole situation and summarize the results of our studies.

National and international events may affect the Survey in the next 15 years. Those who study the matter foresee increasing scarcity in petroleum, beginning in about the middle 1990's, based on the production of oil from the North Sea reaching a maximum and starting to decrease. The Middle East is no more stable now than it was over the last 15 years. One can anticipate possible short disruptions of supplies. This may result in renewed emphasis on such studies as coal and oil shale resources and related hydrology.

A continued and growing dependence on foreign supplies of metals may be seen for the next 15 years, again with possible interruptions of supply. Hence there will be a greater emphasis on international programs focused on international mineral and energy resource supply.

Finally, national concerns and political events will affect us in the future, as they have throughout our past 106 years. These are even harder to predict than magnitude-six or greater earthquakes in California.

Surely, there will be some changes in the leadership. President Reagan cannot run again. And there are going to be changes in areas of emphasis. In 15 years, there will probably be a number of changes in the political control of both the White House and Congress. In the next 15 years, we can anticipate surely five Secretaries of Interior. There will be three or four Directors of the Geological Survey, each with his own priorities.

Hopefully, within the next few years we will develop a consensus in the country on what the size of the deficit should be, the entitlement programs, the defense budget, and the tax rates—so that we can have a somewhat more stable budget and hopefully a somewhat less constrained budget.

What could some of the direct effects be on the USGS? Political events, such as the formation of a Department of Trade, for example, could result in a reassessment of NOAA and might result in the establishment of an independent agency or transfer of NOAA to the Department of the Interior. In either case, there surely would be a reexamination of the functions of NOAA and the Geological Survey. With the capability shown by our National Mapping Division, I hope that would result in the transfer of some functions, like the National Geodetic Survey and perhaps the preparation of nautical and aeronautical charts, to the Survey.

It would not be too surprising if some event took place, like the Santa Barbara blowout, on an offshore platform; or perhaps just a misunderstanding concerning oil leasing. A change in the Department of the Interior leadership could result in another realignment of mineral resource and oil leasing responsibilities, particularly on the outer continental shelf. It is conceivable that some of those functions could come back to the Geological Survey.

In any case, I expect the Survey to provide increasingly prominent leadership in a number of fields, particularly in the application of our national digital cartographic data base and other data bases to geographic information system technology and application, and continued and expanded leadership in water-resources research and data, both in water quality and water quantity.

CHALLENGES FACING THE DIVISION

PHILIP COHEN, Chief Hydrologist, Reston

As our previous speakers have noted, it is difficult to predict what the future will bring in 15 years. In fact, we do not know now what our budget is for the current fiscal year, nor do we know precisely what our personnel ceiling is for this year. Consequently, this is not an easy time to predict the future. Nonetheless, I think one can make some general philosophical statements about the future and I'd like to focus on some of those.

I think the Water Resources Division is in outstanding shape to meet a busy and challenging future. I say this with confidence because we have all of the ingredients to accomplish that general goal. We are staffed with talented, dedicated workers. We know our business. We come from good hydrologic stock. We work for the finest scientific government agency in the entire world, the U.S. Geological Survey. To make such an assertion with confidence, as general as it is, is fairly simple. It is also a lot easier than spelling out the details of our future.

The next 2 or 3 days will be spent thinking about our future and making predictions. I suspect that my predictions might hold for the next 3 or 4 years. But beyond that I am uncertain.

In addition to trying to delve into the future, I would like to lay out for you seven precepts that I think we are going to have to live with. It is my view that we have little or no control over most of those precepts. I think we can control some, and I think we should. But by and large, most of them are beyond our control.

Perhaps most of you have heard me say that for all practical purposes, we have lost what we had before the early 1960's—namely a virtual monopoly in the field of hydrology, hydrologic data collection, and hydrologic investigations. Some of you view that loss of monopoly as disconcerting. However, in my view, we have not only lost our monopoly but it has been good for the Water Resources Division, good for the Geological Survey, and more importantly, its been good for the Nation.

The application of hydrology to the formulation of public policy has expanded widely during the past 25 years, as have the number and variety of water problems that have grown rapidly during that time. As a result, we saw a widening participation by other governmental agencies, universities, and the private sector in what we and others viewed as being our traditional domain.

The increasing demand for water information began in the early 1960's, when the Nation became involved in the environmental ethic: concern about the physical, chemical, and biological health of the Earth. That concern stimulated, as it does in most societies, intense political action, which resulted in a host of legislation.

In the two decades between Rachel Carson's "Silent Spring" in the early 1960's and Carl Sagan's "Nuclear Winter" in the early 1980's, the Nation has seen the results of intense public awareness and public pressure. Some of these results are the Clean Air and Clean Water Acts, the National Environmental Policy Act, the Safe Drinking Water Act, the Resource Conservation and Recovery Act, the Coastal Zone Management Act, the Endangered Species Act, and the Comphrehensive Environmental Response, Compensation, and Liability Act or Superfund. I could go on and on but these will suffice. Hundreds of billions of dollars have either been authorized or contemplated to meet the requirements stipulated in that legislation.

It is clear then that our agency could not and should not develop the expertise to provide all the hydrologic information needed (a) for the effective development of the legislation and (b) for its implementation. For example, if we aspire to meet the needs of only the Environmental Protection Agency, for only one phase of its work—site-specific, ground-water investigations—we probably could commit the entire resources of the Division, and perhaps the entire resources of the Geological Survey. That is virtually impossible. We do, however, have to stress the fact that we have something to contribute to that issue, as well as to many other similar issues. At the same time, we cannot and should not try to dominate the activities, at least in terms of quantity. We may however, attempt to dominate the quality of the input we provide.

Dr. Wolman found himself in print recently with his observation that the years before the current activity "were hardly the Environmental Stone Age". He noted the early accomplishments of Federal, State, and local health departments working together in their conquest of water-borne diseases and the development of basic sanitation practices. Without question, Dr. Wolman makes a valid and significant point. I remind you that our own Department of the Interior played a significant role in environmental issues around the turn of the century.

Some of our earliest Water-Supply Papers were involved with water quality, the potability of water, wastewater management, and the anthropgenic effects on water quality. Although there was an explosion of environmental action, that explosion was more in terms of scale than content. Because of the evolutionary development of the skills and expertise of this organization, we were well-positioned then to meet the needs thrust upon us by legislation. We are also well-positioned now.

Perhaps one of the major complications that we have to live with is that legislation individually addresses such vital issues as the quality of our air, land, and water resources. I think George

Pinder stated that one of the results of that type of legislative activity is that our concern about contaminating ground water largely has resulted in a shell game that we are playing. We are moving contaminants from place to place. Clearly that is not the optimum position for the Nation.

During this period of increased environmental consciousness, hydrology became a pivotal science. Clearly, there was a tendency among some of our people to view the hydrologic activity outside the Survey as threatening, although it quickly became clear that we could not do all the work ourselves. Now, regardless of whether or not we characterize the past several decades of our history as a time of heightened competition, I think most of us agree that the Division thrived during that time.

We thrived and we will continue to thrive because of our heritage and our continued commitment to good science. Another phrase that I like to use is "good science that is policy neutral, but policy relevant". Much of the firefighting that we have done in the last 3 years is a result of intense activity associated with the establishment of the Office of the Assistant Secretary for Water and Science. In all of that activity, I am not aware of any compromise of the Division's basic principles and tenets.I cite the work that we did for the Garrison Diversion Unit effort, the work that we are doing for the High Plains Artificial Recharge program, and the work that we are doing at Kesterson.

We are under pressure. We are moving resources around. But there is no change in our basic philosophy of how we approach our work. We are going through the process of demanding the best science possible.

Thanks to George Ferguson we have a 780-page manuscript documenting the Water Resources Division's organization, program, and personnel, in the years just before the so-called Environmental Age. The period that George selected was 1947 through 1957, and he referred to that period as the Paulson years. Carl G. Paulson was the Chief Hydraulic Engineer during the post-World War II period—a period in which the Division underwent the most pronounced growth in our history.

Carl Paulson's tenure was followed by the tenure of Luna Leopold. We have not yet arranged for someone to work on the history of that period. But clearly the years 1958 through 1965 are worthy of documentation. Clearly we anticipate that the resulting historical view of that period will be referred to as the Leopold years.

I suspect that many of you were not on the Survey rolls during those unprecedented years. The goals that Luna set for the Division reflected his perception of the broadening demands for our services and an intense commitment to strengthening the multidisciplinary hydrologic sciences.

One suspects that Leopold must have heard the message delivered by Dr. Wolman in 1951. Shortly after Luna came on board, he addressed the very same issues that Dr. Wolman addressed to the Water Resources Division before reorganization. In that talk, Dr. Wolman referenced the fact that we were well-known as the outstanding water-data collecting agency in the United States. But he expressed some concern that we were not interpreting and integrating that data.

I interpret some of his remarks this morning as the same type of criticism, perhaps going one step further. Clearly, we have been doing more and more interpretation during these past 30 years. We also have taken the next step—simulation modeling. We've taken those models and addressed real-world problems, and on many occasions, we have addressed problems and issues that were politically very sensitive. I think this is the general thrust that the remarks of Nancy Lopez were directed toward, as well as those of Dallas and Dr. Wolman, about where the Division should be going. I take those comments as an elaboration of my "policy neutral, but policy relevant" nature of the work of the Division.

Luna's tenure as Chief Hydrologist was clearly a controversial period in our history. But the reorganization and program revisions implemented by Leopold played a major role in permitting us to thrive when the Environmental Age burst upon us.

We were well-positioned to absorb new hydrologic responsibilities because of Luna's bold and timely initiatives. These strengths are now comfortably woven into the fabric of the Division. Two of those significant strengths are the Regional Hydrologist/District Chief structure and our strong National Research Program.

I noted previously that many of you did not serve under Luna Leopold, but most of you did serve under his successors, Roy Hendricks, Chief Hydrologist from 1966 to 1973, and Joseph S. Cragwall, Chief Hydrologist from 1974 to 1979. Very briefly, I would characterize those years as times of adjustment to the new organizational structure, redirected goals, consolidation of our gains, and significant expansions of our program. That new program includes work in ecology, environmental issues and problems, water-quality protection, pollution, and waste management.

At Ocean City in 1981, our last national meeting, we found ourselves constrained by a limited budget. Our concern and pessimism at that time was in fact confirmed. The most significant dip in the budget of the Geological Survey and the Water Resources Division in the last decade or so occurred just after that meeting.

In anticipation of that budget exercise in FY 1982, I used the phrase, "small is beautiful" to try to emphasize what I thought we might be able to do in the next 4 or 5 years, even though the budget might be somewhat reduced.

We have, in fact, become smaller in every sense of the word—smaller in real dollars, and smaller in the number of personnel. But I believe that all of us can be proud of our accomplishments during that period and that we will continue to serve the Nation well despite the budget climate and despite the personnel restrictions. It is for others to say whether or not we have become more beautiful. I sincerely hope that some of you and perhaps most of you agree that we have.

Several weeks ago, we distributed a new chart that outlines the reorganization of the Water Resources Division. This reorganization, which is largely at the headquarters level, reflects several major responsibilities that have been assigned to the Division. Virtually all of those responsibilities have been referred to or alluded to in Dallas' comments.

The reorganization is an attempt to distribute those responsibilities somewhat more evenly and somewhat more effectively among the management staff in Reston. At the same time, we saw the need to give separate program identity to several growing activities that formerly were nestled within other programs. Consequently, we have changed terminology and elevated a number of those separate program elements into separate branches or offices.

I would like to take a few moments and detail 12 points of progress that have occurred since our 1981 meeting, initially focusing on changes related to functional and organizational factors.

1. First, I cite the development and implementation of a major in-house program of hazardous-waste hydrology. To handle the Division's increased responsibilities in this area, two branches were established: a Branch of Nuclear Waste and a Branch of Nevada Nuclear Waste Storage Investigations, which reflects the substantial and growing efforts at the Nevada Test Site.

2. We established an Office of Atmospheric Deposition to coordinate and manage our acid-rain program—in part to manage our own activities internally and to allow us to interact with a complex Federal structure developed to manage an acid-rain program.

3. We established an office to aid in our long-range planning and to prepare the "National Water Summary" report. All of you have been deeply involved in three National Water Summaries: the 1983 and 1984 Summaries have been published and were well received. The 1985 Summary is well along and we anticipate that

it, too, will be well received.

4. We established an Office of External Research to deal with the broadening responsibilities of the Water Resources Division, specifically under the aegis of the Water Resources Research Act of 1984. In addition, we aspire for activities over and above those we have brought together in Marshall's new shop.

5. We designed a National Water Quality Assessment (NAWQA) program. I would like to thank the four members of the Survey who were most responsible for developing the concepts and principles behind that program—Jake Rubin, who chaired the committee, Bob Hirsch, Jim Bennett, and Sam Luoma.

6. The next major activity that I would like to mention is the implementation of the work that our researchers have done in data-network design and network analysis. We have undertaken a massive effort of which about 60 or 70 percent is completed. I think it will serve us well in the years to come.

7. We have refocused the Federal-State Cooperative Program dramatically. We can look at the growth tallies of the types of work we are doing and see a dramatic shift in the area of water quality. This refocusing, then, was generated by you and your cooperators and spurred along by activities that we were involved in at headquarters.

8. I would like to call your attention to the reorganization of the National Research Program. I would guess that we are very far from a consensus as to whether that was a good or poor move. I think many fine things have occurred. If we continue in this direction for 10 or 15 years, we probably will look backwards and realize that this was a right decision. I certainly believe that the Division is in a much better position because of that decision.

9. Dallas mentioned our distributed information systems and the use of satellites. We have about 1,800 gaging stations that are using GOES satellite telemetry. I will not attempt to predict what the number will 5 or 10 years from now; but our customers seem to demand more and more of the data that result from this activity. A year ago, I would speak for this Division and say, "If others want it, fine; let them pay for it." Now, I don't want to pre-judge the results of our committee activity; but I get the sense that we may be able to develop a rationale to fund such technology in-house because it's a more cost-effective way of doing business.

10. I would like to mention the improved instrumentation development and management structure, and particularly the work that was done at the Hydrologic Instrumentation Facility. It is not appropriate for me to take credit for this activity, which was initiated by Joe Cragwall and was implemented largely by Tom Buchanan and Dick Paulson. However, I am delighted to tell you that it was a rewarding experience to see the results.

11. Another activity of particular interest is the revitalization of the Water-Supply Paper series. Five or six years ago, this series was virtually moribund; but now things are picking up. It is purely coincidental that one of the most interesting, exciting, and rewarding experiences for me with regard to the Water-Supply Paper series was the very last one that crossed my desk a few days ago. Some of you may not have seen it yet; it is the third edition of John Hem's classic treatise on inorganic water chemistry.

I am delighted that the Water-Supply Paper series is still alive and well. The release of John Hem's report in the new format is a signal of where that publication series is going. We are making considerable progress—albeit slow and with some difficulty—with our "Selected Papers in the Hydrologic Sciences" subset of the Water-Supply Paper series. But whatever problems we had and still have, I think it is generally acknowledged that the contributions are first-rate, and that this "journal" is outstanding.

12. We have sought new ways and have been strongly encouraged by the Director and by the secretariat to be more responsive to the needs of other government agencies and to the private sector.

For example, I have been very busy in the past 2 or 3 years testifying before Congressional committees and subcommittees and briefing Congressional staff both in Reston and on Capitol Hill about once a month. This is very frequent, considering that 3 years ago it was virtually zero. I believe we are in a position now to begin to influence the drafting of legislation.

It is one thing to sit back and say that current legislation is contradictory and that the regulations are impossible to enforce. It is another thing to get involved and say, "If you want to develop legislation, here are the hydrologic bases and the hydrologic principles upon which you should develop that legislation."

Congress is not always going to accept our suggestions. Clearly, there are other factors involved. But at least we now have a process where we can offer some suggestions.

To continue with our responsiveness actions, we have increased the number of management initiatives, such as reorganization of our laboratory system. I view this reorganization as merging two laboratories into one, which in combination represent perhaps the finest water-quality analytical facility in the world.

Another activity that is particularly close to me is the implementation of the Research Grade Evaluation Guide (RGEG) in the Water Resources Division. We started initially with the National Research Program, which was not a very significant breakthrough. It had been used by our colleagues in the Geologic Division for years. I wonder why we have not used it in the National Research Program before; it is tailor-made for that program.

Very quickly after it was initiated by others for the National Research Program, we took the lead to implement it in what we call our operational program; and we now have 44 RGEG's in the field. Looking back 3 or 4 or 5 years, I think 44 would have been a bit disappointing but that reflected naivete and ignorance on my part. Now I think we are in good shape with those 44, and I look for continued growth. More importantly, I look for continued paybacks to the organization as a result of implementing that approach.

You have heard reference to interaction with other Federal agencies, especially EPA. We've spent a lot of time with EPA. It's been difficult at times. Things are not as sweet as you might be led to believe, and decisions were not made as crisply as one might imagine. There were political considerations, and as a result of those political considerations, some of the things just didn't go the way we wanted them to go. But by and large, I think the Nation is better off for those deliberations, and for those that are going on now with other Federal agencies.

Finally, I would like to mention that the Water Resources Division, largely as a result of initiatives by Walter Langbein, Nick Matalas, and John Bredehoeft played a major role in the establishment of the Water, Science, and Technology Board of the National Academy of Sciences.

Perhaps many of you are not familiar with that Board. But let me assure you that it is one of the major players in the National Academy of Sciences. It is one of the major players in Washington, D.C., and, more importantly, it is one of the major players in the field of water in the United States. Three years ago, there was no Water, Science, and Technology Board.

I think we can all be proud of the role that the Geological Survey played in the establishment of that Board. Even more important, we can all be pleased with the role that the Board has taken in focusing on hydrology and other aspects of water resources science and engineering and problem solving throughout the United States.

I would like to get back to those seven precepts that I mentioned earlier. I think we are going to have to deal with them one way or another during the next 15 years, and perhaps for the indefinite future.

First, *the Nation will continue to demand more water infor-*

mation at an accelerating rate. If you accept that precept, and if you accept the validity of what I have said about how hydrology and water-resources investigation have developed in the past, you will believe the pattern will continue. In fact, for the world of hydrology that we are in, the pie will get bigger and bigger. In absolute terms, the resources that we are going to deal with in the next 10 or 15 years, may increase slightly. Or, as Dallas indicated, the next 3 or 4 years may bring a dramatic dip, from which recovery to our present position may be slow. Nonetheless, this pie is going to increase continually, and it follows that we are going to have an ever-decreasing slice of that pie.

Second, *the way to thrive in that kind of environment is to accept and do all that we can to improve the quality of our work as our percentage of work decreases.* In the last 5 years, I think we have done that. I think we can continue to do so.

Third, *we will still have a significant degree of stewardship over our own fate.* We are not concerned about whether our employer is going to be in financial difficulty or not. There are other factors going on. Witness that the concept of a National Water Quality Assessment (NAWQA) program was developed during a period that is probably as limited in terms of resources and manpower as any that I have seen. At the same time the Gramm-Rudman bill was being considered by the Congress. Moreover, the Department's present position with the Office of Management and Budget (OMB) is that if the Congress adds funds in FY 1986, those funds will be considered part of our base. So if both actions are agreed upon, within the next 2 or 3 weeks we may be looking at $10 million of new money for NAWQA.

The optimistic view would be that there would be a conference report which would agree with the House add-on. We would have $5 million in 1986. We get our OMB pass-back in about another 10 days. That OMB pass-back is supportive of the Department's view, and we may have $10 million of new money for a national water quality assessment program. This may or may not happen. The chance is probably less than 50-50 that both of those things will happen, but if they do it is not by accident. It is the result of our hard work, vision, and efforts. I think we can continue in that vein.

Fourth, *in the next 10 or 15 years, it is unlikely that we will have the forces to support all of our present major program initiatives, as well as those programs that we hope to get involved in or we are requested to get involved in.* As a case in point, it seems to me that the national streamflow program is at a threshold where its viability would be seriously threatened if we allowed it to decline much below its current level. I also think that the National Stream Quality Accounting Network (NASQAN) may have declined below a level at which it is a viable program. If you accept those two precepts, it follows that we make some decisions and then take related action. It is my position that we must maintain the integrity and the vigor of the national streamflow measuring program because the Nation needs such a program. I also have similar thoughts about the NASQAN program.

Fifth, *it is unlikely that we will be given the resources that we think are necessary to accomplish those items that are of highest priority to the Nation.* NAWQA is a case in point. If funding is not forthcoming at the right magnitude and under the right circumstances, I propose to do all that I can do to attempt to redirect resources from elsewhere in WRD's program to support NAWQA. That is within a framework of no increase or perhaps a modest decrease in budget. I repeat, under the right circumstances I strongly support significant redirection to make sure that NAWQA is initiated and underway.

Sixth, *the budget process favors program proposals supportive of issues having high political visibility.* So, what else is new? That has always been the case. We are going to have to respond to those issues; but the challenge is not merely to be responsive. We have demonstrated in the past 2 or 3 years that we can do that. The challenge is to be responsive in a way in which we meet the political needs of the present, but still maintain the basic characteristics of this organization. When the political winds shift, as they will, we will be in a position to continue to move forward (a) to serve the long-term needs of the Nation, which are longer than any one or two successive administrations, and (b) also to serve the needs of those administrations. Because, in fact, that is the way the system operates.

Seventh, *the Nation will continue under the influence of economic and political policies directed to reduce the Federal budget deficit and reduce the Federal role in public programs and services.* Prudent planning should accept that policy as a given, at least for the next decade or so, inasmuch as that policy clearly is well-rooted and transcends the politics of both parties.

Without treading on our deliberations to follow, it seems possible to draw a few quick conclusions from these seven precepts. At most, we should expect no more than moderate real-dollar increases in funds; and we should develop the contingencies to deal with the possibility of moderate decreases in real-dollar funds and in personnel resources.

Dexterity and ingenuity in programming will be valuable assets. Water-quality issues almost certainly will continue to dominate our programming efforts. Personnel relief in more than modest numbers is highly unlikely. On the contrary, for the next 3 or 4 years, we are looking at modest personnel decreases regardless of any success or lack of success with new program initiatives.

Nevertheless, I think we are justified in a strong feeling of personal and professional security because we are who we are, and we are what we are. We are an arm of the Geological Survey, and its reputation and respect probably have never been greater. Our capabilities are well known where it counts. Our contributions are recognized and their value appreciated where it counts.

We have the self assurance that our products contribute tangibly to the public well being. We have the momentum of our inherited traditions of hard work and good science. We have a splendid organization that guarantees us a productive and effective future.

EXPECTATIONS AND PREDICTIONS

Introduction of G. T. ORLOB by R. G. WOLFF

Our first speaker is Dr. G. T. Orlob, who is a native of Washington State, and has been a resident of California throughout most of his professional life. His professional experience has been divided among the fields of civil engineering, education, research, and consulting. He holds Bachelor of Science and Master of Science degrees from the University of Washington in civil and environmental engineering, and a Doctor of Philosophy degree from Stanford University in hydraulic engineering.

More than half of his professional experience has been concerned with the development and application of mathematical models and system analysis in environmental management, primarily related to the hydrodynamics and water quality of natural systems. As we heard this morning, that is the topic that will dominate the Water Resources Division for the foreseeable future.

He founded a consulting firm, "Water Resources Engineers, Incorporated", and developed it into a nationally recognized leader in this field. He is the author of more than 150 technical papers, reports, and monograph contributions on system analysis, mathematical modeling, water-quality management, and other topics in environmental engineering, hydrodynamics, hydrology, and water-resources engineering.

He has received awards for research papers from the American Society of Civil Engineers, the American Geophysical Union, the Water Pollution Control Federation, and the American Water Works Association, and a Fulbright Award for a lectureship abroad.

Dr. Orlob has served as a consultant to both national and international agencies and corporations, and that list is very impressive. He is a Registered Civil Engineer in California and Washington, and a Registered Professional Hydrologist. At present, he is Professor and Chairman of the Department of Civil Engineering at the University of California at Davis.

G. T. ORLOB, University of California, Davis

I would like to share some of the special experience of a consultant in the water-resources field who has often been asked to find solutions to challenging problems. Also, I would like to relate this experience to yours as water-resource managers.

First, I note that the Geological Survey has a unique role among agencies. It has expert capabilities that are often attributed to a consultant and it has the special reputation of being unbiased and objective. So, in this sense, perhaps this consulting comparison is not altogether new to you.

Much of my own experience in engineering consultation has been concerned with developing technology that can be applied to the solution of difficult problems. Most of these were mathematical in character, requiring systems-analysis techniques that were not fully accepted by the profession. Perhaps some of these are not fully accepted today. Nevertheless, they are among the tools we have available to solve tough water-resource problems.

A consultant is presumed to have special expertise and, consequently, may be called upon to provide expert testimony in court. The consultant is placed in an exposed position and may be open to criticism. However, it also affords unique opportunities in courtroom settings to express opinions and to exercise judgement based on his experience.

Usually, in service to a client, the consultant is required to make a quick "turnaround". In my early experience, I occasionally competed directly with the academic world as a private consultant for opportunities in research and development in applied mathematical modeling. I found that our firm could be competitive because we could complete a job in a reasonable time, without the red tape that is usually associated with large bureaucratic organizations. The ability to provide a prompt response is an attribute of the effective consultant.

In consulting we occasionally need help beyond our own limited resources. This is where agencies like the U.S. Geological Survey can be of special service. For example, we invariably need hard data that are not available except in the files of agencies responsible for data collection, assembly, and collation. Moreover, we require documentation to make the data credible. In some instances we need interpretations made by people in the field, like yourselves, who know the quality of the information gathered. I believe your Water-Supply Papers are excellent examples of such a resource.

As consultants we also need the latest technology available. For example, this may take the form of a mathematical model capable of simulating pollutant travel underground. Some of these tools are not available in the public sector, perhaps because of proprietary restrictions. But, others may be drawn from sources such as the Survey where new technology is being developed, refined, and made available outside of the agency itself.

I may be presumptuous in defining the Geological Survey mission, but I believe that one of its most important services is in research and development of new technology that the consulting profession can use. For example, one of the most popular groundwater models in use today, the Konikow-Bredehoeft model, was developed within the USGS. It is now available to the consulting profession for application to real problems.

It is obvious that the USGS has been engaged for a long time in providing basic data upon which this technological development depends. These data are an essential resource for private consultants and public agencies who are engaged in solving water-resource problems.

A goal of research is to advance the state-of-the-art, that is to provide better tools for decision making. In our case "art" is in applications of these tools, such as mathematical models, even though they may not be fully refined to the satisfaction of the researcher. As consultants we must move ahead with deliberate speed to solve societal problems. We need to do this cautiously, to be sure, but progress is essential. A solid research program like that of the Survey is mandatory.

It is important also that the Survey establish lines of communication, not only with other agencies of government, but also with the practicing profession outside of government, that may utilize the expertise, technology, and data that only you can provide. There is a need to improve communication and to assure the immediate availability of new technology.

Those of us who have ties also with the academic community seek stronger connections with agencies that have their own research programs, like the Geological Survey. In the academic environment, research is a major part of life. We would like to exchange research accomplishment at a pace greater than is usually possible through traditional publication channels. With this brief introduction to the world of the consultant let me illustrate two examples.

First, let us examine the San Joaquin Valley, where the basic problem is one of progressive salinization. Development of the water resources of this valley has progressed to the point where we are acutely aware of negative consequences. For example, there is the concentration of selenium in Kesterson Reservoir. This is not really a new problem, it has been building for years. Yet the recent notoriety has forced us to look more closely at the exploitation of water resources at regional scales and what this may mean in terms of the future of agricultural water use in California.

For this kind of a problem we need a long-term, water-quality record. Unfortunately, available records do not go back far enough

to provide the essential "no project" condition needed to evaluate later project effects. It is most often the case that adverse impacts of large-scale, water-resources developments are not anticipated by the planners and designers. Water-quality data collected following implementation of the project are often too sparse to signal damage until too late. In this case the first water-quality monitoring stations along the San Joaquin River were installed in 1953, shortly after the Central Valley Project commenced operation. There are virtually no data that can help us determine what the water-quality situation was along the river before the start of large-scale, water-resource development in the valley.

The geographic area we are concerned with here is the southern part of California's Central Valley including both the valley of the San Joaquin River and the Tulare Basin. The Tulare Basin is a landlocked area, isolated from the San Joaquin in all but a few very wet years. Our focus will be on the San Joaquin system.

A result of water development in this valley, including extra basin diversions, has been a marked decrease in annual runoff by more than a million acre feet per year. This reduction is a consequence of exports from the valley plus increased consumptive use by irrigated agriculture in the service area of the Central Valley Project (CVP). Not only has the outflow diminished, but the salinity has increased. If we perform a simple salt balance, we conclude that increased salt concentration is merely the consequence of reduced diluting flow.

Actually this is this only part of the story. The total tonnage of salt delivered by this system also has increased, largely as a result of putting new lands under agricultural production, and importing more salt through the Delta Mendota Canal than leaves the basin with runoff. Of course, the Central Valley Project was created to increase the gross production of agriculture by supplying adequate quantities of good-quality water to new, assumedly fertile, lands. Unfortunately, the quality of the lands most recently served by the CVP has not been so high as those developed earlier; they have generally contained large amounts of soluble salts. Application of water to these lands has leached the salts and added them to the burden carried by natural drainage from the valley.

We can follow the historic trend of salt load delivered by the San Joaquin River at Vernalis since the 1930's. The salt-load accumulation at Vernalis is related to the average for the period before major water development from about 1930 to 1950. The CVP actually began operation in the San Joaquin Valley in 1951. From about 1940 to 1965 the salt load remained more or less stable, rising and falling with hydrologic variations. The valley experienced a dry period in the early 1930's in which the salt load declined below normal. A wetter period followed in the 1940's when the salt load rose. About 1965, after the CVP had been in operation for about 15 years, there was a decided change in the balance. The amount of salt delivered from the basin increased markedly. The excess salt load since the mid-1960's was about 200,000 tons per year, roughly 30 percent greater than for the period before 1951.

This experience suggests some special problems that we may have to anticipate in connection with large-scale, water-resource development. Unfortunately, with a sparse monitoring program we may not see developing problems in time to correct them. In this case about 15 years passed before a significant salt imbalance was detected. It actually took 30 years before we acknowledged that a real problem existed, and then we had to experience the Kesterson episode to bring it to light.

A major impact of San Joaquin Valley salinization is felt far downstream in the Sacramento-San Joaquin Delta where water quality is degraded in the Southern Delta channels near the point the river enters the estuary. In years of poorest water quality and low runoff, substantial acreages of prime land are deprived of water of the quality necessary for productive agriculture.

Future resolution of salinization problems of the San Joaquin Valley lie with improved drainage systems, more efficient water management, and certain structural modifications to improve the conveyance of salt from sensitive areas downstream.

A second case of interest is a reservoir in the Sierra Nevada of California. On February 28, 1984, a rock slide occurred above a powerhouse complex on the Upper Feather River. The slide ruptured a penstock and washed transformers and switching equipment into the upper end of Belden Reservoir, a small forebay for a downstream power facility. The equipment was laden with oils containing residual polychlorinated-biphenyls (PCB's), toxic substances that are of increasing concern because of their potential for bioconcentration in the aquatic food chain.

This crisis was treated on an emergency basis by immediately shutting down the power facility to control releases to hydropower installations lower in the system and to preclude possible contamination of the stream below the reservoir. A major unresolved question was: Could the project contain the spilled PCB's within the reservoir until cleanup could be accomplished?

An answer to this question required considerable information, most of it not immediately on hand. This included estimates of future runoff, and direct measurements of PCB's and sediment in the water. Operation of this project, following the February slide, required the release of water from the reservoir by mid-May to accomodate melting snowpack and spill from storage upstream. This water could induce flushing of sediment and associated PCB's that had been accumulated in the reservoir, carrying them downstream where they could endanger the indigenous ecosystem.

Water-quality information was not available before this accident, so there was very little understanding of how the reservoir would behave hydrodynamically. A monitoring program was initiated immediately, continuing throughout the summer during the period of operational adjustment while the owner of the project carried out cleanup operations. The monitoring program consisted initially of sampling and analysis for PCB's and suspended sediment in reservoir outflow. But soon it was discovered that analytical capabilities were limited. Within the analytical detection limits, no PCB's were detected in downstream releases nor were suspended solids present in sufficient concentration (1/2–1 mg/L) to be a practical indicator. However, PCB's were found in bottom sediments, so it was clear that a potential hazard did exist. That is, if flow velocity increased to scouring levels, sediment could be carried from the reservoir. What was required for continuous water-quality monitoring was a surrogate for PCB's and sediment in the water column. Turbidity measurements (NTU) served this purpose with a high degree of sensitivity ($\pm$0.1 NTU in the range from 1 to 10 NTU).

A revised monitoring program was initiated, including temperature and turbidity observations at selected locations within the reservoir, and at inlets and outlets. This provided information sufficient to detect any disturbances in bottom sediments caused by changes in hydropower operation, natural hydrologic variations, and cleanup activities to remove PCB sediment from the reservoir. This program revealed the tendency for weak thermal stratification in the impoundment which was apparently sufficient to confine sediment within the reservoir. This was corroborated by turbidity measurements in the water column which showed a persistent clear water layer in the region of the thermocline that would not have been possible if vertical transport of sediment were occurring.

To evaluate possible future project operations that could disturb bottom sediments, a two-dimensional, finite-element model of the reservoir was employed to simulate the resultant velocity fields. Studies for extreme cases of high runoff rates and lowest likely power-pool elevations (conditions most likely to produce scouring velocities) revealed that under the most adverse conditions, old sediment was likely to be retained within the reservoir

and covered by uncontaminated deposits.

An important realization from the investigation was that direct analytical detection of PCB's could not serve to monitor the fate of these substances. Surrogate measures (turbidity, thermal structure, and the velocity structure within the reservoir) were necessary to guide the operation through the critical period of potential hazard. Mathematical methods, such as the model used in this instance, were also valuable resources but not sufficient by themselves. Considerable innovation and judgement based on experience still will be required to solve the tougher problems and to assure the desired protection of the aquatic environment.

There are certain general conclusions, derived from consulting experience, that suggest the future for water-resource management. I believe the following are the most pertinent:

1. Water use, despite increased competition, seems destined to increase. Even in the face of drought our society's adjustment to shortage is transient. When the drought passes so do our efforts to conserve, as we have learned from the California drought of 1976-77. There appears to be no lessening in demand.

2. Water quality probably will continue to deteriorate, especially ground water, before it gets better. While we made substantial progress in reducing pollution loads in the 1970's, we have since moved away from a strong "clean water, zero waste-water discharge" philosophy.

3. Public health concerns are destined to rise, largely because of toxins in ground water.

4. Costs of developing water from new sources will increase more rapidly than costs of treatment or conservation and management. The latter alternatives will become the more attractive.

5. Real-time operation for water-quality control will become necessary. Hence, there will be greater emphasis on high technology methods of remote sensing, monitoring, and operation control.

The most important targets for the future of the Geological Survey will be in preserving and enhancing the quality of Nation's water resources and in developing the necessary technology. This will require development of an extensive water-quality data base with immediate access, on nearly a real-time basis. Satellites, radar imaging, and other remote-sensing techniques will figure prominently in the development of needed basic data and information. Spatial and temporal coverage must be improved, which will lead inevitably to processing increased amounts of information. While computer technology may hold promise for dealing with the increased load, it will be necessary to devise new methods to digest, reduce, and present water quality and hydrologic data in more usable formats. Video-graphic techniques and computer interactive software will be needed to translate data into the forms required by managers of water-resources systems. Modeling and simulation methods for planning and design, and especially for operation, will be essential techniques for the future. Capability to assess uncertainty and reliability in the water-management decision process will assume greater importance.

If there is a single word that characterizes the future challenge, it is "quality"—quality of the water resource, quality of the technology of water management, and quality of the management effort itself. The Geological Survey, I am confident, will continue to deserve its established reputation as an agency of quality in all aspects of water resources.

CLIMATE AND HYDROLOGY

Introduction of ROGER REVELLE by E. A. IMHOFF

I had planned a modest introduction of Dr. Revelle, but I think that would be a disservice to his audience. Some of you have had a close association with the speaker, but some may know only of his background or only his name. Therefore, I insist on taking some time to mention a few of the highlights of a long and illustrious career.

He is a trained geologist, PhD in oceanography, researcher in geology, researcher in oceanography, and researcher in a number of other disciplines. He took time off from research to serve as a naval officer in World War II. He was the head of, and one of the founders of, the Geophysics Branch at the Office of Naval Research. He was Science Advisor to the Secretary of the Interior from 1961 to 1963. He was director of Scripps Institution of Oceanography from 1950 to 1964. He was the University of California Dean of Research for all campuses. I heard him speak when he was the director of the Harvard Center for Population Studies at Harvard University, where he was Professor of Population Policy. He is presently Professor of Science and Public Policy at the University of California, San Diego. He is affiliated with the Goddard Institute for Space Studies in New York. For many years, he has been a prominent member of the National Academy of Sciences. He has been Vice President of the American Academy of Arts and Sciences, and President of the American Association for the Advancement of Science. His resume lists some 20 other professional society activities.

Dr. Revelle's honors include prominent awards from the National Academy of Sciences, from the American Geophysical Union, from several Nations, from the National Science Board and the Tyler prize for energy and environment. A college has been named for him at the University of California.

In closing, I will read a little note pinned on his resume from his secretary: "PS: R.R. has authored or co-authored several hundred scientific publications. I've run out of copies. Apologies, C.B." Secondly, I'll read from a science-magazine, biographical sketch: "Dr. Roger R. Revelle, whose spectrum sweeps the whole earth. . . "

ROGER REVELLE, University of California, San Diego

I want to talk about hydrology and climate for the next few minutes. All hydrologists are aware that climate varies and they take account of it in such things as estimation of the probability of floods and droughts.

Few hydrologists have been able to consider the potential of climate change because nobody knows how the climate will change with time or in different regions. However, I think that there is more and more general agreement that the climate is going to change over the next few decades. One of the principal reasons will be increase in atmospheric carbon dioxide due to the burning of fossil fuels and the cutting of forests. Secondly, it will be due to the growing concentrations of other so-called "greenhouse" gases, particularly methane, nitrous oxide, tropospheric ozone, and the fluorocarbons.

At a recent international conference sponsored by the World Meteorological Organization, the United Nations Environmental Program, and the International Council on Scientific Unions, the assessment is that a warming of climate will occur over the next 50 years. Somewhere between the year 2000 and the year 2040, the equilibrium climate will correspond to a doubling of atmospheric carbon dioxide from the 19th century value of about 280 parts per million.

The reason for this estimated speed-up of climate change is because of the recent recognition that the other greenhouse gases also are important.

Charles Keeling of the Scripps Institution of Oceanography, shows that atmospheric carbon dioxide increased from 1957 to 1982. During that period, atmospheric carbon dioxide increased about eight percent, from 315 parts per million to 345 parts per million.

Other greenhouse gases—methane, ozone, nitrous oxide, and the fluorocarbons are in there, too. Those other greenhouse gases

have a very much lower concentration in the atmosphere than the CO but have a much more pronounced effect atom by atom. A nitrous oxide increase from 300 to 600 parts per billion would cause a three-tenths or four-tenths of a degree rise in atmospheric temperature. Methane with an increase from 1.5 to 3 parts per million would cause an increase in temperature of about three-tenths of a degree. The freon going from nothing to one part per billion (freon did not exist before manufacture by people) would have an effect about equal to the methane. Tropospheric ozone, doubling in concentration would cause an increase in temperature of about nine-tenths of a degree.

Together, these greenhouse gases would cause an increase in temperature without feedback effect of about one degree, which is about what carbon dioxide doubling would do without any feedback effect. A temperature increase of one and one half to four and one half degrees Celsius can be estimated because of several feedbacks. One is that water vapor will increase as the temperature increases, and water vapor absorbs infrareds, as does carbon dioxide. Another reason is that the albedo of the earth will diminish because of melting snow and ice, and again this feedback causes a further increase in temperature.

Methane apparently started to increase about 1650 and is increasing between one and two percent a year. God knows why. Most of the methane apparently comes from the belching of cattle. Cattle have a big forestomach called a rumin which is a large anaerobic bacteria laboratory. One of the products of that laboratory is methane which the cattle cannot digest, so they get rid of it.

Another possibility but not a very high probability, is methane produced by termites. There are about 10^{17} termites in the world with a total weight about equal to the total weight of human beings. They have essentially a bacteria laboratory in their guts like cows, but on a very much smaller scale, in which the anaerobic bacteria produce methane. A third source of methane is swamps where the bottom mud is anaerobic. A fourth is rice paddies where the same thing is true.

So cattle, rice paddies, swamps, lakes, and maybe some other sources like peat bogs are responsible for the continual influx of methane into the air. Presumably this increase is due to the increase in numbers of cattle, increase in the number and size of rice paddies, and maybe the increase in termites. In any case, methane is clearly increasing and seems to be increasing more and more rapidly.

Fluorocarbons and the freons are increasing by about five or six percent a year. They are parts per trillion now, but are rapidly nearing one part per billion, primarily because of refrigeration and air conditioning. They have been banned (in spray cans) in the United States but not so much in the rest of the world. The freons are increasing rapidly.

Tropospheric ozone also is increasing, at least in the northern hemisphere. Tropospheric ozone is a function of the concentration of hydroxyl ion. Presumably the increase of methane and unburned hydrocarbons in the air have caused a decrease in the hydroxyl ion in the atmosphere. The result is that O_3 in the troposphere is increasing.

Global temperature has increased during the last hundred years by about one-half degree Celsius. This is still within the noise level of natural variations. within the next 10 to 15 years the average global temperature will climb, and we will have clear incontrovertable evidence of climatic warming.

The ocean will be warmed if the atmosphere warms. The ocean has huge heat inertia and turns over slowly. We must heat the top 1,000 meters of the ocean before we arrive at the equilibrium warming of the atmosphere. It may take anywhere from two to six decades to approach equilibrium warming. This inertia of the ocean is probably why we have not seen much warming even with the 20 percent increase in carbon dioxide over the past 120 years. This assumes that in 1850 the atmospheric concentration was about 280 parts per million. So, we will only slowly approach equilibrium as the ocean warms.

One other thing that must be considered is that carbon dioxide acts as a fertilizer. It increases net photosynthesis. There are two possible relationships between the increase in CO and the increase in net photosynthesis. One group thinks it is a logarithmic relationship; others think it is arithmetic. In either case, for a doubling of CO_2 , we should expect about a 50 percent increase in photosynthesis. We can expect at the same time that the leaves of plants will partly close their pores, with the result of less transpiration for a given leaf area.

However, at any given water availability, the total transpiration remains the same. The plants simply grow more and transpire less per unit area. But the total leaf area increases just in proportion to the decrease in transpiration per unit area. In an experiment with four different water regimes (wet, moist, dry, and very dry), wheat plants in each regime increased their production as the CO_2 in the atmosphere increased. But of course they did not grow anywhere nearly as well with low water availability as they did with high water availability.

I would take it from these data that if plants in natural ecosystems behave like these plants in the experiment, the net photosynthesis will increase as carbon dioxide increases and that the effect on transpiration will cancel the effect due to the physiology of the plant. It will not cancel out, however, as it is related to temperature. As the temperature increases, evapotranspiration will increase, particularly in the tropics and high temperatures. In high initial temperatures, evapotranspiration would increase a good deal with the increase in temperature expected from increased carbon dioxide.

Walter Langbein and his associates estimated runoff for any given temperature at any given amount of precipitation. Walter's curve covered the whole United States. In an arid area of the United States with precipitation at 400 millimeters per year and a mean weighted average temperature of about four degrees, we would have about 78 millimeters of runoff. As we go to lower precipitations, say 200 millimeters, there will be no runoff at all at a temperature of eight degrees but still a little bit of runoff at a temperature of two to four degrees. As we go toward the higher precipitation, the proportion of the precipitation that ends up as runoff increases. Langbein and I would be the first to admit that these data are rough and do not really apply to any particular river basin. But for small changes they are probably pretty good. For a two or three degree increase in temperature and about a ten percent change in precipitation, these data probably give us a good idea of what will happen.

Next, consider what will happen to runoff as the temperature changes, where initial temperature of zero degrees Celsius changes to plus two degrees at average precipitation of 300 millimeters. There will be a 30 percent decrease in runoff. For a temperature of say four degrees and an average precipitation of 400 millimeters, there will be a 25 percent decrease in runoff, and so forth. The temperature alone will have a big effect on runoff.

Consider the next the effect of changes in precipitation at a constant temperature, again in percentage. For example, a four degree change in temperature and a 10 percent change in precipitation when the initial precipitation was 400 millimeters would cause a decrease in runoff of about 16 percent. The 10 percent change in precipitation had only about half the effect of a two degree increase in temperature.

Paul Wagner and I calculated the effect of climatic change on the so-called virgin flow at Lees Ferry on the Colorado River, the virgin flow being the flow without any diversions or any reservoirs, storage, evaporation, or other human activities affecting the river. We used estimates of virgin flow, over the 45-year period of 1931 to 1976. Those were estimates made by Myron Holbert of the Metropolitan Water District. We took the average temperature

directly for the year and the precipitation for the year. The temperature varied by about four or five degrees from one year to another. Precipitation varied by a considerable amount, but what varied even more was runoff. It varied from about 9,000 million cubic meters per year to about 24,000 million cubic meters per year, so we had a good statistical range.

We found by multiple correlation that both precipitation and temperature affect the runoff. We got an R correlation coefficient of about 0.75. And we found that for a one degree increase in temperature, runoff at Lees Ferry would diminish by 2,400 million cubic meters, about 15 percent. For a two degree change there would be about a 30 percent decrease in runoff.

In the Colorado River basin, the temperature probably will rise between three and four degrees, so we are very conservative when we consider just two degrees. But such a two degree rise in temperature would cause about a 30 percent decrease in average runoff. We cannot tell from the general circulation models what is going to happen in any particular region, for example the region of the Colorado drainage. We can tell in a general way what will happen to the temperature because the temperature rise will be a large-scale phenomenon. We cannot tell what will happen to precipitation. In fact, the regional accuracy or precision of these so-called general circulation models is very low.

We can say three things that are important to hydrology even if we only are certain about a rise in temperature and uncertain about a rise in precipitation. First, the demand for water will increase. It will increase because evapotranspiration will increase by about 30 percent for a two to three degree rise in temperature. Second, the water demand will increase because the growing season will be longer. Over the entire United States, with a postulated rise in temperature due to an increase in CO_2, we find about a 30 percent increase in the length of the growing season. The water demand will increase more or less in proportion with the increase in the length of the growing season. Third, there will be a rise in sea level because of the warming of the ocean and presumably the melting of glaciers.

The melting of alpine glaciers, probably some increased ablation of the Greenland icecap, and the warming of the ocean waters, will cause a rise in sea level around 70 centimeters during the next century. There is a big range of possible error here, but there will certainly be a rise several times greater than during the last 50 years. Sea level is now rising about 20 centimeters per century. The next century we can expect that to increase by a factor of three or so.

What does this mean for hydrology? It means that, because of the Ghyben-Herzberg ratio, the depth of fresh ground water in coastal regions will greatly diminish. A two foot rise in sea level would mean about a hundred foot decrease in the depth to fresh water.

In places like Cape Cod, where there is not enough water now, a two foot rise in sea level could be disastrous from the standpoint of the ground water resource. That would also be true in Florida and many other coastal areas.

To summarize, I would say that *there are three effects of global warming that we can talk about with considerable confidence and that need to be considered in water-resources planning. These are the effect of the increased length of the growing season because of rising temperatures, the increase in water demand because of greater evapotranspiration, and the rise in sea level.* The ramifications of the first two of these may be widespread. For example, water economics in the Western States should be severely affected by the change in water supplies and the change in water demand. We are already seeing the attempt by the San Diego Water District to buy water from Colorado and to buy water from the Imperial Irrigation District. I expect that this market approach to water law and to water allocation will become more influential as time goes on and as the water situation gets tighter. Such things as the Law of the River in the Colorado River basin are likely to be drastically affected by political pressures as the conflict over limited supply intensifies.

This is particularly true in years of subnormal supply, subnormal precipitation, or above normal temperature. We are more able to predict extremes of climate than to predict the mean climate in any particular region. General circulation models, good as they are, do not really tell us much about extremes—what the frequency of drought is likely to be or how it is likely to change, or what the frequency of floods is likely to be and how it is likely to change with changing climate. Clearly, those are the extreme climatic conditions and are the ones that will be of most serious concern over the next 30 to 100 years.

Now let us consider what the general circulation models tell about the temperature during the next decade. An estimate by the general circulation models indicates a rise in temperatures during the 1990's. In the United States, only the southeast can expect much rise during the next 10 years. There will be a considerable rise in northeastern Canada and a marked change in large areas of central Asia. In Europe, if anything, the temperature will get colder during the next 10 or 20 years. During March, April, and May very little change will occur in North America, the change is mostly in eastern Asia, with little change in Europe. In June, July, and August during the next decade, the United States will warm only in the southeast and south-central regions. In Europe, the climate will get colder in the summertime and it is only central Asia that will have warming. In September, October, and November in the next decade, there will be warming in the west-central United States and warming in southern India.

In the first decade of the next century, there will be very little change in the United States, very little change in Europe, large change in eastern Asia and in southwestern Asia, and in parts of South America, and of course major changes in the Arctic—changes on the order of 6 degrees because of the melting ice. In March, April, and May there will be no change in the United States, marked changes in Canada, Africa, and large parts of Asis, and of course the high latitudes both north and south.

In the second decade of the next century, there will be a general warming all over the United States, a very marked warming in Canada, and beginning warming in Europe, in South Africa, and most of Africa. About 25 years from now, we find a large area of warming in the southwestern United States. This is the time we really have to worry about the Colorado River. There will be marked warming in central Asia, and some warming in India as well as in China and Japan, and large areas of Africa. In September, October, and November there will be universal warming over very large areas. In the western United States there will be about 4-degree warming, and the same is true of China, but not of western Europe. In the winter, large areas of the United States will be warmed by 2 or 3 degrees, Canada will be warmed by about 4 to 6 degrees, with little change in Europe. There will be marked changes in eastern Asia.

That is about everything I have to say about the relationship between climate and hydrology, on the basis of what we think we know about future climate changes.

TECHNICAL CONCERNS OF THE DIVISION

J. D. BREDEHOEFT, Research Hydrologist, Western Region

I think it would be presumptuous for me to predict the concerns of the group over the next 15 years or so. Therefore, I would like to talk about some technical concerns that I see on the horizon and about the health and well-being of this organization.

I would like to start with our current view of the hydrologic cycle. Our traditional view states that quantity really was of primary concern to us, that quality was pretty much independent of quantity, and that human activity was an external perturbation to the natural hydrologic cycle. That view that has persisted until recently, and I think we are beginning to see that view as no longer adequate for the way the system operates today.

Our current view of the hydrologic cycle sees man's activities as inseparable from nature. Indeed, man is an integral part of the cycle itself. Quality and quantity are of equal concern, and we cannot really deal with quality or quantity independently of each another.

One can state this viewpoint in another way: the atmosphere interacts with the earth and then interacts with man; they are inseparable. The active model has man on the earth's surface, and man interacts; then the whole thing feeds back on itself. I think that is a more realistic view of how we currently view the hydrologic cycle. With that sort of philosophical introduction, let us consider several problems.

I will start by citing the problem of water supply in the West, about which one of my colleagues said, 'You're really not going to talk about that again, are you?' I am, because I think it illustrates some concern. I remind you that the whole thing starts with precipitation. An average annual precipitation map for the United States shows no great surprises. We have an arid area in the Southwest, rainfall on the Coast Ranges, and a humid area in the East.

Rainfall translates into runoff. There is a very large part of the country in which the runoff is less than one inch. In fact, there are parts of the West where the runoff is virtually zero. For much of the Western part of the United States, the runoff really comes from snowfall that occurs in the mountain ranges and translates into spring runoff. Again, these are not great surprises.

Runoff occurs in a really limited number of streams in the United States. There is the Columbia system and its tributaries, the Princess and the Snake; the Colorado system which is really very important because it occurs in this arid region; the Mississippi and its tributaries; and the St. Lawrence on the East Coast. In Alaska, the Yukon is the principal stream.

On the average, there are 40,000 billion gallons of water in transit in the atmosphere above the United States every day. Of that, roughly 10 percent falls as precipitation. Of that ten percent, roughly two-thirds transpires and evaporates back to the atmosphere. Almost all of the remainder runs off — 300 billion gallons a day to the Pacific, 1,000 billion gallons a day to the Atlantic and the Gulf. We use a little bit also. We consume about 106 to 120 billion gallons a day.

Remember, the hydrologic cycle is a dynamic system in which we are really talking about movement of water through the system. We are not talking about things in storage. We are talking in some sense, about the gross national product.

What can we do to that system in terms of managing it? Our options are relatively limited and fall into the following areas. We can change the timing of the flow through the system. We can change the geographic distribution of those flows through the system. We can mine ground water that has largely been in storage since before man's history began. We have a corrolary to those options that says that each of those actions has a potential to change the water quality. There really is a very limited set of things that we can do.

Consider for a moment the sorts of changes that we make. Crop demand comes from surface water and from ground water. Surface water, a lot of which is stored in the Upper South Platte Basin is released as the demand comes. Again, it is a situation in which we have changed the timing and used the ground-water reservoirs or used the surface-water reservoirs to meet the crop demand.

How do we use this water on a national scale? Steam electric utilities and irrigation withdraw about 100 billion gallons a day, and then everything else comes down from there. Really, those two withdrawals dominate the picture.

The situation with respect to consumption looks considerably different. First, most of the water is consumed in the Western States. Eighty-four percent of that occurs in the 17 Western States; only 16 percent of what we utilize and put back in the atmosphere occurs in the other 31 Eastern States. We consume most of the water in this country in irrigated agriculture. Irrigated agriculture uses something more than 90 billion gallons a day, and everything else is basically less than 10 billion gallons a day. In the western part of the United States particularly, practically 80 to 90 percent of the water is used for irrigated agriculture.

Where is our surface-water supply depleted? The depletion occurs to a large extent in the Western States. The critical area, really, is the southwestern part of the country—southern California and Arizona. To some extent, the High Plains also is a critical area.

Those are the areas where we really have a shortage with respect to the quantity. And of course, those are the areas where we utilize much of the water for irrigated agriculture.

One can look at the depletion in another way, and this is to say, "Where is the streamflow depleted more than 70 percent in an average year?" Again, we come up with the same areas. We make up that depletion by pumping ground water for the most part. There is a rather steep growth in ground-water utilization since the 1950's. Again, irrigation dominates the use of ground water.

It is interesting to look at the distribution of those ground-water withdrawals in the United States. Twenty percent of the withdrawals occur in California, another 13 percent occur in Texas. So, Texas and California account for one-third of the ground-water withdrawals in this country. If you add to that Nebraska, Kansas, Idaho, and Arizona, you have two-thirds of the ground-water withdrawals in this country. Two-thirds occurred in those six States. Of course that correlates rather nicely with the distribution of irrigated agriculture in the U.S. In fact, there is roughly 50 million acres of irrigated agriculture in the U.S.; 10 million of that is in California—20 percent of it. That 20 percent accounts for 10 percent of the agricultural output of this country.

Let us consider where the ground water is being mined. Basically, there are only three areas of really significant mining: the southern part of California, and our own work on the Central Valley suggests that is not terribly large, probably less than a half-million acre feet a year; Arizona, where the overdraft is probably about 2-million acre feet a year; and then the High Plains with a significant overdraft.

It is interesting to look at the High Plains. Our High Plains Study indicates that the major depletions occur in New Mexico, Oklahoma, and Texas. If we figure that perhaps only 50 percent of the water in storage can be recovered, we can see that New Mexico is in trouble. There is a tremendous quantity of water, virtually untapped, in storage in Nebraska—over 2,000 million acre feet.

What has been our traditional solution to utilization of the water supply? The traditional solution was, of course, to build reservoirs. Our reservoir capacity grew rather steeply until the 1960's, and from the 1960's on, the capacity has decreased rather steadily. This is the capacity for our withdrawal purposes. Indeed, the picture looks like the same for all purposes.

What this is saying is that we are not building reservoirs at the same rate as in the early part of the century. Indeed, the water supply is finite and we are reaching a situation where most of the water available to us has been utilized, at least in the western part of the United States. We have about a two percent chance of deficiency, indicating that our chances of being short of water are increasing as our reservoir capacity decreases.

What does all this mean? Well, let me try to explain my own interpretation of what it means. From roughly 1960 on, we have met the treaty requirements on deliveries of Colorado River water at the Mexican border. So we conclude that the water in the Colorado River is basically all utilized; there isn't any more available. It is all being essentially used at the present time, and we are delivering to Mexico about what our treaties demand.

That in no sense means that there is any less water available. Certainly, roughly the same flux of water is available in the hydrologic cycle. It simply means that the water, at least in the southwest part of the country, is basically all used at the present time.

Other interesting things to consider are the interbasin transfers in this country. There are not many that are significant. There is about 600,000 acre feet being transmitted into the North Platte in Colorado in the Big Thompson project, and another 80,000 or so in the Arkansas Frying Pan project. Those are relatively large. The only other reasonably large inner basin diversions occur in California. The magnitude of the California diversions is really astounding in terms of the rest of the country. About three million acre feet come into the Imperial Valley, another 700,000 from the Colorado into the Los Angeles basin, another 300 come from Owens Valley into the Los Angeles basin, another 500,000 come from the California Water Plan. The diversions from the North slope into the Central Valley are about 800,000 acre feet. It is astounding that these interbasin transfers are as large as they are.

My own perception of the situation is that the magnitude of these diversions has been possible only because it has occurred within one State. It is inconceivable to me that those diversions could have occurred had there been multiple States involved. I think the politics would simply not permit it.

What is the meaning of all this? It means that we have reached a new situation with respect to water supply, at least in the Western part of the United States. That situation is that all available water is basically used, and that there really is no more readily available, cheap water. We have reached the situation where there will be future competition for available water. In a classic sense, water is a scarce commodity. As a scarce commodity, one would expect that the price of water would rise.

Traditionally, we have not dealt with water in that fashion. We dealt with it in a political fashion—political competition for the water that was available.

Remember that 90 percent of the water being used in the Western part of the United States, and the country as a whole, goes for irrigated agriculture. If we were able to take 10 percent out of that irrigated agriculture, we could double all the other uses. Whether it is a serious problem or not depends upon whether one is willing to take that ten percent from agriculture. It seems fairly clear that in the Western part of the United States there will be a shift from agriculture toward other uses.

I also would like to talk about our environmental problem. It seems that there has been a shift in our view of the environmental problems over the last ten years or so. When one thinks about environmental problems, it seems to me it is instructive to think of a kind of hierarchy of problems.

At some level, one is really worried about subsistence. Do I have enough water to keep myself alive? Do I have enough food to keep myself alive? Once we have satisfied those needs, we become concerned about longer term needs. What is the impact of environmental damage on human health? Then, perhaps at a somewhat lower level, what is the threat to our food supply from environmental damage?

Finally at some level, when we have satisfied ourselves that these things are reasonably taken care of, we worry about aesthetic concerns. Are we killing the pupfish in Nevada? Are we killing the shad-dogger by building another reservoir in Tennessee? Are we going to somehow drill for oil off the coast of California and damage the coast line? Those are aesthetic concerns. We are destroying something that we value, but our concerns are at a lower level.

Many of the concerns that we were worried about in the 1960's were in the aesthetic arena. We were worried about damage to the environment because it affected our sensibilities. I think that those concerns have shifted, and we are concerned now about contamination in the environment because it is a threat either to our food supply, or to human life itself. That is a different level of concern and it manifests itself with things like Love Canal, where we are really worried about living.

It manifests itself in things like contaminated water supplies in Silicon Valley. It was interesting in Kern County last summer that a supply of watermelons was actually taken off the market. It is not clear whether those watermelons were contaminated because there was some residue of earlier herbicides, or whether the watermelons themselves had been treated—mistreated—during their growth. We are coming back now and seeing legitimate concerns to our health and our food supply. That is something different from what we experienced in the 1960's.

Our damage to the environment really damages the entire ecosystem on which we are dependent. We depend on some sort of a food web, that concentrates contaminants as they move up the food chain and finally reach the human being. The point is that things work their way up in that food chain, and contamination that resides in the food chain may ultimately both affect our principal food supply as well as ourselves. One of the difficulties with the water-quality problem is that we are not quite sure how these substances move through these food chains. We are not quite sure about the toxicity levels of the various substances that we are releasing into the environment.

We are particularly not sure about the things like the mini-organics which we have been generating and releasing into the natural environment. We simply do not know how many of these organic compounds impact the food chain or ourselves.

In some sense, we use water quality as a surrogate for our concerns. We really do not care about water quality for its own sake. What we are really worried about is the *impact* of water quality on human life, our food system, and to some extent the natural environment that we would like to preserve for aesthetic reasons.

We do not know what those interactions are. Therefore we try to set some standards in ignorance of the real impacts of these things, particularly with respect to impacts of organic and trace metals on the systems that we are concerned about. We have quite a bit of data on the principal constituents, the common constituents. But when we look for data on organics and trace metals, the data base is virtually nonexistent. We simply do not have it.

One of our concerns is that society is asking how much of

our water supply is contaminated. How much of the ground-water system is contaminated and how much of the surface-water system is contaminated? And the fact of the matter is that we do not know. People have made various estimates based on certain assumptions. But we have little hard data saying, "This proportion of our water supply is indeed contaminated." We simply do not know.

The proposal that the Rubin Committee put together for this Division was an attempt to get some sort of overall geographic assessment of contamination. Geographic assessment may not be the right term, but some sort of assessment is needed of the magnitude of the water-supply contamination in this country. If things proceed as the committee designed them, we should have answers to those questions in a reasonable period of time. Those are the questions that society is asking us. I hope that we do not lose sight of what is being asked about how much of this water is contaminated.

We may get lost in the shuffle. We may do a lot of nice work but we still may come down the road later and still not have the answers to the question "How much of our water supply is contaminated?"

In terms of quantity alone, there are significant parts of the country where the water supply is depleted. If we add instream demands to this, we see that large parts of the country do not have much water available. With the addition of requirements with respect to water quality, we may find that we really do not have much water that can be shifted from the stream system. We need it there for both water-quality purposes and water-supply purposes.

Our energy comes in largely as short-wave radiation from the sun. Much of it is converted to long-wave radiation that then heats the earth itself. The amount of heating is very sensitive to the way we radiate that long-wave radiation back to the atmosphere. In the long run, what comes in equals what goes out. Certainly, we do not manufacture energy and to a large extent what comes in from the sun is basically balanced by what goes back out.

If we start to tinker with the way this goes back out, we begin to see that there are seeding effects in the atmosphere. That is the greenhouse effect that, to a large extent, is the consequence of CO_2 built up in the atmosphere. Data from Mauna Loa in Hawaii indicate a gradual increase in the CO_2 in the atmosphere from 1958 to 1985. Long-term data, from ice cores going back to 1750, indicate a gradual buildup of CO_2 in the atmosphere.

The problem with all this is that the atmosphere is balanced with respect to its energy input and its energy output. There are a number of feedback loops in the atmospheric system, and there are a number of feedback loops with respect to atmospheric carbon dioxide.

There are enormous reservoirs of carbon dioxide. One is the ocean, and another is vegetation. So, the system is not simple and we are not really certain what CO_2 is going to do to the long-term climate of the earth.

Most of our estimates of the impact of CO_2 are based on a set of global circulation models. There are numerical models that simulate the atmosphere and the atmospheric interactions. Several models look at this CO_2 buildup and predict the effect on the atmosphere.

It is fair to say that most of the global circulation modelers see an increase in CO_2 as causing an increase in temperature. There is a reasonable consensus on that point. Projections show that the mean average temperature of the globe will increase on the order of one degree Celsius.

Various other models show approximately 1 and 5 degrees average increase in temperature for the globe. That does not sound very significant. But when you realize how delicately balanced the globe is with respect to parts of the continents covered by ice, you will understand that small shifts in the global temperature will put a considerable amount of water into the system.

One of the interesting things about all of these model results is that the magnitude of the temperature increases are magnified with latitude increases. A number of these models suggest that while the global average might only be one or two degrees, we might be looking at as much as four and five degrees in temperature rise at the middle or higher latitudes.

What does that mean in terms of the hydrologic cycle? Most of the models also show that there would be an increase in the amount of water vapor in transit in the cycle. In fact the globe would be wetter if we saw one of these increases in temperature.

The problem is that nobody is sure how that change in the hydrologic cycle would be distributed. Some of the models suggest that North Africa and Europe would be wetter, and that much of the United States would be dryer. Most everybody is convinced that we are going to see a shift in global climate. I do not think anybody sees that mankind will cut down on combustion of hydrocarbons. As a consequence of that, we are going to see a change in global climate. The question is what are we going to do about it? I do not think anybody believes we can stop it. So what are we going to do in terms of the consequences.

With respect to the CO_2 problem, it is really man that is impacting the climate. There is no doubt about that. It is not a natural phenomenon we see. We are looking at man in some sense changing the climate for the future.

The other problem that falls in the same area is nuclear waste. We are attempting to make projections of 1,000 and 10,000 years based on little data, particularly when we look at those data in the time domain. We are not going to have much data to try to verify those models, and yet we are going to try to predict far into the future and make decisions based upon those projections.

I would like to make just a few remarks about the health and well-being of this Division, the Water Resources Division; and my own perceptions and aspirations about what I think this Division should be.

If we look at our organization, we see some unique advantages. One is that we have been around a long time. The Geological Survey has been there—and expects to be there for some period of time. We have a certain degree of continuity. We have a degree of credibility. We certainly have an impartial outlook. We have a national organization that we can utilize, and we have a reasonably large staff. Our credibility is based to a large extent upon the scientific nature of this organization, that we are indeed a scientific organization and that we look at ourselves as scientists and aspire to be scientists.

Before taking the position of Regional Hydrologist, I published a very controversial article in the Water Resources Bulletin, in which I defined the gray and white literature. As you may recall, I divided the literature into those things that one could find in scientific literature anywhere—journal articles, water-supply papers, etc. Then I defined the gray literature. I might quote from a part of that article: "In my opinion, in the past 10 or 15 years, we as an organization have lost sight of some of the scientific traditions of the Geological Survey. We have become responsive to producing projects solely for the supporting agency on time and, with rare exceptions, we are not viewing ourselves or our employees as scientists achieving goals to further careers in science or, even worse, we are not attempting to further the scientific reputation and stature of this Division."

The situation in the Western Region, when I took over in 1981, was not much different from what I saw for the entire Division. In fact, in 1981, the Western Region produced two journal articles. That was the extent of the outside publications and, indeed, the total number of publications in the Western Region, exclusive of abstracts which was something like 80. It was not terribly large. That did not appear to be the profile of a scientific organization, and I guess I stated my view rather clearly. Of in-

terest though, was what would happen if we made a concerted effort to turn this around. Could we change the situation and make the organization, at least in my own view, a much more scientific organization?

With some concerted effort on the part of the management, we changed that situation from what it was in 1981. In fact, the number of reports roughly doubled; the number of journal articles went up from two in 1981 to nearly 60 in 1985. The number of abstracts—and the abstracts represent a measure of participation of individual scientists in a scientific society—grew dramatically as well.

Gray literature remained about the same through 1984. In 1985 we see that we have decreased the gray literature somewhat. I had expected that would happen, but it took longer than I had expected.

As Regional Hydrologist, or as ex-Regional Hydrologist, I take a great deal of pride in this result. But I do not discuss it here because I am particularly proud of it. I discuss it here to say that this growth in journal articles is an expression of the interest in being truly a scientific organization. If we decide that is the kind of organization that we would like, it is certainly possible.

We have doubled the report output in four years, with fewer resources. We have doubled the productivity of the Western Region with about the same amount of money and fewer people. I think we did it because we had a message that we were looking for a scientific organization, that the Region as a whole bought that message. Certainly, the District Chiefs bought that message. A number of the troops responded to that message, and they responded positively.

The results of what happened in the Western Region over the past 4 years demonstrates that if we want the Water Resources Division to be a scientific organization, it is indeed possible. There is no question about it. I think the tradition is to be a scientific organization—that is within the traditions of the Division, within the tradition of the Geological Survey.

I see this Division in a state of transition. If we look at the people in authority in this Division, we see a changing of the guard. People now in authority will not be here in 5 years or so. There will be a number of younger people taking over this Division. My statement to you is that the health and well-being of this Division is in your hands. If we want this to be a scientific Division, it is possible.

If we decide that is what we want, many of the other issues that concern us will fall into place. Once we make this decision, a number of other decisions are simply frosting on the cake. If we do not decide about what we aspire to for this Division, all the other things are particular problems.

I would like to finish on a philosophical note. I started by saying that I thought that the traditional hydrologic cycle was no longer operative. We have to look at an active cycle in which man is an integral part. The active cycle is really a corollary of the sort of modus operandi of society. We have a philosophy in the world that we can modify the natural environment to support a very large population, and the size of that population is poorly defined. We have a belief that science and engineering will make all of this possible, and that we can support this very large population with no real trauma and anxiety. I suggest in closing that the jury is still out on that belief.

PERSONNEL RESOURCES—PANEL DISCUSSION

Moderator Remarks

T. J. BUCHANAN, Assistant Chief Hydrologist for Operations, Reston

We all recognize that people are the most important resource that an organization has. We would like to take some time this morning to talk about the people resources of the Division, and we are going to do this with the five panelists that you see on your agenda. Each of the panelists will take about 10 minutes for a presentation and then, we hope, for some discussion.

I am going to give you an overview of where we are and some of our plans. Vern Schneider is going to talk about the hydrologic data program. Roger Wolff is going to talk about the research activities. Bob MacNish is going to discuss scientific and technical skills needed by the Division's operational program. Irv Kantrowitz is going to talk about staffing, career development, training, use of cooperative students, and use of full time equivalents (FTE's).

Think briefly about the past in WRD as far as our human resources are concerned and the changes that have taken place. In 1977 we had 1,471 full-time professionals in the organization. By 1980 this had increased to 1,600, and presently we have 1,660 full-time professionals. I think this is a sign of how we have increased our productivity with a dwindling FTE. I believe we have taken those full-time positions from our support personnel and attempted to have our support work done by using more temporaries, by using some contractors, by using cooperators, and by other such devices.

We may be able to squeeze a little more out of our FTE's but we probably have done about as much as possible in increasing our number of full-time professionals.

When we look at the disciplines in the organization, some of the data are encouraging and some are a little bit discouraging. For example, in 1977 we had 665 engineers and in 1985 we have 551. I do not think this reflects a need for fewer engineers; I think it reflects the fact that it is difficult for us to hire them—that we have not been able to compete. But we have to compete because we have to reverse the trend. Engineers bring us a good background in the basic sciences of math, physics, and chemistry.

Another dramatic shift is in biologists. In 1977 we had 134 biologists, and today we have 233. I think this indicates WRD is looking at other parameters and broadening the multidisciplinary approach to our studies.

Some other interesting statistics show that we went from 160 to 178 chemists, from 564 to 636 geologists, from 139 to 198 physical scientists, and from 36 to 47 geochemists, a trend that we have to continue.

We have to remember that attrition in the Division is about 150 people a year. Of that 150, usually about 64 are professionals; 30 of those we lose by retirement. So, even if we have a constant personnel ceiling, we still have 64 professional vacancies each year.

We also did a staffing analysis recently at the urging of the Director. We looked at the GS-12's and above and found that we had 1,048 in the organization. Right now, 114 of those 1,048 are eligible to retire. Thirty-six more become eligible in 1986. By September 1986, 150 people at GS-12 and above will be eligible to retire. By 1995, half of the 1,048 will be eligible to retire. By 1995, all but one of the SES'ers in the organization will be eligible to retire; in fact, I think some of them are eligible to retire now. In 1995, 39 of our 52 GS-15's will be eligible to retire. In 1990, 45 of the 70 GS-14's will be eligible to retire. All of the senior scientists at GS-16 and with PL-3014 appointments will be eligible to retire by 1995. In the scientific area, 23 of 51 GS-15's will be eligible to retire and 50 of 97 GS-14's.

In the next 10 years, possibly more than half of the management and technical leadership of this organization will be retired. Almost 45 percent

of those above GS-12 and 57 percent of those above GS-13 will be eligible to retire by 1995. If we look at GS-14 and above, 64 percent will be eligible to retire by 1995. As a result of the staffing study, the Manpower Resources Committee put together a staffing action plan consisting of nine different activities.

One activity, and I think this is very important, is to continue the recruiting by the Districts and the National Research Program (NRP). I do not think we have any criticism of where we are. I think we have done fantastically and I think the Districts and the NRP have really brought well-qualified people into the organization. We want to continue that.

We have identified some disciplines that we think are important in the organization: organic and inorganic geochemistry, sedimentology, computer science, statistics and mathematics, soil chemistry and physics, and transport modeling. We have to continue to hire hydrologists but the disciplines I just mentioned are going to address some of the major programs in the future.

Then we identified some universities to recruit where we have not been successful in the past. We decided to ask two people to be responsible for each university and those memos went out a couple of months ago. I am delighted to say that everybody we asked to participate has agreed. Nobody came back and said, "I'm too busy; I can't take the time." Everybody has been enthusiastic about it and we really appreciate that. I will just list the schools for you: Cornell, Hampton University, Johns Hopkins, Rutgers, MIT, NC State, LSU, New Mexico Tech, University of Iowa, University of California at Berkeley, University of Washington, and the University of Waterloo. You might say, "There are better schools than some of those." But those are the schools where we have not done well and where there are good students in the disciplines we need.

The people in WRD we asked to be responsible are District Chiefs who are close to the universities and a researcher or someone from Headquarters who has good faculty contacts. We are asking them to try to find one or two people for us in the coming year from each of those universities.

We also have decided to increase our post-doctoral program. We have had some success with that in our research program and Roger Wolff and the research program are going to increase the number of post-doctorals that we employ. We are also going to hire four master's candidates each year for the next few years, and we are going to put them in the research program for 2 years. After 2 years we are going to transfer them to the operational program. We think there is some benefit to this in technology transfer. We know that our training program and consulting by researchers fosters technology transfer. Putting some people in the research program for a couple of years and then moving them over into the operational program will be a way to increase the flow of knowledge from our research program to our operational program.

We also are going to increase the use of co-op students. We think this is a valuable tool. We are developing a plan to have the Water Resources Research Institutes identify good students for us. We have a nice working relationship with the Institutes now and I think that we can use the working relationship with the Directors to help us find good students who would be interested in the Survey. Jim Daniel has put together a computer skills staffing plan to bring to us the computer skills that we need in this organization. These are some of the steps that we are taking in staffing to help replace the people that we will lose in the next 10 years.

Science and Research

R. G. WOLFF, Chief, Office of Hydrologic Research, Reston

Water—it's quantity and the factors affecting its quality—will be of increasing scientific and public interest for the foreseeable future. There are some things on the horizon that may help us with the coming energy crisis. There are some genetic engineering things underway that will help us in health matters, food production, etc. But no matter what we think about, water is still the basis of what makes this a unique planet. The problems that will be associated with water will be with us over geologic time.

That, coupled with the thing that makes this a really exciting organization, makes what we do and what we plan, very important. As we discussed yesterday, this is of course, the people. That is the topic of this panel.

I think we need two things in the people that we will be looking for in the future. One is we need people with excellent capability, good basic training. Second, once we lure them to come to work with us, we need to provide the proper environment for them to perform efficiently. That includes acquiring what I call the USGS philosophy, the good science, and impartiality. Considering the purpose of this meeting, most of us have been around long enough to have acquired that philosophy, or else we would not be here.

It would be nice for a lot of our newer people to hear Abel Wolman give some of his discussion, the Director impart some of his philosophy, the Chief Hydrologist, all those speakers who imparted some feeling of our reputation. That is what I think makes this THE organization.

What I came to say deals with more than just the National Research Program (NRP). It deals with all of the good science and research of the entire Division, which is the basis of the organization. To keep attracting the good people that will make this organization grow, we must find ways to increase our interaction with academic institutions. I do not see any other way. They are the organizations that do the preliminary screening to get the capable students. They provide the necessary environment for stimulating inquisitiveness. They give people some of the basic tools that we need and that the whole discipline needs.

We feel that if we can hire these good people, we have that special something to make those people grow. The question really is: How can we improve that interaction with the academic institutions? Certainly we have had good relations with the institutions in the past. The new relationship that we have with Water Resources Institutes provides us an opportunity that we must pursue.

As Herb Snyder and Gerry Orlob mentioned yesterday, we should be increasing personnel interaction in both directions—intergovernmental personnel actions, sabbatical leaves, and whatever. We have a lot to offer to the academic institutions and vice versa.

Another thing that works well for us is the close physical relationship we have in some of our situations, such as the University of Arizona with our office in Tucson and the Menlo Park Research Activity with Stanford. There are many others. Another approach that we are working on is the staffing plan regarding the post-doctoral program. I see no reason why we cannot have them in locations other than the research centers. In other words, we can have them work in some of our District offices, as well as at the research centers.

Linda Friedman has recently come to work with me and takes care of our post-doctoral program. If you have any questions, call her. The main thing we need to do is get activities listed in the National Research Council (NRC) booklet. The system has worked well for us in the past: we can observe the individual and vice versa. It provides the individual an opportunity to do good work under our stewardship and we get something out of it. There is no obligation in either direction. The nice thing is that this system does not take any FTE's. It is a contract arrangement through NRC; we give them the money and they take care of all the other details.

Another thing that we need to increase is use of professorial WAE's—professors in the academic institutions that work closely with us. That seems to have declined somewhat because of the Survey's rules regarding conflict of interest. Most of the professors can make more money consulting, and that has hurt us.

To summarize, I did not come up here thinking that I would present any new ideas. I would like to restress more succinctly some of the things that Dr. Wolman, the Chief Hydrologist, and John Bredehoeft have said. If we can attract and keep the well-trained, capable people who can tolerate the good science environment, that will resolve our problem. It is a continuous process. To maintain our stature, we must find better ways of working closely with academic institutions to get the people we need.

Data Collection

V. R. SCHNEIDER, Chief, Office of Surface Water, Reston

My job on this panel is to speak briefly about the hydrologic-data collection program. The hydrologic-data programs are a complex series of activities performed by highly qualified professional and technical personnel. The capability to perform these activities on a routine basis is one of the unique functions of the Geological Survey. It is a function that has evolved with time. The cost to replace this capability with another organization such as a contractor would be enormous and probably prohibitive.

Hydrologic data collection has become increasingly expensive, however. It has been shown that we have succeeded in holding the cost of gaging station operation level in constant dollars. However, because cooperators pay in real dollars, the data-collection costs receive constant scrutiny and review.

The cost components of a data-collection program include salaries, equipment, travel, and overhead. In recent years, we have devised methods to evaluate the overall accuracy of our streamflow information as well as the gaging station monitoring system. For example, we are now completing studies of the cost-effectiveness of the use of satellite telemetry as the primary sensor. This is the first attempt to measure the impact of the introduction of equipment on cost and accuracy. In all of these studies, it is necessary to postulate the efficiency and productivity of personnel in using these new instruments. It is also necessary to estimate the benefits in terms of improved accuracy attributable to the new equipment and practices.

The preliminary results of a study in Illinois show that the cost of using DCP's depends on how cost of the equipment is amortized after purchase and how much of the network is converted. The study also has shown which part of the network to convert first, in the case of a partial conversion. As we gain experience in the use of telemetry, the data needed can be measured and factored into this evaluation.

These studies are continuing in Nebraska, South Carolina, and Massachusetts. Each of these States has different characteristics, different lost-record experiences, and different types of streams. In about six months, we anticipate having all of these studies complete and we will be able to provide a better picture of the benefits of using DCP's as the primary sensor.

Other equipment in the pipeline includes smart electronic data loggers, including the ground-water minimum recorder. DCP's are being rapidly introduced. Districts and projects are experimenting with Campbell 21's. Arizona is converting one field office totally to DCP operation to test its effectiveness in that setting and to attempt to operate on an event basis.

The challenge in personnel management is to acquire and equip people with skills necessary to use the new technology effectively and to accomplish the WRD hydrologic data-collection mission. In the short term, we will make the best possible use of available personnel, provide additional training, and accomplish this job as we have always done. In the long term, personnel will become increasingly skilled in using electronic equipment.

The recruitment goals discussed this morning address the needs for new professionals. To the extent possible, these new professionals should receive training in hydrologic-data collection and records computation. Certainly some of these professionals will choose a career path and become the future managers of the hydrologic data-collection activities. It is, in fact, an exacting and challenging task.

I believe that through the use of network-evaluation tools, cost studies, training, timely introduction of the new technologies, and the recruitment of appropriately skilled professionals and technicians we can continue to provide a cost-effective hydrologic data-collection program.

Needs, Constraints, and Resources

R. D. MACNISH, District Chief, Arizona

I have divided my presentation into responses to a few questions. The first is, "What personnel do we need?" This question is not simple to answer anymore. The first thing we have to do is identify the overall data and information needs in the area where we are working. Once upon a time, we were the only game in town. Once we had that task accomplished, it was easy to identify the people and skills we needed to accomplish that work.

Today there are many of other actors in the hydrologic-data and information game. So the next step is to evaluate outside interests and capabilities of doing the work, and also look at some kinds of work that we might encourage outside interests to do. This is the biggest part of the problem. Once we have identified all of the data needs and information needs and evaluated and encouraged the outside agencies to take on what they can, we end up with a set of residual data and information needs. From this point on, it is relatively easy to identify the skills and people needed to perform the job.

Second, "What are the constraints?" The constraint that everybody talks about is the full-time equivalent (FTE) limitation that we are all up against. There are some alternatives that we can consider using. One of them is cooperator capability. About 7 years ago in Arizona, we had six FTE's involved in ground-water basic data collection. At that time, we encouraged our principal State cooperator to staff up and develop capability in ground-water basic-data collection. We provided an appointment to him for about 2 years to train these new people and to provide quality assurance on the program.

Today, we have three FTE's involved in ground-water basic data collection, still providing quality assurance to the cooperator, reviewing the data that are produced, and training the people that are hired. Today we are receiving about twice as much ground-water basic data as we did 7 years ago and our FTE's have been reduced by one-half.

Roger spoke of encouraging students to come into the Division. Many of us have used the student appointments. The "W" appointments, or the so-called excepted, are excepted from the personnel ceiling and are very useful to bring undergraduates into the Division. It gives us a chance to look at them as potential employees, and they also get a fair amount of work done for us. There are some disadvantages. The turnover is relatively rapid, and we lose some of our own full-time resources training these people. The Minority Participation in the Earth Sciences (MPES) program appointment is not used as frequently but actually it is a much better appointment in that it goes from high school through PhD. It is slightly more difficult to set up. But if you have an opportunity, it can provide a longer term employee and can work out very well.

We recently concluded a cooperative agreement with the Navajo Tribe of northeast Arizona. One of the elements of this agreement is that the tribe will hire two technicians and assign them to our Flagstaff offices for 2 years. We will lose some personnel resources in training these hydrotechs but, over 2 years, we expect to have a net benefit in terms of work produced both in FTE's and in dollars. Eventually, we envision that this program will parallel the program that I described earlier. We also are negotiating with the Potligo Tribe for a similar arrangement. Given the number of Indian tribes in Arizona, we may make a serious dent in our ceiling limitations.

Another way we can approach this problem is to improve

our existing resources. In the near term, we can look at training and image enhancement. *Unfortunately, training is something that we consider cutting when the budgets get a little bit tight. Actually it is the last thing we should cut.* Almost all our people want to do the best job they possibly can. If we make a substantial and continuing commitment to training, we will provide them the tools to do that and they will respond.

Image enhancement goes back to something that John talked about yesterday—and I used the same figures that John used. We had a bounty system on reports in the Western Region. The bounty system was spectacularly unsuccessful and we no longer use it. Nevertheless, we have substantially increased the productivity of our professional scientists.

Most of us found that the increased production of reports, which was primarily the increase in production of journal articles, had no substantial cost for the Districts. It simply was a matter of repackaging material that would have been included in another report. The amount of personnel resources involved in producing journal articles versus slightly longer WRI's was so minimal that it was not significant. We all are operating with less personnel and we are producing significantly more reports.

In the mid-term, we can redirect effort from service work. I do not mean that we need to throw out our cooperators and our other Federal agencies (OFA's). We do need to minimize our FTE commitments in service-related work. We need to learn what that minimum amount of data is and commit only enough manpower to provide that minimum on the operation and maintenance stations.

In the far term, we can work to improve the labor pool. An example of this is at Langston University in Oklahoma, a historically black university. Here, a node of the Distributed Information System (DIS) has been installed for the university to develop an educational program on computer applications in the earth sciences. This will provide the Survey an opportunity to attract and hire students down the road. It will. It is one of the neatest ways of addressing the Nation's objectives in terms of equal employment opportunity. Even if we do not attract these people ourselves, we will have increased the labor pool of skills in that field.

Hiring Practices

I. H. KANTROWITZ, District Chief, Florida

I would like to address the lack of recent hiring, our need to overcome it and some potential dangers of our current hiring practices. We have not hired many people over the last few years and attribute that mostly to the personnel freeze and a relatively stable budget. But the increased cost of doing business has been imposed on top of that. In Florida over the last 5 years the budget increased by 20 percent, but the number of full-time and part-time employees decreased by 20 percent. The trends went in opposite directions. The money that was freed by the loss of personnel was used to install and maintain four Prime minicomputers. That money also pays increased rent and it pays for $1,500 laboratory analyses instead of the $150 analyses that we had in the old days. Our work is becoming increasingly complex and we need the new skills that only highly trained, new professionals can bring us. I do not know if we can solve the dollar problem but we certainly have to work hard to overcome the FTE paralysis.

We start each year facing gloom and doom. We are going to be over ceiling, we cannot hire, we have to cut back, and so on. But as the summer comes, we find plenty of hours. If we do not spend them quickly we may "lose" them next year. So what do we do? We hire four summer employees. I have nothing against summer employees; I know at least one Regional Hydrologist who started as a summer student. I started as a field assistant, so HFA's are very dear to me. After this exercise is over at the end of the year, I always feel like the person in the V-8 commercial. I slap myself in the head and say, "Gee, I could have hired a geochemist for a year instead of four HFA's painting a recorder shelter." We need these kinds of specialized people and we have to learn to live with our personnel ceiling. We have to learn to manage; we have to look at the attrition rate. We have to overshoot the mark early in the year so we can hire people for the full year. We cannot hold hours back the way we hold money back. Traditionally we hold money back and do a lot of spending at the end of the year; hopefully it is wise spending. But we cannot spend 2,080 hours the last day of September and buy a solute-transport modeler. We have to get that modeler on board October 1 if we are going to use those 2,080 hours effectively.

Other agencies have looked at this problem and perhaps we should learn from their experience. If, after learning to maneuver within our ceiling, we find we have a real hour shortage, then we have to fall back on direct services, contracts, IPA's, and so on. These are the quick fixes. They get the job done but they do not improve our scientific reputation. We can, however, use these mechanisms to free hours to get the first-class scientists we need. First-class scientists come from first-class universities and we have to make our contacts in those universities, capitalizing on our new relationship with the Water Resources Research Institutes.

We have to build a recruiting network and we have to work for the entire Survey. We have to identify quality graduate students early in their academic career so we can be in a position to hire them at graduation. Maybe we should circulate information on potential hires the way we circulate the names and the skills of the people going into our graduate-school program. Then we can bid for these people a year in advance—if we can identify them a year in advance.

As with the new hires in recent years, those of the future almost surely will have advanced degrees. Their fields of study will be specific and narrowly focused and we are going to need their skills immediately. We are going to throw them right into project work. Our experience over the past few years, with the few people we have hired, is that they hit the ground running. They are very highly trained and we can expect immediate results from their work. But, if we continue along that path, we are going to have a group of ground-water geologists who have never put a piece of blue chalk to a steel tape or run a pumping test. We are going to have surface-water engineers who have never used a tag line and we are going to have water-quality chemists who have never collected a sample. There is danger in becoming too highly specialized. Because we need these people right away, we have not planned an orderly training program for them. We have always talked about putting new professionals into the data program. We have paid a lot of lip service to that concept. But invariably we find we have a project vacancy someplace and we pull that person out of the data program and put them into a project. Certainly we are going to do that in the future because of the need for skilled people.

We are not going to hire generalists in the future. We are not going to hire people and say, "This is our library. Read these books in your spare time and become a hydrologist." That is the way I was trained. Now we are hiring very talented people, but with very specific skills. They are not going to have the total perspective of the Division and they are not going to have a broad understanding of the scope of our work. We require that our supervisors have 80 hours of training and 8 hours a year of refresher. We certainly can put that kind of effort, and more, into our new hires. We can make sure that they have short-term assignments to multidisciplinary projects.

We have to make a real effort to cross-train and broaden these new professionals. Most of the bright, new people coming into the

District program are going to go into the research grade evaluation (RGE) system. These people may stay in the system and progress as high as they can in the scientific line. But some of them are going to become section chiefs, District chiefs, and so on. The Chief Hydrologist 25 or 30 years from now is obviously going to come from the ranks of today's new hires. I think it is important that the new scientists we bring into the Survey develop a real feeling for the broad scope of the organization. We have to prepare them for management and leadership roles.

I have been talking about District operations, but the same thing is even more true of the National Research Program (NRP). The NRP scientists are even more highly specialized and, while we certainly have to do basic research, some of our research should have some practical applications. I think it is important that our research people know what the rest of us do for a living! Somewhere along the second or third year of a researcher's career he or she should be assigned to a District project. He or she need not physically move there, but should spend at least half a year working on a District project and then continue that relationship on an adjunct basis. This will insure the relevancy of our research and broaden the perspective of our NRP staff.

I would like to summarize what I have said. We have hired at a reduced rate over the past few years. At the same time, our need for hiring highly trained people has increased. So, we have to manage our FTE's and we have to use contracts and direct services so that we can hire the people we need now and the people we are going to need in the future. *Because it is unlikely that we will ever be able to hire all the people we need or all the people we can afford, and each hire is going to be a very precious commodity. We have to prepare these people to assume leadership roles for the Survey in the future.*

PROGRAMMING—PANEL DISCUSSION

Moderator Remarks

M. E. MOSS Assistant Chief Hydrologist for Research and External Coordination, Reston

The panel on programming may be a more difficult challenge than some of the other panel topics. I think this because (with the comments of yesterday by the Assistant Secretary's office, the Director, and the Chief Hydrologist) it leaves us very little maneuvering room in the short run. Also, the Chief Hydrologist's memorandum on programming for the next fiscal cycle, which is just now beginning for 1988, shows that things are not like they were.

I do not know what my fellow panel members are going to say because I have not had much chance for interaction with them. I prefer that we try to maintain spontaneity. So, I will sketch how programming has been interpreted in the past within the Water Resources Division. Then perhaps I can draw a few comparisons with of where we are now, particularly in light of the Chief Hydrologist's memorandum, and then let the panel carry on from their own individual perspectives.

With that, I would like to go back to the summer of 1984 and transport us to the equestrian competition in the 1984 Olympics. You can recall the horses had to take off and go over various styles and heights of hurdles. Some were low, some were high, some were multiple, some were at the bottom of the hill where the rider and the horse had to negotiate a downslope and then immediately spring back up. Some had water hazards, and that is perhaps the most applicable part of this analogy.

The first hurdle is one that is usually jumped yearly between November and late January. That is within the Division. A number of horses are lined up by many of the people in this room and many of your staff members. Many of the horses leave the gate all at the same time. Then I guess my analogy breaks down because in the equestrian events they run individually. The horses take off and many of them are wiped out at the first hurdle. The senior staff usually meets sometime in mid-to late January to express their thoughts about the horses that they want to go over the first jump, which is the Chief Hydrologist.

The senior staff offers the Chief Hydrologist their thoughts. The Chief Hydrologist, with possible input from the Division's program officer, puts together his thoughts, and then he passes those horses that can jump that hurdle. Those horses then are directed to a higher hurdle on the seventh floor, the Director's Office. The Director's Office lets certain horses through, at least in a provisional manner. Then he gives the Chief Hydrologist and his staff a chance to rebut (if that's the proper word) the selection of the horses that can get over that hurdle.

Those horses then are passed on to the Secretary's Office where they are filtered in a different manner and perhaps other horses added that somehow had been lost in the past. The Secretary's Office imposes a certain philosophy from the President's Office, which was available but possibly misinterpreted earlier by the individual agencies and divisions within those agencies. After this hurdle, the remainders are passed on to a super clearinghouse, the Office of Management and Budget.

If the horse is still in the running after this hurdle, it goes into the President's budget—almost a year after the senior staff first discussed it with the Chief Hydrologist. The budget, of course, then goes to Congress. The House of Representatives, is charged with getting it off the ground. That is another hurdle. Things may be added, things may be subtracted, and things may be modified. After that, the horse may not look like the horse that came up to the hurdle.

Concurrently, the Senate also is in action. Here again the hurdles are different—different heights, different widths, different witnesses. Given that the horse does not look the same as it comes from the Senate as it does from the House, it will go to Conference Committee. Then, if the horse has been modified to be acceptable to both sides of the Hill, and the budget is passed in both Houses of Congress, it goes to the White House. Again there is a potential that the President himself can still whack that horse at the final slot. If the President signs it, our horse is a finisher.

That is about the way it goes, and it takes more than two years for a horse to run the event. During that two years, there may be an election, and the rules of the game may change in the middle of the course.

So, that is what we have to put up with. However, over the past several years we have developed a bunch of good horses. We have a stable of good horses in terms of a lot of proposals that can run some good races if we are ever permitted to put them on the starting line again.

National Water Quality Assessment

D. A. RICKERT, Chief, Office of Water Quality, Reston

I would like to pull together the history of the National Water Quality Assessment (NAWQA) proposal. Then I would like to discuss what needs to be accomplished over the next 6 or 12 months to prepare for NAWQA and to make it a successful program.

The program had its inception in the repeated questions that Phil received during Congressional hearings. Questions generally asked were, "What is the quality of the water in the United States?" and, "Is water quality improving or deteriorating?" These questions were asked 2 or 3 years in a row, and Phil could only reply with general information, but no real answer. Next, Jake Rubin and others put some principles together describing a program to answer this type of question. In January 1985, the Division decided,

although the report was not completed, that we should proceed with an official Management Implementation Plan (MIP) on NAWQA for the FY 1985 budget. Bob Hirsch, Gordon Bennett, and I put the MIP together, including cost estimates, to achieve the program envisioned by the Rubin committee.

We had two alternate funding levels on the MIP, the largest being $64 million per year at full implementation. We had many discussions with the Director's office and the Program office about reaching for such a high level, because the entire Division budget from all sources is about $240 million. We finally decided to go for the $64 million funding level.

Next, as the MIP went through the budget process, we developed an internal program document that began to define our study methods. This document was very specific about the approaches for surface-water studies, and non-specific about the ground water studies. Later, we learned that Interior asked the Office of Management and Budget (OMB) for $5 million to plan an assessment program in FY 1987. Yesterday, Phil said that if both of these came true, we might have a $10 million program in 1987.

As these developments were going on externally, internally we started thinking about how to initiate the surface water and ground-water studies. For surface water, we would choose a certain number of basins to assess on a rotational basis. We could do 3-year studies, and write a comprehensive report the fourth year. We selected four basins to begin in FY 86: the Yakima, the Kansas, the Kentucky, and the Upper Illinois.

In ground water, a lot of thinking went into ways to get this program started. We decided to try a number of different approaches for FY 86: expand or enhance the regional studies under Steve Ragone's ground-water contamination program, enhance water-quality-data collection in studies where the ground water physics is defined, begin two prototype study unit investigations; and begin research on optimal search techniques.

Bob Hirsch and others are spending a lot of time briefing organizations about the program. These organizations include the National Academy of Sciences, offices of the Environmental Protection Agency, agencies in the Department of Agriculture, and the Fish and Wildlife Service. At the same time there is a committee inside Interior attempting to determine who is going to use the information, and the likely value of the information.

Let me now switch to what the Office of Water Quality is doing to prepare for the program. First, there is the laboratory reorganization. The reorganization is independent of the new program, but a lot of the present thinking is being pushed because we eventually will have a National Water Quality Assessment program. We see a great need for enhancement of trace organic analysis capability, in water, sediment, and tissue. We also need considerable enhancement of sediment chemical analyses for nutrients and trace metals.

We are establishing a Methods Development Section in the new lab to adapt existing technologies and promising new technologies that are nearly ready to use. We also are establishing a liaison group to facilitate communications between the Districts and the laboratory. Personnel for the liaison group will come from the Operational Services Section. Senior analysts at grade 12 and above will spend as much as 30 percent of their time working for the liaison group. These people will be available to help Districts develop projects, interpret data, write reports, and review reports. This gives the contact between the field work, the laboratory analysis, and the data interpretation that we have been missing. We also hope it will attract and keep high-quality people in the laboratory, because they will not be there just to grind out analyses.

In addition, we're going to develop a quality-assurance group outside of the laboratory that encompasses field, laboratory, and data storage/retrieval issues. We must link these three activities. We will need a very professional quality assurance program to be successful with NAWQA.

Another issue is the National Stream Quality Accounting Network (NASQAN). The options are: keep the network as designed, incorporate it into NAWQA, stop it completely, or redesign it. At present, we want to keep NASQAN but also to put equal emphasis on sediment chemistry, to increase periodic sampling frequency loads to a monthly frequency, and to initiate high-flow event sampling. These are all costly, and achievement will require a sharp decrease in the number of NASQAN stations. We have initiated a NASQAN evaluation study to determine which stations are most important.

What is the relationship between the Surface Water Toxics Program and NAWQA? Briefly, the Surface Water Toxics Program will incorporate basic and applied research into the occurrence, distribution, movement, and bioaccumulation of trace elements and trace organics. This will provide the principles and the methods needed for the trace-substance part of NAWQA.

New and different training courses need to be developed on stream, chemical, and biological processes; on trace element chemistry; and on trace, environmental, and organic chemistry. Finally, we are going to have to hire new types of people to conduct NAWQA. These include people in organic environmental chemistry, some trained in the principles of testing.

New Mission of the Division

D. W. MOODY, Chief, Office of National Water Summary and Long Range Planning, Reston

My assigned task this morning is to discuss the new mission of the Geological Survey, to discuss factors that will influence the future workload, and to discuss the future opportunities for the Division.

I will not try to defend the notion of multi-year or longer range planning. I will simply say that I think it is worthwhile. It is worthwhile because it forces us to think. It forces us to think about our future, our purpose in society, our challenges, and the directions we would like to pursue. We share those perceptions with each other, fully recognizing that conditions change and our direction will change over time.

It has been pointed out that many factors influence our future and that many of them are beyond our control. But we have choices as to our response to those influences—the mix of personnel skills, the allocation of efforts, and so on. These choices are available. The trouble is that they often are made incrementally over time at all management levels. That, in the end, will determine what WRD is in the year 2000. It is you, making your daily decisions, who will determine what we look like.

Last year, the Director formed a team of Division representatives to reexamine the goals and missions of the Geological Survey. Bob Hirsch and I represented our Division in that task and the product was distributed to your cooperators. That product contained a series of goals like water assessment, water use, hydrologic processes, and so on. They are very broadly stated. They are very general, topical areas of activity. We are now being asked, by the middle of January, to come up with a set of subgoals and objectives that support those topical goals.

This should be fairly straightforward at the Federal level, but what about the co-op program? I visited Ted Arnow a few weeks ago at a meeting of State cooperators to review the District's long-range plans in response to encouragement from Al Clebsch that Districts in the Central Region consider possible programs for the next decade or so. I was struck by their useful experiment at getting the cooperators to discuss their information needs in terms of

District 10-year planning. It offered some interesting points for collaboration. I think that the document will provide a reference for information on our mission and give us a chance to think about the future.

A number of points have been made over the past day on characteristics that will influence our future. I think I would start with population as the driving force behind water demands, land-use changes, and the driving force of our programs. Where is water-use demand going to increase? What are the patterns of non-point and source discharges over the next decade, and what will they look like?

Interesting technological changes of all sorts are occurring, which are interesting. Biotechnology promises to eliminate chemical pesticides, perhaps in the next decade. That would eliminate a major source of non-point ground water contamination. We have new organic chemicals, new composite materials. What is going to happen to the cathode ray tubes when you junk your home computer and the goodies inside those tubes leak into the ground?

We have fiscal constraints which already have been mentioned. The growing role of the States in water management necessarily decreases our role. Then water scarcity and competition, driven by population growth, lead to one of the fundamental changes in water management. That is a truly institutional revolution in water law, particularly in the west. You see the eastern States becoming more like western States with systems for ground- and surface-water withdrawals. You see many States on the verge of passing legislation that will eliminate the obstacles of transferring water from one point to another. This will open possibilities for water markets, water trades, water leasing, water banking, and a whole variety of other non-structural measures to alleviate water-supply problems, as opposed to developing new reservoirs and other structural measures.

We talked about water quality almost continuously over the past few years, perhaps to the point where we forgot about water quantity. If you accept Walter Langbein's idea on the increasing or decreasing reliability of surface-water systems, as a result of increasing withdrawals but no increasing capacity, there is some reason to become a little alarmed. Of course, John Bredehoeft pointed out that the transfer of water from agricultural use to other uses will free a considerable amount of water.

We are going to change the pattern of withdrawals, diversions, and return points. We are going to change the pattern of waste loading and the types of waste as a result of these shifts. The water engineer at the State level is going to be sorely tested to look at the third-party impact of these changes. Every time we change the position of a diversion or a return flow, and the quality of that return flow, we alter the system. What does that say? We need more information on the quality impacts of the loads, information on time and travel, on evapotranspiration, on the flow forecast, and the short-term flow forecast.

There is room for a national water-quality/quantity assessment. Quantity should be part and parcel of an assessment at the local or regional level. I can see water-accounting schemes, such as those being used in the upper Missouri River, that would allow changes in water withdrawals and the rest.

Can we become the Nation's water bankers? This has begun to be suggested in the Delaware. As we move water back and forth between States, we find that States do not trust each other. They would like a reliable, consistent, objective, scientific, organization to keep their water accounts. There we have the Geological Survey with our real-time data system, our modeling capabilities, our objectivity, and so on—all leading to the stimulation of more research in each of these areas. As we meter the water more and more precisely, the amount of tolerable uncertainty decreases.

An information clearinghouse is a possibility that many of you might not consider an opportunity. It is another burden, but it is a very visible burden. It is one that we have said we can handle. If we turn around and say we cannot do it, that would lead to some credibility problems in some areas of government. At the same time, this is an important issue. How do we cope with increased use in technology, remote-sensing geographic information systems, supercomputers for three- dimensional ground water modeling, and so on?

We must not become slaves to technology. We must master it and not lose sight of hydrology. I have an idea that right now we have become addicted to technology itself as opposed to what it does for us.

Water use—is it given? It is one of the most significant programs we have now in respect to water conservation. We are making progress in terms of recycling water and the use of that technology; this gives us quantitative information on that. I would add the quantification of return flows in terms of the quality in loads to the water-use program. That ties in very nicely with NAWQA and other such programs.

Finally, consider the standards and training in data collection for the States. The States, over the next decade or two, are going to spend more money than we are on ground-water contamination, surface-water quality, and data collection. Are we going to be able to use that information? I would say "yes," if we provide standards, coordination, and guidance as to the selection of that information.

Processes for Developing Programs

E. P. PATTEN, Chief, Office of Ground Water, Reston

When I was asked to address the processes available for developing programs, I was rather unsure as to how to do it. You District Chiefs, Office Chiefs, and Regional Hydrologists all make your living programming at the most basic and the most productive level. It seems to me that there are four properties of the programming process that we all should be aware of, and I will give some examples.

First, the programming process should be anticipatory. Of course, it is. The process is based on things that have been done in the past and the problems that have been recognized in doing those things. There is no better organization to anticipate the needs of the community than the Geological Survey. Probably our programming is strongest because of knowledge of the needs of local communities and the needs of many cooperators.

Second, the proposed program must be evaluated. Once having anticipated problems and needs, an evaluation is necessary. That, of course, is done day by day, year by year. But is this evaluation a better process than something else? How does any particular facet fit into the national program?

Third, it must be documented. Evaluation is fine, but documentation also is necessary. Documentation is required to set our ideas on paper in a manner that makes sense to others and to record our programming initiatives and hopes. They will be executed at a propitious time when the relevance of an initiative is recognized and when there is money around to pay for it.

Last, it has to be promoted. Once it has been anticipated, evaluated, and documented, that is still not sufficient for a new program to fly. The Office Chiefs, District Chiefs, and Regional Hydrologists have to promote it. The process is largely one of gaining consensus—convincing the Director, the Department, the Congress, and OMB, that this is an appropriate activity and time for the money being appropriated.

Marshall alluded to the hurdles in each of the steps in that process. That brings in a fifth component, one that none of us likes.

Our ideas, of course, are magnificently polished when they leave our minds, but compromise is a necessary ingredient. We see that all the time. The Chief Hydrologist wants a greater component of water quality in a ground-water proposal. The Department wants a greater participation by a sister bureau. The Congress has its own hopes and aspirations.

So, I think that is the basis of the programming process. Does it matter whether the process starts at the top and extends downward or does it matter whether the programming starts at the very basic levels and propagates upward? It does not make too much difference because ultimately everyone gets involved.

A few years ago we had a process that was much more formal than we have now, when the Districts were solicited for proposals for thrust programs. What we generally mean by a "thrust program" is something that is a line item or a component of a line item in our budget. Maybe a million dollars is the lower cutoff limit. I remember that because one year I had to read something like 124 proposals, as did many other people. Most of those proposals were in the $200,000 to $500,000 range. They were darn good project proposals, but they did not have the scope and the breadth of what was requested in the long run—national thrust-type programs.

The Chief Hydrologist has requested five, possibly six, topics to be discussed at the forthcoming senior staff meeting in January. Really two of those are on the same topic, so essentially there are four and there are interconnections. That is a top downward type of direction.

To give an example of programming success within the Survey, I think one of the winners was the Regional Aquifer System Analysis (RASA) program. The RASA was pretty much a top downward process. The chairman of the House Subcommittee on Appropriations suggested that it would be appropriate to define the regional aquifer systems as a drought component of the total national water supply.

The Division responded very quickly to that. Why? It had subliminally, perhaps, anticipated the need for such an activity. On the basis of the Professional Paper 813 Series (the summary appraisals of the Nation's ground water) it was pretty clear that those 25 or 27 documents had some things missing. One, they were based on river drainage basins, which was offensive to some of us ground water types. Two, they were not consistent in format; they were descriptive rather than interpretive. Also they had a myriad of other problems that we all recognized. Nevertheless, it was a good start.

When the RASA program was proposed, all of those ideas from throughout the organization were combined, evaluated, and synthesized. Gordon Bennett documented what he thought all of those ideas meant, argued it well, and the thing flew.

Another component of the programming process is who pays for it? There was a little money the first year but not nearly enough. So one of those dusty line items in the Division budget, the subsurface-waste program with about $1.2 million, was reprogrammed into the RASA program. The subsurface-waste program ceased to be; that money became part of the RASA base which grew over the ensuing years.

The toxic-waste program started from a multitude of small proposals that Headquarters evaluated and synthesized into a Management Implementation Plan (MIP). After that, Lenny Konikow had a tremendous amount of work and frustration with a MIP for the toxic-waste program. Through continued talk, better documentation, and extensive promotion, that program flew. What happened concurrently with the toxic-waste program? A program called Subsurface Waste (yearly budget of about $1.8 million) that had endured for about 8 years, was reprogrammed to support the toxic-waste program.

The new NAWQA program, which Dave spoke about more extensively, came from the top down. It came from the same chairman of the same House Subcommittee on Appropriations like a bombshell. What do we do? The Division and the Chief Hydrologist had anticipated, for whatever reasons, the need for a national water-quality program. That was not its exact name; it was called the perennial program. But Jake Rubin and his group, anticipating the Division's anticipation, produced a lengthy document for our view and discussion. Certainly it was promoted. It will be discussed at the forthcoming senior staff meeting. Attendant to the evaluation of NAWQA as the major program for the future is an evaluation of redirecting the RASA funds to this new effort. This is wholly consistent with the process that has gone on for other major new programs in the past.

Both Nick Matalas and Dr. Revelle mentioned evapotranspiration (ET) as something in which we should become more interested and active. Does ET make a thrust? It does not. But an evaluation of a particular and important component of the scientific inquiry can very quickly and very easily be inserted as a major portion. It requires evaluation by a number of scientists. Pick out the best elements—what is the goal, the direction, the objective of the activity? It needs to be documented and someone has to put those ideas on paper and promote it in a persuasive way. It will not support itself as a thrust program. But it can very well be an important element of an ongoing program. I will finish by saying that programming is a continuing process of communication.

Research

D. C. THORSTENSON, Research Geochemist, Northeastern Region

I will start by saying that I am a substitute for Ike Winograd on this panel. Where Ike brings close to 30-years perspective into the comments that we was going to make, I will not get my 30-year pin until the year 2007. I am one of the few people in this room who is actually going to have to live in WRD in the year 2000, so I am interested and concerned.

Ike's message, which I was going to deliver, has been preempted by Irv Kantrowitz' comments and the discussion they generated. I will simply try to summarize Ike's feelings and point out that the need for generalization is also recognized by a lot of people in the National Research Program (NRP). In an area of continually increasing specialization, we also face a continually increasing need for generalization. The concept has already been discussed.

I get to ad lib a little bit, so I will try to make a point of my own. When I come into the office after a long, hard night, I tend to wander in, get a big cup of coffee, put my feet up on the desk, and sort of let awareness creep into my body and brain. If someone stops by the office with a comment like, "Boy, what a life. I thought you were supposed to be working." I say, "Hey, I'm doing creative thinking." For purposes of what I am going to say here, let us use the word "undirected" as opposed to "creative". Undirected thinking in the research program and in the operational program has, in fact, led to a lot of concepts, knowledge, expertise, experimental techniques, development of models, etc., that are used in a very practical way throughout the Division. I think you can argue that a lot of these concepts, models, etc., if followed back to their origins, probably had their start with people (at least figuratively speaking) sitting with their feet on the desk sort of daydreaming, or maybe doing things just because they were fun.

We are moving into an era of increasing need for immediate relevance of the research program in terms of the Division's activities. That translates into an increasingly direct involvement of the research program with the various thrust programs and the District activities associated with them. This is not necessarily bad.

In the first place, it is probably a political necessity. It is certainly going to generate much greater interaction between the NRP and the operational programs.

But—it is also a fact of life that the more time that you spend on specific studies the less time you have to sit with you feet on the desk and worry about the implications of climate changes. I have no immediate answers to this. Based on my own limited perception of what is going on in the Division, I feel that the research program is getting into a new ballgame. It is not necessarily a bad ballgame; there is no way to predict the results of it. However, we are moving into an era of more and more directed research as opposed to a relatively free and undirected ability to pursue scientific interests. I think that getting through these next 10 or 15 years successfully is going to depend on some very creative interaction between the NRP personnel, the thrust coordinators, and the District people.

Challenges in the District

D. E. VAUPEL, District Chief, New Jersey

I would like to preface what I am going to say with just one observation. Here I am again on another panel, advisory committee or whatever, and I am here to present the lone view of the District operation. I do not know who makes up all these advisory committees or panels or whatever. Maybe we should take it as a compliment that we only need a minority of District personnel to combat the majority of Headquarters all the time. But I for one feel the burden is a little large for one person.

Nonetheless, I will try to address the challenge that faces the District in programming future WRD projects. I believe this can be done by funding programs that will increase our knowledge of hydrologic principles, provide a challenge to our staff, maintain leadership in the hydrologic sciences, provide useful and timely information, and direct our program to meet WRD thrusts.

It seems that these programming objectives are the same as when I joined the WRD a long time ago. It was as I reflected on how I might best discuss these objectives that the problems arose. I believe it would be presumptive on my part to assume that I could define the types of programs needed by each individual District. After all, each District has different customers, different sets of hydrologic problems, and solves problems at different points in time.

So, where is the common ground for discussion? I believe it lies in the roadblocks that we face in developing programs to meet our objectives. Therefore, I would like to spend the remainder of the time on some of these roadblocks.

First, let us list some of the roadblocks. Certainly shrinking cooperator resources affects all of us in the field. Also, shrinking Federal resources, both in money and manpower, is something that affects us dramatically. The rise in outside competition affects us in our daily programming. The increased competition for resources means that the rising priority of Federal thrust programs relates very strongly to a falling priority of the cooperative program. A rising priority in the National Research Program is a problem we deal with constantly. And finally, the always-increasing Federal bureaucracy is a problem that we face every day.

To accomplish our programming goals, we must try to eliminate as many of these roadblocks as possible. I think we can divide this list of roadblocks into two groups. The first group has to be addressed by District managers; this includes shrinking cooperator resources, shrinking Federal resources, and the rise of outside expertise. We can address these roadblocks with creative program planning—we are using cooperator services and expertise, as mentioned earlier. We are selling unmatched coop programs that are resource hogs to get more bang for the buck, and we are selling the credibility, the continuity, and the objectivity of the USGS.

However, the next group of roadblocks—that is, the rising priority of Federal thrust programs and the NRP coupled with a stagnant coop program and the increase in bureaucracy—I believe can only be addressed at the Regional and the Headquarters levels. I believe the rising priority of Federal thrust programs must be carefully considered in view of limited FTE hours. That is to say, I think we can all list the Federal programs that have been laid upon District offices without proper funding of personnel. The rising priority of the NRP versus the falling priority of the co-op program has left the District on the short end of competition for funding of thrust programs and an inability, therefore, to compete successfully in the recruitment of high-level scientists.

Also, the increase in Federal bureaucracy has invaded every aspect of the District program, where compliance has become the rule of the day with no regard to meeting mission objectives. It may be useful to point out some specifics. The Surface Water Network Evaluation, the National Water Summary, MBO programs, the percentages of funding distributed to the Districts in the acid rain program and the toxic waste program, the senseless limitation of authority in procurement, personnel classification, travel, and the acquisition of space.

These problems have been brought up time and again at regional District Chief meetings, advisory-committee meetings, and through normal communication channels. To my knowledge, none of them have been addressed successfully. So, when we raise our voice in protest, it is not just to hear ourselves, but because we are hurting at the District level. We hope that we can acquire the support of Region and Headquarters to address some of these roadblocks. If this occurs, I am sure that the District Chiefs can handle Group 1 of the roadblocks and reach the goals of dynamic, scientific programming listed at the beginning.

I would like to close with a couple of observations on yesterday's program. Several times we heard about bringing pieces of research together to address the overall program. I believe this is being done and will be done to a greater extent in the District programs because our customers demand it. They demand facts with which to solve water-management problems and they demand them regularly.

And finally, we heard again and again about the need for increased water-quality programs. I also believe that is true, but I would like to caution that a thorough understanding of the physical system is a prerequisite to successful water-quality programs. There are many holes in our knowledge of the physical system, not the least of which is evapotranspiration as pointed out by Nick Matalas.

Comments

G. D. BENNETT, Senior Staff Scientist, Reston

In the past several years, many Federal agencies have experienced severe funding cuts and some of them have been dismantled. This has not happened to the Water Resources Division. Our funds have grown and our personnel resources have remained relatively stable. Why? Because when we were asked to mount a study of regional aquifer systems, we did it. When hydrologic relevance required that we initiate a new program in toxic waste, we initiated one. When we were told to produce a National Water Summary and were not given adequate resources to do it, we produced one anyway. Everybody had to contribute to this. The Districts had to contribute to it. They contributed their services without dollar compensation equal to the hours that were put in. But everybody benefited because we have not been dismantled as an agency. We are still strong; we are still going.

Now, we could certainly change our programming system. We could stop responding to the forces in Washington. We could initiate a system of programming where we simply poll the Districts, ask them how much

money they want and then go to Congress and say, "Hey, here's how much money we need." Systems of that sort have actually been used by some of the agencies which have been dismantled. I think everybody ought to think about that before they jump all over the history of our programming in recent years.

Regarding the statement that emphasis on a Research Program has grown at the expense of emphasis on the District program, maybe that is true but it is not true in the areas of funding or manpower, where we can quantify things. As a fraction of the total Division funds, as a fraction of the Division manpower, the Research Program has shrunk progressively in recent years. I wish that the Research Program had grown at the expense of everything else in the Division. I say that as someone who has never worked in the Research Program. I wish it were true because our work is changing, the technical demands on us are changing, and we need the research input.

We are now well below 10 percent in both dollars and manpower, particularly if you do not count year-end funds which are difficult to utilize. Maybe a consulting business can get along will less than 10 percent of its resources in generic research, but I do not think that a scientific organization can. So, if we share John Bredehoeft's aspiration that this be a scientific organization, I think we all have to question whether we are putting enough resources into research.

We certainly could have reduced our research more steeply in recent years. Had we done that for example, we might not have a three-dimensional flow model. We might not have Cliff Voss's transport model or Lenny Konikow's transport model. We might not have WATEQ balance or PHREEQE or some of the other tools that are being used routinely in District projects. If we did not have those tools, our capability to do these kinds of things that are being demanded of us in the Districts would be severely reduced. I guess the only thing that would not be reduced would be our capability to gage streams or to conduct ground-water appraisals.

BANQUET SPEECH: WATER THEN AND NOW

Introduction of JOSEPH F. COATES by ROGER WOLFF

Joseph F. Coates is an authority on technology assessment and future research. His area of research is the impacts of science and technology on society and the future. He is President of his own consulting firm, J. F. Coates, Inc., of Washington, D.C., and is an Adjunct Professor at George Washington University. A chemist, he holds degrees from Brooklyn Polytechnic Institute and Penn State University. Previous experience includes positions with major oil companies, the Institute of Defense Analysis, the National Science Foundation, and the Office of Technology Assessment of the U.S. Congress.

J. F. COATES, J. F. Coates, Inc., Washington, D.C.

It is a great pleasure to address the 25th anniversary of the CALARIZMEX Provincial Water Council which was, as we all know, established coincidentally with the New Constitution in the year 2010. I would like to review the past 50 years of progress in moving toward a totally managed atmospheric and water environment. I select 50 years, of course, because it is a convenient period over which to examine a record of impressive and steady progress. Also, 50 years have passed since water first flowed into the, then famous, Central Arizona Project.

Another important factor today is coincidence. Almost 50 years ago today, my father spoke on this very spot on a similar subject to a group that belonged to what I believe then was called the USGS, United States Geological Studies—an agency under the old Federal system. But let us review some of the major events.

1. Canada's joining the Union in 2002 had strong consequences for the management of resources:

- We achieved complete integration of North American waters above the Mexican border.
- The severe northern-climate water became a continental resource, witness the great trans-Rockies project in this very region,
- Relief was also found for a number of the energy problems in the Northeast and in the Northwest regions of the old United States.

Perhaps it would be appropriate to review some of the Constitutional changes since the younger members of the audience might not be fully familiar with them. Recall from our history books that the Pre-Convention occurred from 2005 to 2007. The New Constitution, or as it was then called, the Second Constitution, was adopted in 2009 and implemented in 2010. Among the principal consequences administratively was the elimination of 61 States and their replacement by 9 Provinces and the 22 Administrative Districts.

The consequences of that, of course, were enormous for the old system. They included:

- Wiping out of thousands of so-called Counties. These were quasi-independent political bodies carried over from the old English system.
- Tens of thousands of so-called special districts controlling incidental aspects of the infrastructure, sewage, water supply, education districts, etc., were eliminated.
- The principal of super-succession replaced the old and even then outmoded laws affecting infrastructure with a new body of laws and regulations. Effectively the Constitutional transformation wiped the legal and administrative slate clean.
- The status of the Native Americans (many called them Indians back then) was also established under the new Constitution. The uncertainty about their rights and obligations was clarified as the old treaties were superseded (some said abrogated).

2. The Federal Mediation Act of 1992 led to a broad-base involvement in many participatory processes under the old Constitution. That was so successful that it became the effective base and the administrative root that permitted the smooth transition to the new Constitution and the vast numbers of codes and regulations required.

3. A major physical event—the earthquake at New Madrid in 1998—had substantial effects on our business. It was a real monster quake. Using the so-called Richter scale, it was an 8.4 quake. It had a number of striking consequences:

- Some 32 dams were destroyed.
- The Ogallala Reservoir was restructured.
- $143 billion in structural damage occurred in the four States principally effected.
- The quake was, incidentally, felt in 17 States—the Mississippi River flowed backward for 36 hours.

The primary effect of the New Madrid quake was a strong and intensive drive toward planning for infrastructure and land use. The event was so dramatic that it galvanized the Nation to act on an effective approach to effective land use and infrastructure planning.

4. By 2010, atmospheric management was routine.

• Snow enhancement was generally practiced throughout the Rockies from the Mexican border to Alaska.

• Hail control throughout the central region was routine.

• Drought control was not quite so successful. The Department of Atmospheric Management, however, jointly with the North African Republic, has a project which over the next decade, is almost sure to yield a new drought-control data base which will be applicable in the United States of North America.

5. The Mexican trouble led to "Project Popsicle" in 1994, which was completed in 2001. It is curious how we seem to have this strange custom in North America of seeing ice as frivolous. Recall the hurly-burly about the purchase of Alaska, the so-called Seward's Folly. "Project Popsicle" has given the lie to charges of foolishness. Currently two icebergs per year are floated to Baja and upper California and 12 to the rest of the world. "Project Popsicle", unlike most international programs, has had a primary impact on world water resources and drought. Another point to notice about the project is that it was the first of the true planetary engineering projects to be unequivocally successful.

6. By 2015 the Cost Recovery Act led to the demolition of some $4 billion in old hydrologic projects, which were found to be money wasters. Today, less than one and three-quarters percent of water is subsidized, with subsidies originating 150 or more miles away from the site of use. Of course, substantial subsidies occur at the local level as part of Provincial and District local land planning. But we no longer have the national subsidy system of one region subsidizing another.

7. Some sticky points in environmental management continue. Perhaps the most prominent of these is ground-water contamination. I would say that today, in 2035, there is consensus that for two decades or more our number one environmental problem has been ground-water quality.

• New intrusions of undesirable materials into the ground virtually stopped by 2005, and the bulk of new intrusions of contaminants was basically over by 1995. Unfortunately, most of the contaminants already in the ground had only begun to be mobilized by natural processes in 1995. The contamination problem has worsened steadily since new additions ceased.

• The key event precipitating public concern was, of course, in 1992, when a congregation of Episcopal bishops fell ill at a church picnic. Six of the clergymen and 12 laymen became extremely ill. This occurred, I believe, in what was called northern New Jersey. There were two deaths, none among the clergymen.

• The numerous and promising programs of the 1990's, subterranean dams, reverse flushing, chemical neutralization, all proved ineffective, so that today, or at least more properly in 2033, 25 percent of all potable water goes through 6, 7, or 8 stages of purification. This, of course, has been a boon to the beverage industry. Another datum worth noting is that 19 percent of the land of the old "lower 48" is now triple-piped (potable, domestic, commercial water). Twenty-eight percent of it will be triple-piped by the end of the decade.

• As early as 1995 ground-water contamination had begun to effect land use and internal migration patterns. That quarter of the land in the "lower 48" with certifiably good ground water underwent its own mini-boom, accompanied by strong regulation after 1990 to prevent contamination.

8. The global collapse of the soybean market from biotechnology, production of synthetic proteins, and the migration of cotton growth and textile manufacturing overseas reduced much of the water demand in the midwest and the southwestern arid region. Incidentally, along those lines, I strongly recommend that you visit the Department of History's restored cotton farms. I particularly enjoyed Old Alabama, where they use Walt Disney Class A-6 robots, so-called audioanimatronics to carry you through the whole process from planting and harvesting through ginning, baling, and carting. I particularly liked the pre-Civil War touch with the singing at nightfall.

9. Innovations do occur in curious and strange ways. Almost 30 years passed from conception of the proposal for instant feedback and water effluent control until a complete system was in place. But it is now nearly universal. All industrial facilities employing 25 or more people must take their influent water from within 50 feet below their effluent.

10. Some technical developments, such as biotechnology, have enormously affected the quality of water. "Project Kidney" is yielding fresh water at a vast rate throughout the Southwest. You recall that large areas of the land surface are now devoted to "Project Kidney" biotechnology purification across the United States of North America.

11. Biotechnology decontamination has also been especially effective with heavy metals and less effective with residual organic materials. In fact, the process partly pays for itself with the heavy metals that are recovered.

12. The Archeohydrology programs at the old USGS—by the way, let me correct myself; I recall that its name was the United States Geological Survey—set up in 1996, basically proved to be useless. We did learn a tremendous amount about the technologies that were successful in the Middle East, particularly in the biblical regions and biblical times.

13. The old "use or lose" principal was abandoned. During the 1990's there was a move to "water marketing" but that proved unsuccessful and by 2006 we had moved to MAXPU—the Maximum Public Utility principle in the allocation of water.

14. Let me make one last note about some experiments that have been partial successes: the decentralization of the control of water was one of them. Privitization aspects of this led to the adoption of the French affermage system in the Central Utah Project (CUP) where it worked out quite well. For those of you who are not familiar with affermage, it involves turning government building projects over to private enterprise to operate.

In summary, let me say in looking back over the past 50 years, we must also acknowledge the previous 100 years. It has taken 150 years for water to be fully controlled and effectively managed. Water management cost per capita, as revealed under the Tax Assignment Act of 2012 is $140 per capita per year. This sharply contrasts with the experience of some 50 years ago when individual per capita subsidies in some regions ran as high as $4,000 and direct costs in others as high as $500 per capita.

What you have heard is one possible picture of future water developments in the United States. It is only one picture, albeit complex, of how that infrastructure might evolve over the next 50 years. There is nothing in this which is scientifically, technically, or public-administratively bizarre. And yet it does represent, in the aggregate, developments that together create a future extremely different from the present.

The point of all of this is to help shape our present action. By understanding the wide range of ways in which the future can evolve and seeing some hints of the significance of direct and indirect human intervention in the management of our world, we may be stimulated to create more desirable futures and act systematically to encourage the desirable and discourage the undesirable outcomes.

Let us turn briefly to the way in which the scenario was constructed, so that the reader may pick up the interest or the challenge of creating his or her own. It was constructed by first defining a list of variables that seemed critical to the evolution of the long-term future of water. These variables include quantity and stability of supply; source and reliability; qualitative factors such as health effects, salinity, and microorganisms; cost, both direct and indirect; administrative mechanisms; equity considerations in the short and long term; institutional frameworks; technological developments;

social trends; political values; the users of water such as the general population and industry; the location of users and their special requirements; environmental factors in general; and a number of other variables.

It then was created by setting a value for each of those variables in a way that is coherent, that is, hangs together and is not self-contradictory. With those elements in mind, one then embellishes a story or framework around them—in this case, a presentation to a water conference in 2035.

Above, we did not give due weight and attention to the important role of telecommunications and computer technology, which will affect the collection and information, the modeling of patterns, and the management of water facilities. Telecommunications and computers will also open up the public policy process to more effective participation and decision making.

The importance of scenarios is that they permit us to deal in an intellectually satisfying way with a complex of material normally too difficult to conceptualize as a whole by concentrating merely on individual components. As a tool for managing complexity, they have the advantage of presenting alternative images of the world, giving some relationship among them, and, in turn, stimulating an interest in either how to get to or how to avoid those outcomes. They are tools of planning.

PERSPECTIVES ON THE DIVISION'S ROLE IN THE FUTURE—PANEL DISCUSSION

Moderator Remarks

J. F. DANIEL, Assistant Chief Hydrologist for Scientific Information Management, Reston

We are going to try to give you some perspective, as we see it, from special vantage points of District Chief, Regional Hydrologist, Research, and Assistant Chief Hydrologist for Scientific Information Management (SIM). We are not necessarily saying that these are representative of the category, but just some things as we see them.

The way we will work it is that I will give just a couple of minutes from the Assistant Chief, SIM standpoint; then Jim Blakey will give the District point of view; Stan Sauer will follow with something from the Region viewpoint; and Bob Averett with something from the research viewpoint. I am also supposed to recapitulate some of the salient remarks from earlier in this meeting. I will take a few minutes to do that at the end.

Let me just give you a couple of things from the viewpoint of Scientific Information Management, that we think might bode well for our future. About 1983, we started to write many more reports. The number of reports has gone up about 30 percent, a result some sort of a conclusion that the business of our agency is reports and data, and that we really should be putting out more good reports and use as many possible outlets as we can.

Nationally, that increase reflects an increase in interpretive reports. That includes about 300 or 350 abstracts. So we are really talking about 900 interpretive reports per year, up from about 600 to 700 before 1982. The number of data reports has remained generally stable through the years. The number of State annual data reports, of course, is about the same.

I draw a little different conclusion about this increase than others might by adding one more piece of data. Starting in 1982, we had a thing called the Distributed Information System in which we bought x million dollars worth of computers, installed them nationwide, and made them available. We have somewhere around 70 sites that have the hardware. We are using it like crazy. They are all saturated. The biggest equipment purchase at the end of this past year was to buy more memory and more disks for the machines.

I submit, without any scientific proof, that a major factor in our increased report productivity is the use of these machines. They have provided the analyst more interpretation and more time for interpretation that was previously needed to develop a data base alone.

John Bredehoeft and Phil Cohen are really super salesmen for getting us to pay more attention to reports. But an almost equal amount of credit might go to the increased capability that we have put in the hands of the project person to get that done.

There are two reasons why this increased productivity should continue. The first is that we are going to put more and more tools into the hands of the people that are making the interpretations—better software programs, faster machines, better hardware—so that there are more things that they can do. The second is the introduction of computer graphics. Within the next few years, these computer graphics will save a tremendous amount of time and allow us additional staff power to write more reports. And the business of the Division is the reports and the data. So, the machines and their capabilities will allow us to increase that productivity, even with a stable or slightly declining staff power.

From the District

J. F. BLAKEY, District Chief, Colorado

Jim Daniel told me Monday that I should say something about the future of the cooperative program. I will say something about the cooperative program, but I am more concerned about the future of the Division. From the Division point of view, and even more so from the District point of view, the cooperatove program is more important. It totals more than $100 million. It represents 60 percent of the gross funds going to the Districts.

As many of the speakers have done this week, I would like to look back for a minute. A number of you here were around when our organization had three Branches. The Branch Chief was at the Washington level—there was one each for surface water, water quality, and ground water. And that organizational line of authority extended down through the area chief, to the field level with a District chemist, District engineer, and a District geologist in most States.

Also in many locations, there was limited contact among the branches. Stan Sauer and I were in Austin together, and were among the few who had a joint project and coauthored a report. He was working for Trig Twitchell, the District engineer; and I was working for Chuck Hembree in water quality.

My principal reason for mentioning this is simply to ask, "If we were still under that organization, and Luna Leopold hadn't made some changes, where would we be today?" I doubt seriously that we would be here. We would not have met our commitments under that old organization.

I have studied the organizational chart we have today and am particularly concerned about the District point of view and whether we can survive in the 1990's with this organization.

I looked back at Tom Buchanan's Data Book and extracted numbers for FY 84. The Division had gross funds of about $224 million. The Districts' total funding amounted to $167 million.

About 10 percent, or $17 million, went back to WOTSC. So, the Districts spent about two-thirds of the total budget in FY 84. There were 42 Districts. You can quickly divide it up—you have about $4 million per District.

I looked through the Data Book and found that 21 Districts in 1984 closed the year at less than $3 million. Given our cost of all the other things we are paying for, where is the District spending their money—particularly the $3 million District? I talked to a few District Chiefs and came up with the following cost distribution. Ten percent goes back for WOTSC. Computer costs are about 10 percent, or about $300,000. About $200,000 goes for rent, an average of $300,000 for direct services, and on down the line. So, a $3 million District spent $2 million before they paid any salaries for hydrologists and technicians.

I agree with some of the things that Jim Daniel said. We have the technology to do things better. However, I think we must have a nucleus of people and a program size that allows us to use that technology and be able to pay for it.

I have made numerous statements at Central Region meetings, and I will repeat them here. I do not believe it costs $7,000 or $8,000 to operate an "average" gage. But it may cost $7,000 or $8,000 per average gage in an average District, and we are getting into trouble. We are going to be hurting more and more with cooperators and with OFA's if we cannot keep those prices down.

So, I ask: "Can this organization survive in the year 2000 or even in the 1990's? Should we look at some other possibilities?"

I propose that we consider an organization that includes 8 to 10 super-Districts or mini-Regions reporting directly to the Chief Hydrologist. Functions in that super-District would require a gross income of $15 to $20 million. Research would be made a part of that unit. The super-District would include discipline specialists, the necessary computer services, and reports staff. The California model shows how to conentrate our studies, our heavy computer requirements, modeling efforts, etc. in one location. That way we can have a solid nucleus of technical expertise, as well as the support equipment and personnel to accomplish our goals. Perhaps we even should consider some level of laboratory capability.

The super-District must include a solid group of field offices. The data program must continue; but I think that we are getting into situations where some of the small Districts and most of the subdistricts are primarily data-collection operations. I suggest we accept that fact.

My position is biased. It is biased by experiences in the Ohio District and in the Colorado District. In Ohio, where I filled several positions, I never had an applicant. I had to talk some nominee into taking every position I filled. Conversely, in 7 years in Colorado, I have never had to select a nominee. I have always had well-qualified candidates who applied for the job.

Some of us will agree that it is better to live in Denver than it is in Columbus. But I submit that if we had the level of programs in Columbus that we have in Denver, we would get some applicants in Columbus. I think the people who are willing to move around are looking for a challenge and an opportunity for growth. Given the situation we have now and the direction we are going, we must look at a change in organization. Otherwise, the gap between the small District and the large District is going to widen and our problems will grow.

From the Region

S. P. SAUER, Regional Hydrologist,
Northeastern Region

I was asked to discuss the potential needs for activities in the Federal program over the next 10 or 15 years. As discussed yesterday by Marshall Moss and some others, the Division goes through this every year—a formal process of trying to redirect our thoughts and efforts into new activities needed by ourselves, the Bureau, or the Division. Most of you have the opportunity, from time to time, to have input into this particular process. But that opportunity for input varies a great deal, depending upon where you are located. Your opportunity to have input at the Headquarters level is much greater, simply by the nature of the process, than it is in the field location. But you will have the opportunity.

So many ideas that I want to put before you have been raised previously. First, I would like to talk about a perspective on the Federal program that is not necessarily appreciated throughout the Division.

We have a great degree of variability in our Federal program—in the thrust programs, in terms of what we undertake, and what kind of activities are funded. Most importantly, this is perceived differently by different organizational units in the Division. What is perceived at Headquarters as a single monolithic program is generally viewed differently by a District Chief who each year, tries to put together a program of water resources investigations to meet the needs of the State or District.

To many District Chiefs, the Federal program represents an unparalleled opportunity to do some interesting, challenging, and highly scientific work.With that opportunity also comes the chance for staffing with very highly trained and highly motivated scientists to round out their technical staffs. To other Districts, the Federal program represents only a small percentage of their program—a few gaging stations, a NASQAN station, or two or three observation wells.

Another problem is that the Federal thrust program has been perceived by most of the Districts as being one of the least dependable sources of funding. Every District Chief knows the problems faced each year in balancing a budget to match the dollars available to the staff. But the year-to-year variations and the capricious nature of funding change as the public perceives different problems.

When I first started as a District Chief, one old salt who had been through many of the ups and downs of the Federal program advised me, "Don't ever tie yourself too closely to a Federal thrust program." In other words, do not stake your reputation on what you can develop through Federal thrust programs, because they are the most capricious.

I remember the escalation of energy funds during the 1970's, and then the rapid deescalation of that program with the tremendous funding distortions for Districts with coal money.

In looking back at funding stability, I looked at the last 20 years in the Division. During that time, our budget grew from some $40 million to some $222 million, with only FY 1982 showing any decline.

The Federal part of that program ranged from about 23 percent to 37 percent. During the period of 1965 to 1977, it was a narrow range between 23 and 27 percent. From 1978 to 1985, it was higher, ranging from 31 to 37 percent. During that same time, the Federal State Cooperative program ranged from 45 to 59 percent, with 55 to 59 percent during 1965 to 1975; and then the last decade ranged from 45 to 50 percent. That program never declined from year to year.

The OFA part of the program is the most stable in terms of funding for the Division. During those 20 years, it ranged from 17 to 23 percent, but most of the time it was within plus or minus 1 percent of 19 percent of our total budget. From the funding standpoint, the Federal program has probably been the most unpredictable for the Districts.

That range is even greater at the State level. In 1985, the minimum was one District with only 6 percent of its budget from the Federal program. At the other end, there was a maximum of 46 percent. The 46 percent in terms of Federal program, probably would be a little vulnerable somewhere down the line. That is the rather substantial range in the different organizational units.

Within the Federal thrust program, amounts in the last 5 or 6 years have generally run about 60 percent in the total Federal program and have remained nearly stable. Even though the energy funds have declined substantially, other programs such as ground-water contamination and toxic-waste disposal have taken their place so that the overall total has remained about the same.

Despite their variability, the thrust programs that are funded by Federal programs are absolutely essential elements to accomplish our overall mission. There is no other way to focus our efforts on specific problems, perceived by WRD and our supporting constituency, as the Federal thrust program. We certainly cannot provide that kind of focus by any other sources of funding.

Neither do any of the other sources provide an equivalent opportunity to undertake basic and applied research. The NRP, as we know it today, would not exist in that context without rather substantial support from the Federal thrust program. They really provide approximately two-thirds of the total funding for the National Research Program. It is certainly important that we continue trying to make that the best program that we possibly can.

Most of the things that we might undertake over the next 15 or 20 years in the Federal program have been discussed at some time in the past. Unfortunately, there is usually a lag time from perception of a problem until the perception is focused into real program dollars to do some work. In many of these undertakings, although we have talked about some of them before, it is important to continue to press forward on them in the future.

The National Water Quality Assessment program is clearly going to be a very far-reaching activity for the Division. It is going to be a significant driving force for us for decades to come. It is a program that is vital to the Nation and in the best interest of the Division. So, it is not a question of whether we should undertake this, but what are we going to give up to undertake the program. This is the same issue on every new thrust that we talk about, because of the FTE ceilings. It is not so much a problem of what we should be doing; it is a matter of how to establish priorities, and how to redirect our activities to take on this new issue.

Another problem that we need to look at over the next number of years is the availability of water in the East. We have apparently just entered another time of serious drought in the Eastern part of the country. This is something that we keep talking about and really want to do something about. Unfortunately the span of droughts in the East is never quite long enough to provide the necessary time to translate public attention into dollars to do some work. It is a very important issue that we should be looking at, even if we do have hurricanes that mess up those kinds of plans.

Another effort that we have talked about is a major-rivers project, an analysis of the total resources of major river basins and the overall impact of man's activities on them. Surely of all the agencies, we are uniquely capable of undertaking such studies in the public interest. I urge that we continue to press forward on that issue.

We have had a lot of focus on ground-water contamination in the last number of years. Rightly so, because this is a very serious problem. But I suggest that we pay some more attention to the problem of aquifer restoration. This is a very important issue, when we look at the large numbers of aquifers that are contaminated all over the country. This is an issue that should really receive some attention. It is a very difficult problem, but we have proved in several instances that it can be done. I think as a matter of interest to the Nation, we should undertake that kind of activity.

Lastly, we should focus more attention on regional issues than national issues. There are problems in each of the regions that are not necessarily of nationwide concern. Those that I am familiar with in the East are the Chesapeake Bay problem and the entire problem in the Great Lakes. Throughout the West, the accumulation of selenium and other salts due to irrigation is a serious problem.

We have traditionally been loathe to take on such efforts, because they are not nationwide in scope. But each of those issues represents a serious problem to the Nation. In general they are too large in scope to consider undertaking in the State-Federal cooperative program. It is difficult to organize any kind of cohesive effort to address issues as large as the Great Lakes, or the Chesapeake Bay, or the selenium issue out West.

We clearly have an opportunity to develop support for funding through the political process. Frankly, it is much easier to develop the political support for a problem of a smaller scale than to develop that same kind of support for nationwide issues. I urge that we take advantage of these opportunities as they arise.

All of these good things have to be done in view of the FTE ceilings. It is always important that we do not overcommit ourselves to the extent that we cannot fulfill our obligations to other agencies to supply needed hydrologic information. It is a very difficult problem for all of us as managers.

The only other issue that I would like to talk about is the matter of balancing funds among the various organizational units. I am not going to address the issue of how it should be apportioned among the various units, because this is neither the time nor the place nor the format to do that.

But I urge that we consider using some Federal thrust funds, wherever possible, to support and enhance some of the District Research Grade Evaluations (RGE's) who are doing some exceptional work. The most serious issue with RGE's in the Districts is continuing support for these people at their specific level of capability.

There is sometimes a hiatus of a year or so when it is difficult for some of the smaller Districts to develop the support needed for the RGE's. I urge that we set aside at least a small portion of those funds to help those Districts when they find themselves faced with that kind of situation. I would never urge that we do this on a continuing basis because wherever possible, District programs should be supported by the funds that are there.

To summarize, the Federal program allows us to focus on some topical issues in a much more organized way than we can in either the coop program or the OFA program. We need to continue to take advantage of all the opportunities in this arena as we prepare to address the issues that will lead us into the 21st century.

From Research

R. C. AVERETT, Special Assistant to the Chief Hydrologist, Lakewood, Colorado

When I arrived here I was asked to discuss Division perspectives for the future from the research standpoint. Before I begin with some specific comments, I would like to make some predictions for the future, without any caveats placed around them. I do so because I am so sure of them. Well before the year 2000 most of them will take place.

There will be more emphasis on water quality. In fact, there will be a great interest in water quality throughout the Nation—its time has come. One major emphasis on water quality will be its harm to living systems. I predict that this agency will soon be in the water assay business to evaluate water as a medium for life.

Another thing we will have is greater sensitivity of instrumentation. This will provide us with some solutions to our present-day problems and, probably add other problems. We are faced with a large amount of information today, some with very low measurable limits—and we still do not know what it means. This is one of the dilemmas with our water-quality data base.

I believe that before the year 2000, we will initiate a ground-water quality network; and I believe there will be nay-sayers even then to tell us how difficult or impossible the task will be. But we will get on with it and we will have problems. Eventually we are

going to have a national ground-water quality network. The best way to design such a network is simply to get started, and start learning.

Much of the future emphasis on water quality will be brought about because we have neglected it in the past. I hope, however, we will keep our disciplines in balance and not ignore ground- and surface-water quantity. These three disciplines brought us to the ball and I hope that we will still save a dance for them in the year 2000. I think it is very important that this Division maintain a balance among all of its hydrologic work.

I predict also that we will finally move towards multidisciplinary—or if you prefer, interdisciplinary research. This is something that we can do well. Multidisciplinary research is the one edge we have over all other agencies concerned with water research.

I also predict that by the year 2000, we will wish that we had done more research on the natural properties of water, including organic compounds, and had done less on the anthropogenic factors. I am hopeful that our benchmark stations will serve us well in the future. I am also hopeful that we will take a close look at these stations very soon and decide which have truly benchmark characteristics, so that we have a better idea of the natural water-quality and quantity conditions.

European scientists consider it too late to study natural conditions in many parts of the land. Thus, they often have a very small data base with very little knowledge, and consequently very small appreciation of what things were like before the hands of man fell upon them.

Another prediction is that we will move toward better understanding of sediment/organic compound relations. Simply stated, we were late with our appreciation and procedures regarding organic materials sorbed to solid particles. We should be much further along in this field. It is not a trivial matter and I emphasize its great importance to understanding water quality. Permit a little advertisement here; we are proposing a strong methods-development/adaptation program in our Central Laboratory program just for these reasons. We must prevent ourselves from failing to look for new ideas, procedures, and new needs of the Division.

Those are a few items that I can predict without any caveats. Rather than dwell on other concerns, I would like to bring the future a little bit closer. I would like to bring the year 2000 to 1986.

Let me begin by putting it on a common ground. Because there are so many folks from Reston here, I will quote former Redskin coach George Allen. He said, "The future is now." On a more intellectual standpoint, I would like to quote Dr. Cornish, a former president of the World Future Society. He said, regarding world crises, "We cannot go on letting the future just happen to us." Let me combine these quotes by saying the future becomes more and more compressed. Let us think clearly about our goals and guide the future towards good science.

I am hopeful that this Division is not letting the future just happen. I am very pleased about the goals I have heard here. But the quote by Dr. Cornish has a ring of urgency about it. We have an opportunity to direct and guide our future.

I would like to move on with a few things that I believe are important to the Division. All are within the "wriggle room" that Phil Cohen earlier talked about. They are hydrologic activities that we have some control over within the Bureau and the Division.

One of the things that has always been very important to me is providing a publishing medium for our people. It is very important that we maintain within our own house an outlet for our findings. That is one of the great attributes of the Geological Survey. The two most highly regarded and important publication outlets are the Professional Papers and the Water-Supply Papers. I realize there is increased emphasis on both now, particularly the Water-Supply Paper in our Division.

It has always disturbed me that it takes so long, after Director's approval, to get these papers in print. I think there should be a way in 1986, and certainly before the year 2000, to decrease the publication time for those papers. Our people now allow 3 to 4 years for publication. We must shorten the publication periods for these two important outlets because they are our final measure of good science. There is no one in the Division who laughs about the good-science concept. It is taken very seriously; it is truly believed; it is carried to bed at night. Our report production as well as the types of reports and their quality reflect it. We must add the final measure to all of this by shortening the publication time for our Water-Supply Papers and Professional Papers.

I would like to talk briefly about scientific management. One of the things we must ask ourselves as scientific managers is, "Are we keeping up with the science as well as we can?" If I heard the discussion correctly 2 days ago, too few of our management people are attending scientific meetings. I emphasize scientific meetings as an outlet for keeping up with the field and I also emphasize backyard projects and their resulting publications. These are the only way we can truly "see" and "feel" how the system is working and keep the investigative adrenaline flowing. This was a goal of Luna Leopold's and it should still be a goal today.

Continuing with scientific management, I would like to see us initiate a management-rotation policy. I suggest it at least at the level of District Chief, but failing this, certainly at the level of Section Chief. In this scheme, our managers would know their task for a specified time, and would be given assurance of future tasks. I am not urging mass transfers, only reassignment to different tasks. Some of this rotation is underway now; I fully support it because it gives our people a chance to move between science and management. The Geologic Division uses this technique and I believe they are ahead of us in this regard. Few scientific groups subscribe to the professional-manager syndrome of the WRD.

Earlier I said that I wanted to talk about the research program. It is alive and well. I do not need to tell you about the multitude of changes the research program has undergone in the past 5 or 6 years; I will tell you how proud I am to have been a part of and to have initiated some of those changes. The program now has Bureau recognition and is the most modern management structure in the Division.

Let me give you some short statements regarding the research program and its future direction and needs. First, the day of multidiscipline research is here. The day of single discipline, single project research is fading. It will never fade completely, nor should it. We have some excellent people that the Nation owes, and that owe the Nation, an opportunity to conduct single-discipline research. We must permit these scientists to continue their productive work.

We must, however, move toward multiple-project coordination, taking from the ranks those we trust to conduct research (and not build empires) and place them over a group of projects. Coordination and leadership, not supervision, is the key to bringing an umbrella over a number of projects of different disciplines working on a single problem. Truly, that day is coming.

Another thing that I feel strongly about is that research personnel—perhaps I should say scientific personnel—need to be brought more into the planning activities of the Division. Examples of these sorts of things are already underway and working well—the National Water Quality Assessment (NAWQA) committee, people who have assisted with the "National Water Summary", and the in-house Science Advisory Committee. In these days of complexity, more and more of this type of thing is needed. Simply said, we need more scientific input into our managerial decisions.

Finally—and this is very important—we must insist that our research personnel are the very best. Those who cannot or will not produce, those who are not working on contemporary problems,

or simply are not scientifically inclined, should not be a part of our National Research Program (NRP). Very bluntly, we invest only about 10 percent of our resources into the NRP. There is not room for nonproduction with this low percentage. The NRP is our pacemaker. Its products are among our most visible and valuable. To be a member must truly be an earned privilege, not a right. Again, I emphasize bluntly, that the resources we place into this precious group must not be lost on nonproduction. I end my comments on the research program saying it is time to use both edges of the Research Grade Evaluation Guide (RGEG) sword.

Let me talk just a moment about water-quality data. If I were a Czar coming down from the heavens, I would say, "This agency shall collect no additional water-quality data—not one more piece—without a well-developed proposal and a plan for its interpretation." Our data banks contain masses of water-quality data. It might be my own ignorance, but I cannot interpret much of it; few of them tell a complete story. Sometimes I wonder if such data resulted from a random-number generator.

When we have continuous data, such as specific conductance, temperature, and stream discharge, whereby we can connect one point to the other within very short time periods, it's a different story. But too many, far too many, of our water-quality data are collected without a plan for interpretation. They are non-continuous with very large time periods between collections, which in itself signifies a careful experimental design is needed. Soon we must carefully review our water-quality data-collection program.

Let me now turn to the use of our scientific personnel. I believe that in the future, these people will be located in one place, and their expertise will be used at some distant place for the duration of a project. I am not sure we can afford, for example, the number of geochemists we will need in the Division, and have them at the needed places at the needed times. Like water, our scientific resources are not evenly distributed. As a result, I think we are going to see more and more programs whereby a person may be assigned to a particular District or area, but working on a project in another District or area.

We did just that at the Cape Cod, Bimiji, and Pensacola studies. We brought scientific forces to bear, because there were problems at these sites, and we needed scientists from the NRP and Districts working hand in hand to solve them. This procedure can be done nationally, and it ties into the analogy I made earlier on multidisciplinary or interdisciplinary research.

Continuing with the scientific personnel theme, I read a staffing report for the Division a few weeks ago. The staffing report pointed out very clearly that we are reaching some very important decisions regarding personnel. *The important factor is that we are finally realizing that we do not hire people for 3-year projects—we hire people for 30-year careers. People like the Survey, they enjoy working for the Survey. Our reputation is without equal.* I am told that if we can keep a person for one and one-half years, we will have that person for the rest of their career. Thus, we have to look at hiring much more carefully than we have in the past. Such is as it should be with a scientific family.

One matter that I think we have to look at very carefully is hiring in the soft sciences. We must evaluate the needs between "conducting hydrology and operating machines." An example is allocating resources to our national water-quality laboratory. Another is allocating resources to our computer programs. The folks that we hire now will have spent half of their careers by the year 2000. So, I suggest a well designed and thoughtful Division plan on resource allocation.

I also believe that many of our new people are poorly indoctrinated about our history, our goals, and the guiding philosophy of our agency. Last September, we held a 1-day orientation for research project support personnel in Denver. If you want to talk about a group that is ignored in the Division and seldom given the opportunity to shine, it is that group. Stan Sauer gave us an excellent talk on the Division— how it was set up, how it was established, and how it operates. Mike Thurman did an outstanding job on history of the Division. This kind of orientation is important and we need more of it. The Survey has a proud history that is based upon the Philosophy of Powel, Mendenhall, and Leopold. Our new employees need to know about and study the teachings of these great leaders.

I have built this talk on details, and I am sure you recognize that. I want to end now with a plea for the future. I well remember a Burma Shave sign some years ago that read: "We are widely read and often quoted, but it's shaves, not signs, for which we're noted." I have always felt that that rhyme has a ring of advice for the Division. It was an attempt by a shaving cream company to emphasize their reason for being.

This is the first time I have been on a Jim Daniel panel, and it is an opportunity that I am going to exploit. People say, "Do you know Jim wants to hire some electronic engineers for our computer programs?" I say, "Oh, really?" In line with the limericks that Jim often recites, I have written a Burma Shave-type limerick that I hope can be read with truth on our 200th birthday. My limerick reads:

"When it comes to water,
we have no peers.
We've been in the field 200 years.

But we didn't make 2 centuries
by way of computer whizzes.
We made 2 centuries
because we kept hydrology as our only business."

In closing, I would like to say that we have made outstanding progress in the past 6 years under some rather adverse conditions of budgets, personnel, and politics. We have maintained a strong scientific program which truly is our reason for being. With a little effort and tuning it could easily be outstanding. Finally, I believe that the USGS is, among all government agencies, a very noble experiment. It is incumbent upon all of us not to permit its future to just happen. Today we face strong competition in the field of water. We cannot do all things for all people with regard to water resources. But we must and can do one thing better than all others—good science. Anything less will seal our fate; anything more is undefined.

Moderator Summary

J. F. DANIEL, Assistant Chief Hydrologist for Scientific Information Management, Reston

The purpose of this panel, after the excellent discussions we have had in the first 2 days, is to put things into perspective. We purposely did not try to coordinate any single theme in this panel, because we wanted a broad look. So before we discuss what was said here this morning, let me recap some of the things that seemed important out of those two days.

We heard a number of discussions the first day about data and data networks. Dr. Orlob said we need more data, that the world out there needs more USGS data to do their jobs and get the best answers for their clients. But John Bredehoeft convinced me that we already know all the answers, so we do not need any more data. We can interpret everything we need, with the possible exception of a little bit of water-quality data. Bob emphasized some of that too.

Phil Cohen pointed out that the viability of our national networks is in question—funding levels, efforts, and the difficult sale of data networks. Also we are reaching the point in our cutbacks where the viability of national networks is in question. I do not know if we can solve anything

here today, or even identify a solution; but it is a problem we need to solve. We are going to have to deal with that in the next several years and certainly before the year 2000.

Another group of comments came in what I call "THE ANSWER" category. Dr. Wolman and others pointed out that we get lots of pieces, but we seldom get THE answer. We all know that THE ANSWER is elusive. But the call is still there, and it was echoed by almost everyone. We need to do more towards putting together THE answer once we have completed a number of individual studies.

That provides a transition into "interdisciplinary research"; that translates into interdisciplinary studies and interdisciplinary answers. Unfortunately in the past, the WRD defined interdisciplinary as three branches working together, or Districts and research working together. In the Bureau, it meant the Divisions working together; and in the Department, it was the agencies working together. But almost every outside speaker has said we need more synthesis and that we need more studies to develop the true interdisciplinary nature of our reports.

Also, almost every speaker here said, "We know pretty well what the quantity and distribution of water is. And for the most part, we know something about the quality. But we do not know the effects on water resources of legal things, of economic things, and political things, all of which stress the water resource system." John Bredehoeft brought out that the actions of man are as much a part of the hydrologic system as the natural aspects. One speaker said we should rub shoulders with the social scientists, and maybe even ask them to work with us for a year.

Then we discussed programming for the future. I understand both why and how the discussions went the way they did. But I was disappointed because we concentrated on less than one-fourth of WRD's funding resource. We said very little about the $100 million in the coop program. We said very little about the Federal Collection of Basic Records (CBR) program, we said very little about the $30 plus million in the OFA program.

I think we missed the point that programming is everyone's job—from the field person to the Chief Hydrologist. The Districts are the local experts; Headquarters is the congressional expert and the national synthesizer. Both are necessary. We cannot exist without each other.

A personal comment is that there would be no budget against which to dedicate 10 percent to research if we were not successful in the 50-odd programming efforts in our Districts. We need each other, and we have to nurture each other and work as a team.

Now, let us get back to interdisciplinary analysis. I asked myself: "Why has WRD been successful in maintaining and enhancing our program?" It is because we have always understood the users' problems and showed them how our work is appropriate to their solutions. We have this expertise inhouse.

If the water problems in the year 2000 are legal, social, or economic, then we will need to understand legal, social, and economic problems to compete for the Federal dollars as well as the cooperative dollars. Then we need to propose things back to the users in terms of solving their problems, not ours.

If the requirement is interdisciplinary solutions, then we had better have an interdisciplinary staff. We will, in the next 15 years, need to broaden our definition of "interdisciplinary" to get away from a narrow view we have in the Division. I think we will need to have more interdisciplinary studies to find THE answer. And get ready now—if you choked on the thought of hiring 10 percent electrical engineers and computer scientists, you are really going to gag on this one. We will have to hire a number of lawyers, accountants, and political scientists, and indoctrinate them into the scientific system. Then we may be able to understand those user problems and feed solutions back to where they are needed.

I have a closing limerick for the future of WRD:

In our search for our future, we're restless
With an unbiased millstone our necklace.
Just three of our guests
Gave us a bequest
That in 2000, we're reckless, feckless, and Peckless

WORK GROUP REPORTS

Charge to Work Groups

S. P. SAUER, Regional Hydrologist,
Northeastern Region

As you know, the next part of our meeting calls for us to break up into work groups to address a number of issues that are extremely important as management shapes our organization and prepares it for the 21st century. Many of the recommendations made by the work groups in past national meetings have had a substantial impact on our oganizational structure, and the type of work we have undertaken. It is in these work groups that most of you really have a unique opportunity to provide input on an organized, Division-wide basis.

The makeup of the work groups is deliberately diversified to provide a wide range of experience related to specific topical issues. We expect that the discussions will be wide-ranging, and that we will have some excellent recommendations. With a mix of Regional Chiefs, District Chiefs, researchers, and Headquarters staff members, I am sure this will take place.

Issues that were discussed in the 1981 meeting are still being talked about and are still very important. The recommendations that the committee work groups made then are still being used frequently in the decision-making process. I believe this will be the case again for the issues that we will talk about today.

I will not recite the issues. They are all listed for you. You will note, though, that the first four work groups have no Headquarters staff, Regional Hydrologist, or Assistant Regional Hydrologist on them. This was done deliberately to facilitate the discussion because we really need to hear what those outside of the Headquarters staff and senior staff have to say.

The session on alternative funding is made up of almost entirely Headquarters staff plus the Regional Hydrologists and the Assistant Regional Hydrologists. This might have been because they felt that if District Chiefs were there we might never reach a conclusion.

In reading through the advance material, I have some concern because it seems to me that the options group might conclude that we should abolish the Regional Offices. This might be the only place to find this extra $5 million or so that we are going to need.

This years's working groups will have less time than in past years. You really have only this afternoon, but most of you have already done some extensive preliminary work. In fact for some of you, it is really only a matter of modifying your conclusions and recommendations based on what you have heard in the past day and a half.

It is each chairman's responsibility to seek consensus in their group and to report those options to us on Thursday afternoon or to appoint someone to do so. If you can not reach a consensus, minority reports are welcome but you must do them within your scheduled time frame. The specific charge for each work group has been previously communicated to the chairmen.

Ground-Water Protection Role

J. N. FISCHER, Assistant Chief Hydrologist for
Program Coordination and Technical Support,
Reston

The charge for our group was to examine the ground-water protection role of the U.S. Geological Survey. The topic stems from the "EPA Ground Water Protection Strategy" which I am sure most of you have seen by now. Following the publication of that document, a Memorandum of Understanding was developed between the Department of the Interior and EPA that spelled out the role of USGS in helping EPA implement that strategy. As you know,there are funds going from EPA to the States for their work. The idea is that the States would have the option of passing some of that money to USGS to assist them in implementing the strategy.

Actually, the ground-water protection strategy is one of a series of strategies that EPA is developing. The second, which has been approved by the Administrator and will be published perhaps in the next month, is the ground water monitoring strategy. We have had Lynn Torak working on that with EPA. The third is a ground-water classification strategy on which we have also had a participant, John Moore. These documents will be coming soon.

Our approach to this subject was to look at three questions. The first was: What opportunities, risks, and limitations for the USGS are associated with ground water protection programs? The second was: What changes might occur as a result of ground-water protection programs that will impact our operations, and how can we anticipate these changes? Third: What will be the role of the USGS in the next 15 years as a result of the EPA strategies and implementation?

The first question addressed the opportunities, risks, and limitations associated with the strategy. To begin, we looked at opportunities with the strategy. The first was an opportunity to help EPA. Over the years, through the cooperative program, we have assisted the States more than other Federal agencies. That situation should change as a result of our perceptions, but also it is changing as a result of the perceptions of the Department. There is a program that is sensed in each Federal agency that the Administration wants cooperation on programs across agencies. As an example, it is affecting us in implementing NAWQA. One of the NAWQA requirements, for example, is that EPA approve our scheme and that it be useful to them.

This increased cooperation is manifested in a number of ways. We are going to have to examine our work to see if we are as responsive as possible to other Federal agencies. This program of ground-water protection that focuses on EPA-related issues is an opportunity for us.

We also see opportunities for good science on relevant issues related to the strategies. They may give us chances to work on leading issues such as unsaturated flow aspects of recharge pathways to aquifers. They also may lead us to a more visible program, providing increased understanding and appreciation of the Division. It is frustrating to talk to Congressional committees and to the Congressmen themselves and find that they do not know the title of our organization. If they do, it may be associated only with 7.5-minute quadrangle maps. Our name and mission recognition is improving, but is still not good. Working on programs that are nationally prominent will provide opportunities for work that is visible and relevant.

We also have an opportunity to improve long-term relation ships with EPA. That is a difficult thing to do, as many of you know. But it is where the action is in terms of money and attention. Everybody realizes their problems but the States have to deal with them, and they find a way to do it. We must make opportunities to become more closely related to them and be more relevant to their work. We can help them and we have a responsibility to try.

We have an opportunity to eliminate stigmas that we are unable to deliver products within a useful time frame. It is a widespread perception and it is accurate to some extent. We are working hard to overcome it. But it persists. We have had a Memorandum Of Understanding (MOU) with the Department of Defense (DOD) for almost 2 years to work with them on their programs. We have had a great deal of difficulty in getting that MOU to bear fruit. The reason is that there are people within DOD who do not think we can deliver products. When we talk to them, they cite examples of late work and work that has taken too long to be useful. In this ground-water protection program, we will be asked to prepare good reports in less time.

Finally, there are important opportunities to improve our understanding of aquifers, to improve our data bases, to improve our skills, and to increase our program.

Our group then examined the risks. We identified three, but there probably are others. We will be asked to be describe the implications of our interpretations, not only to present the information but also to tell the manager what it means. In so doing, we may be in danger of sacrificing our objectivity and our impartiality. Therefore, it will require good judgment and careful thought. It is a step that our committee thinks will be required, and probably would be useful for us to make in any case.

The second point is that there may be those who are unable to distinguish between our agencies and connect us too closely to the EPA pro gram. We need to be aware of that possibility so that the risk is clear in our own minds.

The third risk involves promising more than we can deliver, creating overexpectations in the States of what we can produce in a short time frame, or that we can do work that is not in our mission. We have very strict FTE ceilings. Other than minor reallocations, they will not change. Certainly Dallas and Phil have given us no hope for improvements in the next 3 or 4 years. This Administration will be making up budgets through 1989. If then there is a change in party and philosophy, it still does not seem that our type of agency will be in line for major increases in funding. For the rest of our careers we will deal with a rather static situation that will require hard choices.

There are two limitations to our EPA cooperation that we considered. The first one is FTE and matching money. The second is that there is no uniform national program within either EPA or the States. EPA has very few unified national programs, and the States are all handling this EPA money in different ways. Some are building their own programs, hiring new people, and buying new equipment. Others are coming to the Survey for help and to complete implementation. It is difficult for us to build national or regional programs on this issue because the policies of the States and the EPA regions are so disparate.

Next we turned to the second question facing our group: What changes might occur as a result of ground-water protection programs that might impact our operations and what actions can we take? We identified seven changes.

The first is the probable increases in State and cooperator offerings. That is not going to be the case for all States. Within our group there were several members who said that their cooperators were going to use the money internally. There were others who said that the money was being turned over to USGS. There are differing situations that will occur here, but there will be increases in some States.

How can we respond to this? Obviously we need to look for increased funding in the State cooperative program. That is a hard choice that the leaders of the Division will have to make.

We also may need to work with cooperators to adjust program priorities. Possibly the EPA priorities will be higher than some of the current programs. Therefore, there may be a change in program priorities within the States and within our programs.

There is a question of using EPA funds from the States to match USGS money in the cooperative program. We found that perceptions differ within EPA from Region to Region and they also differ from State to State. We are working on clarification of the issue.

A second change is probable increased requests from States and EPA for training. We recommend increased capabilities to provide training at State locations by District and regional teams. Our Northeastern and our Southeastern regions are already active in providing training on this scale. It provides an alternative for training at our National Training Center in Denver, which many people find difficult because of travel restrictions. Also we have trouble with our capacity to train in Denver.

We could establish a national training course for those instructors responsible in a regional or District level to provide unifor-

mity to that training. We could produce and distribute the "how-to" type documents such as "How to Install Observation Wells and "How to collect representative samples and the Techniques of Water Resources Investigation (TWRI)-type documents on a slightly simplified scale. And we could organize field demonstrations of these techniques for the State and EPA personnel.

Finally, we could look at other training concepts, such as using university, joint-university programs, and retired USGS personnel more effectively.

The third change that we identified was the requirement in most States for increased assistance in data-base management. The action that we identified in response to this change was the need to put our own house in order. There have been good developments recently in improvement of the GWSI system, but the program still is not used extensively enough in the Districts. There is a certain negativism surrounding it. We need to give it a high priority.

In one of our Districts, the State is taking EPA money and, rather than using USGS software or USGS programs, is developing an entirely independent and incompatible data base. There is work to be done to improve and publicize our data-base capabilities based on this example.

We need to establish procedures for direct State access to the Distributed Information System (DIS). Many States have made good progress and are willing to use the DIS. There are others, however, that require excessive training time. There are protocols and procedures that need to be developed to make this system more accessible.

Finally under change three, we recommend talking to EPA Regions and Headquarters to discuss this problem of the development of independent State data bases.

The fourth change was increasing State awareness and use of the Geographic Information System (GIS). We recommend taking the lead in bringing this technology to the States. Some States have ARC-Info and several of the other software packages, and are moving ahead of us. We need to work with them, if that is the case. We need to help them if it is not the case. It is a very powerful system, more than just a buzzword; it is a system that is going to be with us for a long time.

Another opportunity within the USGS is the utilization of the EROS Data Center. The Center has very skilled people who do remotely sensed imagery work that is useful in GIS work. People hear about the Center, perhaps even visit and get the products and become excited. Then, for some reason, the interest trails off and the activity diminishes. It is a very good program with good people. We feel that there are things we could do with that program to assist our cooperators and ourselves.

There is a need in the GIS program to get our own programs together. As Dallas mentioned, he has more difficulty following USGS activity in GIS than he does in following activity from agency to agency. There is a very active program in the National Mapping Division and you have seen Walt Rennick's work. Ken Lanfear, in our Division, is active and knowledgeable on the subject, but the technology is moving so fast that they have not had a great deal of opportunity for coordination. As a result, we need to make program improvements within our Division and within the USGS.

The fifth change perceived was increasing requests for short-term, site-specific field work and advice. We recommend establishment of internal criteria and guidelines to avoid possible charges of conflict of interest with the private sector. The second was to balance requests in light of of good science and the need to maintain good working relationships with the States and with EPA. Those will be in conflict occasionally and we will have to make decisions based on those two issues.

There was an idea in our committee of pursuing (with EPA) technical assistance for help with short-term requests. There have been programs in the past in which funds of about $20,000 have been available to Districts to accomodate small short-term requests. Such funds are not available these days. We might try to convince EPA to provide funding for this type of activity.

Sixth, the timeliness of our reports and other contributions will become more of an issue. We recommend seeking ways to decrease the review time of reports. Most of that effort might be in the District, and that is being done in many cases. We recommend that Headquarters reviewer(s) be identified at the outset of a project, so that the project leader can communicate with the reviewer throughout the project. The reviewer will know that a report is being prepared. Therefore, when it arrives, the reviewer will be familiar with the project, the project leader, and potential problems with the report.

The seventh change is that States, EPA, and private consultants are moving quickly to staff and fund major ground-water programs. We recommend that we double our efforts to get the best people. We can offer scientific opportunity, challenge, excitement, camaraderie, and continued learning. We produce quality products and impartial information and interpretations. We provide broad perspectives on issues, which is something that other groups cannot do. The consultants are offering primarily cash. It seems that there are opportunities to continue to get good people based upon those differences.

The third question is, "What are the increasing roles of the USGS in the next 15 years as a result of the ground-water protection strategy?" We think that we will be the source of expertise for the media, courts, cooperators, and OFA's on an increasing scale. As a result, our public-relations efforts will be stepped up, also our public-relations skills. We are going to be dealing with people outside of our report process. They will be calling us on the phone; there will be increased contact with the press, etc. We see an increasing role for the USGS in the emerging subjects of evapotranspiration, geochemistry, organic contamination, scientific-data management, and inexpensive monitoring techniques—all of this in the midst of many real-time technical problems.

And finally, we see the USGS increasingly as the primary source of understanding of the description of the hydrologic systems. And we see the responsibility to be the agency that pulls things together and presents the big picture.

In summary, our thoughts are these: The emerging ground-water protection issue is only one of many changes in our science and in our working environment. The increasingly severe problems of water quality and quantity have drawn national attention to our field. They bring our Chief and the Director to the Hill weekly instead of annually. EPA is in the field now with billions of dollars. The Bureau of Reclamation is now active in ground-water issues. The Department of the Interior is requiring that our programs be relevant to a broader range of other Federal agencies. States are developing their own programs. Universities now have broader experience. And of course, the consulting field is growing.

The next 15 years will not be business as usual, but rather a time of unprecedented change, filled with opportunities, hard choices, and risks. It will be a time to recognize the issues early, to use imagination and good judgment for proper decisions. We will require energy and courage to implement them.

Program Balance

C. W. BONING, District Chief, Texas

An initial question that this work group asked was: Why was the balance of data and investigative program in the Districts selected for discussion? Is balance, if such a term can be defined, important to a District's program and to the Division? What benefits can be gained from exploring the concepts of program balance?

Program balance can be scrutinized from perspectives such as funding levels, or personnel structure and responsibility. But are evaluations meaningful to Districts in light of the changing hydrologic problems that require more complex and innovative investigations?

Precise definitions of "data" and "interpretation" can detract from the real issue—program quality and responsiveness to needs for hydrologic information. This discussion provides a general review of program balance in the traditional sense, reviews historical trends from various perspectives, and also reviews the stresses and philosophies that influence program balance. Most importantly, the discussion examines philosophies that have an impact on program balance and that help Districts meet future challenges.

What is program balance? Program balance has been considered an expression of budget allocation to basic data-collection programs and interpretive projects. In the past, it was viewed by managers as an index of the unit's adequacy to satisfy the Division's misson. That mission, succinctly stated, was to provide water-resources information for the public benefit.

How did this concept evolve? Today, many managers question such a monetary index as a measure of a unit's performance. Some might even characterize this "program balance" as a bureaucratic crutch to evaluate a unit's programs without consideration of the program's value.

We can go back in time and speculate on the origin of "program balance" in an environment when it was a reasonable index. Before World War II, the Division stood nearly alone in the water-resources data and information field. At that time, the Nation had little water-resources data in all categories. In such an environment, high-level managers could easily determine the proper balance to produce data and information in support of the Divison's mission. Thus, management could set reasonable program-balance criteria and get a reasonable idea of how the Division was performing its mission through simple budget analyses.

About the time of World War II, the Nation experienced a proliferation of manmade compounds. As these compounds "escaped" to the hydrosphere, a new set of data deficiencies and technologic deficiencies was created.

At the same time, but not significant until the 1960's, was the growth of technical capabilities for water-resources data collection and interpretation by those outside the Division. The WRD also has expanded its technical capabilities, and is conducting more investigative projects.

From 1973 to 1978, data collection accounted for more of the field program than projects. Since 1978, however, projects have dominated the Division's field program. OFA funding has remained relatively unchanged since about 1978. Although there have been fluctuations in the total Federal funds within the Division, there has been a general increase since 1973. Federal funds in the field program have remained relatively unchanged since about 1980. Funding in the Cooperative program has increased steadily since 1973. The general increase in the total field program is mostly attributed to the coop program increases. The major changes in both the total-field and total-WRD funding levels are caused by fluctuations in the Federal funding levels within the Division.

Federal funding for data-collection activities has remained almost constant since 1979. There generally has been a steady increase in cooperatively funded data programs throughout the period. The result has been an overall increase in funding for data programs. Coop funding for projects also has increased, but has leveled off at about $60 million for the past 2 years. Funding of projects in the Federal program increased significantly in 1979 but had smaller increases over the next 2 years. There was a fairly substantial decrease in those activities in 1982, but since then the Federal funding of investigative projects in the Districts has remained relatively constant, with a minor decrease in 1985. Overall, project funding in the field from coop and Federal programs has increased steadily from 1973 to 1981. In 1982, there was a relatively sharp decrease that lasted for 2 years. In 1984, funding for investigative projects in the field fully recovered from the lower levels in 1982-83. A small decrease occurred in 1985.

From 1973 to 1985, project activities funded by the coop and Federal programs increased more rapidly than the data programs. However, the rate of increase has moderated, perhaps because of reduced rates of inflation in recent years.

Additional data show the distribution of projects versus data programs for 1985. Percentages of District programs allocated to "data collection" range from about 25 to about 75 percent. Data show that in 1985, 46 percent of District programs nationwide were identified as data programs. Funding by source shows that 46 percent of the coop funds, 30 percent of the Federal funds, and 59 percent of the OFA funds were allocated to data programs.

The increased funds for projects relative to data programs support the hypothesis that the Districts are responding to new emerging problems. We perceive that data collection and projects cannot be separated or viewed from a funding perspective to assess program balance realistically. If program balance, as defined by the need, value, and use of hydrologic information, is an approach to assessing performance, it has become far more complex as a result of new variables. Data collection in a vacuum cannot be defended. Data deficiencies can no longer be assumed; well-defined local knowledge is imperative. Likewise, the allocation of human and fiscal resources must be adjusted to account for the variety of resources being applied in patchwork fashion by other agencies throughout the Nation. Again, local knowledge is imperative. Thus, we must incorporate many elements of local knowledge to be able to answer the question "Is the Division discharging its mission responsibilities effectively?", or in its surrogate form, "Is the Division program balanced?"

The mission of the WRD is to provide information essential to resolving hydrologic problems. It behooves us to identify those hydrologic problems, identify data needs, and to develop the most effective and efficient means to attack those problems. *Whether data are collected in the data program, or within hydrologic studies and research, inadequate data collection makes program balance meaningless.*

Communication, planning, and effective program implementation are keys to a responsive District program. District programs must reflect the information needs, and the products must be of significant use and value to address hydrologic problems. Because the changing needs for hydrologic information are often perceived differently, agreement on the major issues and problems requires continual coordinated planning. Such communication is needed with our cooperators, our organization, professional organizations, civic groups, and universitites. States and other Federal agencies are particularly more open and responsive when immediate funding is not required. The benefit of long-term planning is the generation of attitudes of progressive program development.

Interaction with the NRP is critical to maintaining a high quality District program. This interaction advances application of the state-of-the-science in District investigative and data-collection programs. In the short term, this is manifested as transfer of new methodology. In the long term, the growth of understanding provides the essential base for interpretations from District data-collection programs. A properly balanced program must consider basic studies of problems and processes to develop the knowledge necessary to design competent data-collection programs. Thus, accumulating "sufficient knowledge" is not simply an open-ended request for more basic science, but an essential component in the balance of our program. As technology advances, the intermingling of research, investigation, and data collection leads a District pro-

gram to more effective resolution of water-resources problems.

An example of technology transfer from research and data collection is the need for a data base on evapotranspiration. Research has perceived that the syntheses of carbohydrates and other organic compounds is more strongly related to evapotranspiration than to rainfall or runoff. Although some evapotranspiration data exist, the development of needed comprehensive data bases will entail both field work and analytical studies.

Communication includes the general public—many programs are generated and initiated as a result of public concern and subsequent legislative action. These may begin as local issues, but develop into national programs requiring extensive communication, planning, and coordination between the Division and the Districts. Examples include the acid-rain issue, which received little attention until the news media publicized the dying forests in Canada and sterile lakes in upstate New York. Also, the energy crisis generated the energy programs. Economic impacts of flooding resulted in the Flood-Insurance Program. Droughts, particularly in the midwest, were instrumental in the initiation of the RASA's. The hazardous-waste program flourished after the public outcry over Love Canal. Recent concerns over selenium contamination in the Central Valley in California will foster more attention on toxic substances. These are just a few programs that the Division has responded to, and that have been very worthwhile issues in terms of program content and quality. Future programs, such as NAWQA, also will stimulate data collection, interpretation, and research, making positive contributions to program balance.

District management philosophy, in addition to communication and planning, are major factors in program balance. The basic resources that a District relies on are funds and personnel. Both of these resources are limited, and their efficient use is critical to program quality.

It is easy to make broad statements about planning and communication and their involvement in program balance. Actions to mold a District program are affected or seemingly hindered by constraints that influence our success in program improvement. Effective management must develop positive attitudes in relating Division management goals to District programs, and capitalize on Division strengths to achieve optimum program balance.

Funding limitations and personnel ceilings have strong influence on program balance. Because we must balance annual budgets, program balance may become a secondary consideration in our efforts to resolve financial problems. Cooperator requests to conduct low priority work affects both personnel and availability of matching funds. With existing and future shortages of matching funds, Districts must examine their programs more critically, and prioritize work that is most valuable to the user. Districts must also continue to improve the efficiency and effectiveness of their operations.

Programs generated by public pressure, legislative action, crisis situations and so forth, frequently impact District routine. Although these programs are reactive in many respects, their initiation is often accompanied with supplemental funds. District managerial philosophy and skill in accomodating such work can enhance program balance. The value of these short-notice efforts is of extreme benefit to the user.

Some Districts bear cooperator pressure for direct services credit for program activities, instead of dollar offerings. The Division itself, over the past decade, has exerted pressure either to increase or decrease direct services depending on personnel ceilings and availability of matching funds. Although Districts have some flexibility to meet these pressures, reprogramming causes uncertainty in resource planning, creates instability in program execution, and sends confusing signals to cooperators. In consideration of FTE ceilings and limited matching funds, Districts must consider program content in examining direct services for program effectiveness.

Unmatched funds are commonly provided to conduct low priority work. Such funds often benefit Districts from budgetary perspectives and commonly allow the utilization of excess District personnel. In coming years Districts must seriously reconsider low priority work, under any funding source, unless program balance will be adversely affected.

In recent years, a seemingly endless number of WRD mandates for assistance in National reports, evaluations, requests, and commitments have filtered down to the Districts with minimal, if any, funding support. The value of these is seldom readily apparent to the Districts. Districts may fail to recognize that many of these demands may result in supplemental programs, moderation of potential budget cuts, or enhancement of the Division's image. Closer communication throughout the Division will encourage more positive attitudes in dealing with these demands. Districts then may recognize the potential benefits that such effort and exposure may produce. The result may be a national thrust program that will stimulate research and investigative work, and at the same time expand data collection and enhance program quality.

Pressures for timely answers to problems generate risks of conducting projects without adequate time or without adequate data, resulting in late reports or less credible reports. Proper planning to resolve these pressures must be exercised, and the program must be conducted with appropriate personnel to meet deadlines and to maintain WRD credibility. Many projects deserve to be revisited to verify or modify predictive results. Such verification, which may be either data oriented or interpretive, contributes to desirable program balance as it relates to value of the product.

The application of good science in District programs has been a strong tradition. However, program size, rather than good science, often has been perceived to be a major criterion in assessing the value of a District program. With the shortage of personnel and shrinking funds, Division leaders have reemphasized the traditional philosophy of good science.

Districts recognize that emphasis on size, with little regard for program diversity and technical advancement, will probably limit flexibility and adversely affect program balance. Small Districts, or Districts with diminishing programs, may have the same problems, even though existing projects may be high quality and very well managed. With the increasing cost of support functions, it appears critical that the Division must seriously explore the sharing of personnel and support resources.

As program needs change, District needs for personnel talents also change. Conducting valuable programs, which may be beyond the talents of existing personnel, is a challenge to District management. Long-term planning can help moderate this problem, but changes in program content often can be sudden. Some individuals cannot be readily transferred because of existing program commitments. Staff members may not be readily transferred out of the District because their talents are not in great demand, and because the Division is sympathetic to personal lives. To help minimize the talent shortage, Districts are developing and training their staff in broader areas in hydrology. However, the inability to maintain a fully viable staff dictates that the Districts and the Division examine the sharing of personnel resources and that they intensify training in state-of-the-art technology.

The Division's hiring practices will be significantly affected by our need for specialized personnel. The need for such personnel is already apparent, as Districts often lack the expertise to conduct such work as merit projects, thrust programs, and new National pilot studies. The impact that these studies have on program balance may become more apparent through generation of scientific interest, identification of data needs, and recruitment of personnel with specialized education.

The real concept of program balance, in terms of program

content and quality, must be kept in mind as Districts address their long-term goals and daily decisions. That concept is that need, use, and value, must justify our programs and the information produced.

Personnel Needs

R. N. CHERRY, District Chief, South Carolina

This report addresses the following topics:

- What should be the composition of the scientific staff in WRD in the 1990's?
- What types of managers will be required to carry on the work of WRD in the 1990's?
- What kinds of support will be required to carry on WRD's mission in the technical, administrative, computer, and clerical areas?
- What kinds of recruiting and career-development mechanisms will be needed to ensure the highest quality work force?

1. What should be the composition of the scientific staff in WRD in the 1990's?

The composition of the scientific staff in the 1990's will be dictated by WRD's need to respond to local and national issues. The highest priority issues will be similar to those of today which are primarily related to the quality of water. The primary water-quality problems will be those relating to health issues.

Maintaining a staff to address the traditional tasks of WRD, and at the same time to address National water issues will require a wide range of talents. The talent areas that need additional personnel are engineering, geochemistry, organic chemistry, computer science, geophysics, hydraulics, hydrology, and statistics.

Overall, the scientific staff of the WRD must be strengthened by hiring more people with advanced degrees. The strengthening must be done within FTE limitations. Such needs and limitations require that only the best qualified be hired. More timely completion of work will also be demanded. Therefore, the staff of the Division of the 1990's must consist of individuals who can start and finish a project in a timely manner and express the findings in a well prepared report.

The Division also must have highly talented personnel in the data programs. Our District data programs, especially surface water have withered from the lack of talented professionals. We must reinvigorate the data programs and convince those persons in the data programs of their value. Our data-collection programs are becoming more complex, and with decreasing personnel ceilings we should clearly start filling vacancies with professionals. The composition of the Division staff in the 1990's must include a higher professional/technician ratio than exists today.

We rely more and more on technicians for more of our basic field work and data collection. They will have to be more highly trained then ever before; they will have to be capable of operating a wide variety of complex equipment; they will have to be well versed in the use of computers. They also must be willing to spend more time in the field. Given the additional capabilities required of technicians, the classification standards for full performance Hydrologic Technician should be upgraded.

The following are considered to be important action items:

- Establish national hiring priorities for a specific number of employees under the listed talent areas.
- Emphasize hiring professional employees with graduate degrees.
- Review and reformulate, as necessary, the WRD professional hiring standards, raising the entrance qualification level of the standards to insure acquisition of better qualified employees.

2. What types of managers will be required to carry on the work of WRD in the 1990's?

The managers of WRD in the 1990's must be technically oriented and also have a wide variety of skills, including administration, data processing, financial management, and personnel management. In the past, many people in the Division have felt that we have two paths of career advancement: management and technical. These paths, if they are in fact separate, should become less so in the future. Our work is becoming increasingly complex, and our managers must be strong in technical skills. Generating new programs, planning, costing, and supervision of hydrologic investigations, research, and the related data collection will need strong technical guidance by the manager.

The manager must be a "hands on" computer user. Almost all of our work—investigative, data, and administrative—involves extensive use of computers. The manager must be knowledgeable in this area to ensure the availability of hardware and software for these applications and to be able to use them personally. The manager who does not have these skills will be considered a dinosaur.

The manager of the future must have excellent skills in estimating reasonable project costs and maintaining accurate cost accounting. Charges for work are increasingly being challenged. We need improved skills in making accurate estimates and our work force must be as efficient as possible.

The manager will need personnel-management skills. The productivity of a group and the quality of its product are greatly influenced by the personnel skills of the manager.

As WRD's work becomes more complex, managing specialized skills becomes more important. Providing needed training to personnel is essential. People with these new skills often cannot be recruited because technology and management techniques are ever-evolving and more specialized. Experts need continuing training to remain current. Increased specialized training will be very important to the Division. Training takes many forms; three of the major types are: (1) formal classroom; (2) correspondence; and (3) on-the-job. Suggestions are made on two of these areas.

Formal classroom training will include the following:

A. Management Training—Set up a regular course with a good university or top-notch management consultant firm for specialized courses or design a course to be conducted by some District Chiefs. All new District Chiefs would attend this course. The course could take up to 4 weeks.

B. Technical—A course similar to the above could be set up for specialized technical areas such as organic geochemistry, chemistry of hazardous-waste compounds, or computer science. Also, we would benefit greatly by setting up some projects with university staff members. University staff members are a technical source that is essentially untapped. We can gain a great deal by using their brains on some of our projects—and gain some "inside tracks" to good students as future employees.

Greater use of the National Research Program (NRP) personnel to address problems would improve the quality of our overall products. This is growing but not yet near an optimum level. Regional Research Hydrologists and District Chiefs should be in structed to emphasize this input.

We could greatly benefit from more personnel details for on-the-job training, including details from one District to another, to the Regions, and to Headquarters. These can be for technical, management, or administrative purposes. If taken seriously, and pushed by the Division, a lot of good training can be accomplished that way such as a detail to an NRP office or lab for a specific application; detail to a "progressive" District to see how they handle project cost development, personnel management, program execution, etc.; detail to Headquarters for administrative experience, Branch experience, or to get the "political feel".

The following are considered to be important action items:

• Establish a WRD Management Training Committee, made up largely of District Chiefs.

• Charge the WRD Management Training Committee to develop a training program for managers, utilizing university personnel, consultants, and WRD managers.

• Charge the WRD Management Training Committee to develop a technology-transfer program for WRD managers.

3. What kinds of support will be required?

Administrative and clerical support—There is an increasing demand for greater detail in accounting, personnel matters, and administrative functions. More and more of these demands are being passed from the higher levels of the the Bureau and Division to the lower levels. Administrative and clerical personnel must be well educated and trained and must keep up with the latest computer techniques. That means they will have to start at a more highly trained level, and the grade structure should be adjusted to retain such highly skilled people.

Computer support—Computer personnel are going to be continuously on the run to catch up and keep abreast of latest methods and technology. Unless we are willing to pay for competent and versatile computer personnel, staffing of these positions will be a continuing problem at all levels of the Division.

General support—For the benefit of smaller Districts, we might consider the establishment of specialty teams in larger Districts or the Regions. These groups could effectively carry out such things as construction (particularly involving complex instrumentation), flood measurements, complex aquifer tests, computer services, and report preparation and processing.

The following are considered to be important action items:

• Develop a formal Administrative Officer training course.

• Encourage regions to establish specialty teams for flood measurements, complex aquifer tests, major construction, etc.

• Develop multi-District report preparation and processing centers.

4. What kinds of recruiting and career development mechanisms will be needed?

An aggressive National recruiting program is needed. We need to look nationwide for talent; we need to identify clearly places to put the talent and place the people where they are needed. Let the Manpower Section coordinate the efforts of the Regions and Districts and push for the placement of skills that we are going to need.

We need to recruit, train, develop, and maintain the relevance of our professional and technical staffs. We should develop formal cooperative student programs with the universities, with emphasis on graduate students. We should actively seek involvement with the Water Resources Institutes. We must develop close ties with many universities, especially the graduate-assistant programs, to identify promising students.

We must not neglect our onboard staff in our search for new hires. The Division should reemphasize and liberalize the options in the WRD graduate school program. A Region or District should be permitted to sponsor and support a student and, for example, permit the student to return to the original District.

Professionals should be rotated through the different sections within a District for career development. Periods of rotation should be of sufficient length that the employee contributes to the production of the section.

Through the cooperative student program, arrange with colleges or technical colleges to develop programs for hydrotechnicians. Field aspects would be coordinated with WRD, and upon graduation they could be offered a noncompetitive appointment.

The following are considered to be important action items:

• Give cooperative student programs national emphasis, utilizing largely graduate students for most Districts and many NRP projects.

• Establish a National recruiting program for professionals emphasizing, but not limited to, discipline skills outlined under topic #1.

• Regional program evaluations will give a high priority to investigative and research proposals that involve university staff and students.

• Broaden the WRD Employee Graduate Support Program to allow for District or Regional support of employees under this program (or a new program if necessary) and the return of such employees to the originating District.

The Division's Mission Conflicts

I. C. JAMES, District Chief, New England District

The topic for this work group is WRD mission conflicts. There are many viewpoints on what is meant by mission conflict—resource evaluation and appraisal vs. process research; responsiveness to Cooperative vs. Federal vs. OFA programs; data collection vs. interpretation. But I do not think that any of these were at the forefront in the Senior Staff discussions that led to the selection of this work group topic.

We considered some of the Division's recent concerns, some externally imposed, that may indicate a change in the Division's mission, its direction, and role. Among these, two that have received considerable amount of attention have been our activities with the Garrison Diversion Study Commission and the Kesterson Wildlife Management Area. In both, the Division has been directed by external forces to an involvement that has been non-traditional, and uncomfortable for some. Here are some of the characteristics of these activities that may have led to our discomfort:

1. They were externally mandated.

2. They required a rapid response.

3. The evaluations had to be both scientific and policy relevant.

4. The results might offend some of our clientele and special-interest groups.

5. We would operate at a high political level and in a strong public spotlight, where few in the Division have extensive experience.

6. The interruption of ongoing work could disrupt long-term cooperative relationships or disrupt our long-term objectives.

Whereas the above two examples focus our deliberations, they are far from the only non-traditional activities that we are now or may be involved with. We are now in the unusual position of running the Bureau of Reclamation's water quality lab. We are consultants to the Bureau of Reclamation on recharge to shallow aquifers in the O'Neil project in Nebraska. Our involvement with the Jackpile-Paquate project may also be considered non-traditional. In the Western states we are continually called upon by either the Bureau of Indian Affairs or the Indian tribes to serve as consultants, sometimes without public release of the results, a notable exception to our usual policies.

Recent interagency agreements with the Environmental Protection Agency and the U.S. Air Force have opened for us a role as consultants, reviewing the work of others, giving expert testimony, and giving advice. We often serve on interagency commissions, work groups, and task forces where recommendations may be made without the benefit of our usual review. I would like to summarize these demands with a quote from the great philosopher of the Big Sky Country, Joe Moreland, "Other agencies seem not to respect our old tradition of keeping our heads buried in the sand." This is at the heart of the issue. Our heads are getting forced out of the sand.

If these are the issues that concern us, perhaps we should review our mission and evaluate them to determine whether or not they conflict with our mission.

A team led by Bill Radlinski, the former Associate Director, has already completed a draft document that examines the "Mission, Goals and Authorities of the U. S. Geological Survey". We use this as our primary reference for the Survey's mission statement.

The Organic Act of March 3, 1879 provides for ". . . the classification of the public lands and examination of the geologic structure, mineral resources and products of the national domain." Land classification, which we might consider a very non-traditional role, was written into our Organic Act. Not only does this include scientific activity, but it also includes management.

Although this Act covers almost everything we do, subsequent legislation further codifies our mission. In particular, chemical and physical research was recognized and undertaken as an essential part of geologic investigations by the Appropriations Act of 1889. This Act further authorized the survey of irrigable lands in the arid regions, reservoir sites, the gaging of streams, etc. Stream gaging and water supply determination were further specified by the Appropriations Act of 1894.

Paraphrasing the "mission" statement as it applies to the Water Resources Division, we find that the Survey conducts the following activities to accomplish its mission:

- Conducts and sponsors research in Hydrology to address national needs.
- Collects and analyzes data on the quantity and quality of water, on water use, and on the quality of precipitation.
- Assesses water resources and develops an understanding of the impact of human activities and natural phenomena on hydrologic systems.
- Evaluates hazards associated with floods, drought, toxic materials, landslides, and subsidence.
- Publishes reports and maps, establishes and maintains hydrologic data bases, and disseminates hydrologic data and information.
- Provides scientific and technical assistance for the effective use of hydrologic techniques, products, and information.
- Coordinates water data acquisition.

Dr. Wolman and others are looking for us to maintain the quality of our research, and also to integrate the results into the issues at hand. We have to have implementation to make research effective. We must give direction about what our research means and how it is to be used.

Our old mission was to assess the resources. The resources have now generally been found, developed, manipulated, and changed. The new mission will be to assess man's current and probable impacts on the resources through these changes. These missions differ vastly in scope. What are the changes and what are their consequences? Congress and the Nation will have the answer, and we will provide it—or our replacements will. Our selection of a future mission and our response to mandated activities may well determine our future existence.

Nancy Lopez gave us the following perspective from the Office of the Assistant Secretary for Water and Science.

1. Unless our work applies to a Federal problem, it will not get first priority.

2. The Administration and Congress are asking for scientific answers that will help them on tough policy decisions.

Considering the above discussions and our mission statement, the work group finds that THERE ARE NO MISSION CONFLICTS. However, there are some real POLICY decisions about the acceptance of work and the conditions under which we must accomplish such work.

Lenny Konikow reviewed several Water Supply Papers from the 1900-1922 period that were very policy relevant and that may help us maintain our perspective on this issue. These reports show conclusions and recommendations that indicate that the Division was actively involved with public policy issues at that time. After reading those, it seems that we may have swung too far to the side of being irrelevant. The direction being set for us now and in the future may return us toward our historical involvement in policy-related work.

Several years ago, the WRD refused a request for a 90-day study of Love Canal. The work was within our mission, but the conditions were not appropriate. We could not do a scientifically credible job in such a short time, under the given circumstances. There have been a number of instances when the WRD has either accepted or rejected work within our mission. Our work group has searched for the key that should govern our decisions in such instances. Certainly if the work is mandated by the Department, we have few options. Yet an opportunity for doing the same work for another Federal agency might cause us to hesitate. Even if a task is mandated, we should try to limit it to the abilities of our technology, personnel, time, and fiscal resources.

The key in these decisions may look parochial, but we think it has merit and is possibly best for the Survey and the country as well. One version of our key is that all of our work should maintain or increase our long-term scientific stature within the scientific community and within the political environment in which we deal. This may sound rather self-serving.

Another version said we should strive to undertake only those studies where the contribution to science or the Nation's well-being are paramount. This essentially has the same meaning as the previous version. We think that any work should lead to our own enhancement as well as meet the needs of the Nation. Any work that does not contribute positively to our stature, with an exception I will note later, should be rejected or modified before acceptance.

Traditionally, we have asked questions such as these:

- Is there ample time to accomplish the study?
- Will the results be released on an equal basis?
- Does it fit our mission of "good science"?
- Will the results not be excessively controversial or political?

Indeed these are, and should be, factors in our decision. But they must be balanced against the other considerations that also affect our reputation, credibility, and well being.

- Are we being "policy relevant"?
- Are we gaining political support for our programs?
- Are we doing something that is good for the country?

It is in the National interest to maintain a strong, impartial, objective Geological Survey with a tradition of equal access to our results. Thus, our interest and the National interest are aligned. This is our key. The possible exception is that there may be times when the good of the Nation may outweigh the good of the Division. I remember of the comment of one of our Directors on whether or not to keep the Conservation Division. He said "For the good of the Survey we should let them go, for the good of the Nation, we must keep them."

Within the context of the above key for accepting mission work, there are several factors to emphasize:

1. PRIORITIES MUST BE SET. If taking on good and needed work within our mission would disrupt work in a higher priority area, we should decline if possible. The incremental benefit to our reputation from meeting our commitments, doing higher quality work, and serving our long-term clients will be higher.

2. THERE IS NOTHING WRONG WITH "POLICY RELEVANT" RESEARCH. Lenny's review found a number of Water-Supply Papers that were very policy relevant.

3. WE MUST CAREFULLY GIVE THE BEST SCIENTIFIC CONCLUSIONS, EVEN WHEN RESOURCES ARE NOT ADEQUATE TO COLLECT ALL OF THE NEEDED INFORMATION. We are professionals who can make interpretations. We should be responsible and estimate the uncertainty bounds around our interpretations. Again, our key in deciding whether or not to make an interpretation is the principle used in deciding whether or not to do the work.

4. WE ARE IN COMPETITION WITH OTHER PUBLIC AND PRIVATE SECTOR AGENCIES AND FIRMS. We neither deny this nor apologize for it. As Phil Cohen pointed out, we no longer maintain a lock on hydrologic skills. However we have some competitive advantages that make our services particularly attractive to the public. We are unbiased. We serve the public at large, equally. We represent a level of quality control. We are a nationwide organization. We are obviously not going into any head-to-head competition with the private sector. Their mission and ours are fundamentally different. We are however, competitive, and we feel that we are respected because of it.

5. NEW THRUST PROGRAMS OR RUSH JOBS SHOULD BE FULLY SUPPORTED IN BOTH DOLLARS AND FTE'S. We realize that management may undertake special projects as a loss-leader in anticipation of more rewarding future work. We recognize that Departmental mandates may not be fully supported. We still think our efforts should be fully supported and that management should negotiate with this as a strong objective. We emphasize this final factor.

With the belief that we are working within our mission and within the criteria for acceptance of our work, we recommend the following to ease the discomfort about our involvement in more sensitive work:

1. The "release" of information to the public at interagency meetings, hearings, and in court requires that we train our hydrologists in the presentation of technical information in an adversarial environment. Lawyers have different ways of thinking and inquiring than other professionals with whom we work. People who are going to face close scrutiny and biased viewpoints need training and support before they get into such an environment. Few of us have extensive experience there.

2. The rapid response to short-term mandates requires the development of a management structure and interdisciplinary task forces management skills in the Division. The skills are scattered throughout the Division, but are not integrated into the management structure. Knowledge and expertise will continue to come from throughout the Division. Task force leadership may have to be integrated.

To summarize, the work we are doing and are being asked to do is within our mission. We have no qualms about that. That thought was unanimous with the work group. The conditions under which we accept such work must protect the Division, be considered within other priorities, and consider both the positive and negative long-term impacts on the Division. We must continue to review our policies, training, and organization so that we can respond to these new mission challenges.

Alternatives for Funding Special Efforts

R. J. PICKERING, Chief, Office of Atmospheric Deposition, Reston

The charge to this work group was to recommend changes in Division funding practices that would improve our ability to carry out a program appropriate to today's conditions and concerns.

In addressing our charge, we examined the sources of funding and program expenditures by major categories. These are shown in Tables 1, 2, 3, and 4. Funding from all sources can be categorized as follows:

- Direct Appropriations
- Reimbursable Funds
  - —States, Counties, and Municipalities
  - —Other Federal Agencies
  - —Miscellaneous Sources

Two new components of the program are the Federal share and the matching share of the State Water Research Institute and Research Grant programs. By law, these program components are exempt from many of the assessments that will be referred to later. They have their own sources of overhead provided for in the Act that created them.

In a preliminary meeting in Reston, the work group developed a list of about a dozen topics that should be discussed further as possibilities for improvement in the Division's funding practices. After further discussion at this National meeting, the work group reduced the list of topics to the following:

1. Establishing a revolving fund for lab equipment, computer facilities, equipment development, etc.

2. Changing the practice by Headquarters of requesting unfunded or partially-funded studies or activities.

3. Use of thrust programs to promote cooperator-funded activity through either formal or informal cooperative agreements.

4. Passing more of the costs for preparation of Federal Series reports down to the project level.

5. Changing the basis for applying assessments.

6. Consolidating support services.

The work group recommends that the Chief Hydrologist appoint committees or individuals as appropriate to investigate the above topics further. It should be noted that creation of a revolving fund would require special approval from OMB and the Congress.

Table 1. Sources of funding—U.S. Geological Survey, Water Resources Investigations

	FY 1985 Estimate ($Thousands)	FY 1986 Estimate ($Thousands)	FY 1987 Estimate ($Thousands)
Water Resources Investigations			
Direct appropriation	132,844	132,747	138,383
Prior year's unobligated balance	660	895	—
States, counties, and municipalities:			
Matched	51,025	52,324	52,859
Unmatched	4,000	5,000	5,000
Permittees and licensees of the Federal Energy Regulatory Comm	1,800	1,800	1,800
Kingdom of Saudia Arabia	1,400	1,400	1,400
Miscellaneous non-Federal sources	290	290	290
Agency for Int'l Development	165	165	165
Bonneville Power Administration	120	120	120
Bureau of Indian Affairs	1,000	1,000	1,000
Bureau of Land Management	1,570	1,200	1,000
Bureau of Reclamation	6,500	7,700	7,700
Department of Agriculture	650	650	650

Table 1. Sources of funding—U.S. Geological Survey, Water Resources Investigations—Continued

	FY 1985 Estimate ($Thousands)	FY 1986 Estimate ($Thousands)	FY 1987 Estimate ($Thousands)
Department of Defense:			
Military	2,500	3,000	3,500
Civilian	16,500	18,000	18,000
Department of Energy	6,000	8,000	8,000
Department of State	478	520	519
Department of Transportation	400	400	400
Environmental Protection Agency	1,300	1,300	1,300
Federal Emergency Management Agency	3,000	3,000	3,000
National Oceanic & Atmospheric Admn.	75	75	75
National Park Service	815	815	815
Tennessee Valley Authority	150	150	150
Miscellaneous Federal Agencies	163	163	163
TOTAL	$233,405	$240,714	$246,289

Table 2. Funding allocations by major program categories

	FY 1986 ($Thousands)
Federal Program:	73,482
Data Collection and Analysis	18,906
Thrust Programs	42,638
Hydrologic Research—Core	6,975[1]
Other Federal Programs	4,963
Federal State Cooperative Program: (Federal side only, States equal this plus $5,000,000)	52,324
Data Collection and Analysis	44,106
Water Use	3,858
Coal Hydrology	4,360
Water Resources Research Act:	7,664
State Water Institutes	5,153
National Research Grants	2,511
Other Federal Agencies and Miscellaneous:	
Reimbursable Funds:	
State side of coop	57,324
OFA	49,295
Miscellaneous	1,348
Technical Support Programs	(19,500)
Chief's Contingency Reserve	4,277
(includes $5,000,000 for NAWQA thrust)	$245,714

[1] In addition, approximately $13,000,000 will be allocated to research effort in other thrust areas (see Table 3).

Table 3. Summary sheet for FY 1985 showing thrust program contributions to National Research Program

Federal Program	Allocations ($Thousands)	Appropriations ($Thousands)	NRP
Coordination	901.84	962	—
Data Collection & Analysis	9,262.64		
Data Anal & Program Support	3,600.25		
Methodology & Technology	3,476.44		
Urban Area Hydrology	314.96		
Water Use	369.75		
	17,024.04	16,899	1,155
NAWDEX	1,242.50	1,318	—
WRSIC	870.61	920	—
RASA HQ	435.10		
RASA NR	2,880.75		
RASA SR	2,783.93		
RASA CR	4,578.13		
RASA WR	3,683.32		
	14,361.23	14,401	2,410
Core Research NR	1,563.88		
Core Research SR	700.00		
Core Research CR	1,329.63		
Core Research WR	3,803.01		
	7,396.52	7,432	7,396
Instrumentation	1,943.89	2,023	27
Support	3,342.82	3,358	—
Acid Rain	3,183.06	3,151	673
SW Toxics	1,506.09		
GW Toxics	9,402.92		
	10,909.01	10,956	5,583
Water Resources Assessment	1,627.04	1,377	—
Environmental Affairs	722.36	768	—
Water Resources Res Inst.	6,254.00		
Water Resources Res Grants	2,543.00		
	8,797.00	8,797	—
SUBTOTAL	$72,321.90	$72,362	$17,244
Energy Hydrology			
Coal HQ	70.78		
Coal NR	355.00		
Coal SR	146.00		
Coal CR	405.00		
	976.78	977	76
Nuclear Low Level	2,804.92		
Nuclear High Level	4,709.06		
	7,513.98	7,494	2,946
Oil Shale	312.54	322	—
SUBTOTAL	8,803.30	8,803	3,022
TOTAL	$81,125.20	$81,165	$20,266
Volcano Hazards	3,364.02	(G.D.)	555
			$20,821

Table 4. Distribution of Technical Support Funds

	Technical Support Budget ($Thousands)	
	FY 1985	FY 1986
HQ Functions	6,422	5,868
SP&DM/SIM	4,474	4,475
Central Labs	212	0
R&TC	3,642	3,694
PC&TS	(2,536)	(2,766)
R&EC	(1,106)	(928)
Regional Hydrologists	5,174	5,108
National Training Center	375	355
	20,299	19,500

CONFERENCE SUMMARY AND CLOSING

R. H. LANGFORD, Associate Chief Hdydrologist, Reston

This 1985 conference of the Division's principal officers was assembled to examine where the organization should be heading, where in fact we are heading, and the discrepancies between the two that require our attention. It is clear now, as the conference comes to a close, that the "forward looking" theme was a good choice. As I look back on the events this week, it seems that we have taken a hard, revealing look at our current policies and programs and where they are taking us, and an equally informative gaze into the future in search of demands ahead. Organization, programs, planning, personnel, and budget are the basic components of Division activity. In various ways we have examined each of them in some detail, with an eye to important trends and projections that have a bearing on the strength and welfare of the Division in the years ahead.

If we were to browse among the historic group pictures hanging on the walls of George Ferguson's office, it would be clear that Division or Branch conferences were taking place as far back as about 1915, and probably well before then. We have the legacy of past fruitful conferences to assure us that the conclusions reached here over the past week will have both near-term and lasting value in Division decision making. Our track record at these gatherings is good. They yield a collective wisdom and foresight probably unobtainable in any other way.

Most useful, of course, are the results of the Division conferences held since 1954 because those are the most recent and the best documented. The worth of these conferences is reinforced each time we turn to the recorded proceedings of bygone meetings for guiding insights on current problems. Oldtimers among us will recall the first fully documented conference, held in Chicago in 1954, at which guest-speaker Abel Wolman raised the provocative question: "What kind of Division would we design if we were given a free hand and started from scratch?" And he then proceeded to help us with the design by lambasting us for what he perceived to be our "semi-moribund state," urging broadened inquisitiveness and imagination as the ingredients of a motivated Division. Though we would like to believe that Wolman's sharp remarks are inapplicable today, reading them 31 years later still evokes a thoughtful stimulus.

More recently, at Ocean City in 1981, our relatively new Chief Hydrologist, Phil Cohen, provided a thoughtful stimulus of a different kind. He outlined some needed perspectives and reassurance during the hectic change in administrations, noting that "in the past we have undergone wrenching changes of major proportions, and in every instance we have demonstrated resiliency and the ability to continue to advance."

So, I say that the important messages from Chicago, Dayton, Gatlinburg, Albuquerque, and Ocean City continue to be germane and useful in our world of water problems today, and no doubt will in future years. Thanks to our hard work here the San Diego conference will add to that legacy.

I think we would all agree that it is a good idea to glance to the rear from time to time as we race forward. This has been called the "rowboat perspective"; that is, to guide the forward course of a rowboat one should look backward over the shoulder upon occasion. For anyone concerned with the Nation's water and mineral resources, past events relating to the study, development, and management of those resources are hardly dead history. To the contrary, their imprint on today's resource problems is easily discernible. In terms of fundamentals, the nature of problems faced by Powell and Peck really are not very different. Even the methods of water study we employ today evolved from investigative philosophies ingrained in the water disciplines in the early years of the Division. *The organization's history is important to authoritative decision making, whether technical or administrative. Those of us who ignore the history of events that brought us to where we are, do so at some peril.* Whereas, those operating from a base of understanding of past events may enjoy a substantial edge in the decision process.

Scientific respect enjoyed by the Survey in and out of government probably has never been greater than it is right now. Explanation of the somewhat unique growth in stature and programs of the Survey and its Divisions is readily evident in its history. For a fascinating weekend of reading, I recommend the Survey publications by Mary Rabbitt, one volume covering the years leading up to the establishment of the Survey, a second covering the years just after its inception, and those for succeeding years being readied for publication. You probably have J. R. Follansbee's four-volume mimeographed set in your District or Regional library; the set covers the inception and growth of the Water Resources Division to 1947. Jerry Parker (the father, that is) devised a geneological tree of the Survey, with emphasis on the evolution of the WRD and accompanied it with a small explanatory text. And, our retiree George E. Ferguson has just completed a manuscript in sequence with Follansbee's series to cover the "Paulson years" of 1947-57. It is interesting to note that all these writers are geologists or hydrologists, rather than professional historians, who apparently were driven to their tasks by their appreciation of the worth of documented scientific history.

The Survey's history makes it very clear that our position of eminence did not come about by luck or happenstance. Success is attributable first to the stubborn, unwavering allegiance of successive Directors and Division leaders to scientific excellence, and second to their political astuteness and dexterity in regard to geologic and water issues. The array of Survey responsibilities has varied with the growth and maturity of the Nation. The Geological Survey fathered the Irrigation Survey, Bureau of Reclamation, Bureau of Mines, Forest Service, Bureau of Land Management, and the Minerals Management Service. Its primary emphasis has always been on information and understanding, however. The shedding of these developmental and management responsibilities progressively enhanced the scientific role of the Survey and its Divisions.

The Division has a history of good news and bad news, a history full of challenges, surprises, changes, and boom and bust. But, problems and stress, after all, are inevitable in any worthwhile venture; and that is the way it has been for us since Embudo and Chamberlin. We can sum it up with Phil's observation at Ocean City that we have stood the test of adversities because the organization is rooted in the sound technical and scientific philosophies of Powell. Fortunately, golden opportunities are continually cropping up as well. We have been able to take advantage of many of them to the benefit of the Nation. Not the least of these was the role of our hydrologists and geologists in the winning of the West; the early establishment of nationwide stream gaging and water-quality networks; the remarkably successful program of cooperative investigations with the States; our stellar National Research program; the Regional Aquifer System Analysis program; and more recently, the assumption of the Water Resources Research Act responsibilities; the implementation of the "National Water Summary"; and the design of the National Water Quality Assessment program which we hope will be launched next fiscal year.

The writings of pioneer Survey hydrologists are fascinating reading, reflecting an astute understanding of water principles and

investigational methods even in those turn-of-the-century days. In the case of ground water, they include T. C. Chamberlin, generally considered to be the father of the early science of hydrogeology in North America and originator of the artesian concept of groundwater occurrence; C. S. Slichter, developer of early equations of ground-water flow and analysis of the geometric and hydraulic properties of pore spaces in granular earth materials; N. H. Darton, who introduced regional flow-system study methods; W. C. Mendenhall, field geologist and hydrogeologist who rose to Director of the Survey; O. E. Meinzer, considered to be the father of modern ground-water hydrology; and C. V. Theis, who introduced transient, time-dependent analysis of ground-water systems which paved the way to today's advanced numerical, quantitative methods; and, of course, a number of others.

The Survey's early proficiency and leadership in surface-water hydrology can be attributed to, among a number of important figures, the familiar names of F. H. Newell, who sparked the development of a nation wide streamgaging program; J. C. Hoyt, who successfully integrated Federal, State, and local gaging efforts into a national program under Survey leadership, and devised a manual of measurement procedures; and W. G. Hoyt, R. E. Horton, and W. B. Langbein, who advanced understanding of rainfall-runoff relations, floods, and streamflow fundamentals.

Early Survey giants in the water-quality and geochemical disciplines include M. O. Leighton, who developed field and laboratory methods for stream-quality studies, including pollution; F. W. Clarke, who identified the effects of mineral constituents derived from rocks and soils on natural water quality, and authored the classic reference, "The Data of Geochemistry"; Chase Palmer and Herman Stabler, pioneers in the geochemical interpretation of water analyses; W. C. Mendenhall, who first evaluated the chemical suitability of water for irrigation; and W. D. Collins, an authority on the chemical character of natural water who expanded the Survey's early, modest water-quality program and laboratories to a nationwide activity.

Those are our proud roots that have held us in good stead all these years.

I have already mentioned the Chicago conference in 1954 and Abel Wolman's incisive remarks as guest speaker. However, that conference dealt mainly with another matter of emerging interest at that time—coordination among branches, Divisions, and all other hierarchial levels of the Bureau. That Chicago conference may well have been the catalyst for the parting of the curtains between the branches and other units of the WRD in the years following.

The 1965 Dayton conference was devoted largely to the comprehensive reorganization of the Division then well underway, with the goal of better capability to respond to the Nation's growing water problems. By the time of the Gatlinburg conference in 1970 the new Division structure was fully in operation, and there was the feeling that the organization rested on a firm foundation. And, then, at the 1975 conference at Albuquerque we examined our work, our programs, and our progress. A large share of the agenda also was devoted to invited papers from Bureau officials and several non-Survey notables who gave us some insights into their work with the WRD, including some very revealing perceptions of how others view the Division and its products.

Then we met at Ocean City in 1981. The new administration was 10 months old at the time of the October 1981 Ocean City conference. As you recall, newly installed top-level policies and programs and their impacts on WRD were the primary topics of interest. In retrospect, the postponement of that gathering for a year was a good decision, because the events of 1981 under the new administration gave us a perspective that would have been unavailable in 1980. Upper-rank guest speakers were able to enhance that perspective even more.

For instance, Dan Miller, then Assistant Secretary of the Interior for Energy and Minerals, provided insight into the new administration's positions that helped to dispel the "environment of rumor mixed with facts, change, and uncertainty", as he described the operating climate of the time.

Nor, if the conference had been held on schedule, would we have had Dallas Peck in attendance, for he had been Director for only a month at the time of the Ocean City meeting. Dallas' remarks reflected his good working understanding of the public issues confronting earth science and scientists with regard to minerals supply, energy sources, environmental management, and—yes—the Nation's water situation. Dallas outlined a balanced program among long-term and short-term activities, by which he meant a rational apportionment of work effort among pure and applied sciences.

Doyle Frederick, fresh from a 9-month stint as Acting Director, acknowledged our historical tendency to avoid direct involvement in policy decisions. But, he encouraged us to apply our expertise more directly for those who make policy and have responsibilities. As an example, he urged initiation of a national water assessment as an appropriate function of the Survey. As you know, that activity is now operative.

Jim Coulter's presence on the program reminded us of the many warm friendships and close working relationships the Division enjoys through its cooperative program. He emphasized the mutual values of that longstanding association citing it as a good example of the concept of State-Federal partnership which was a widely promoted goal of the administration.

Phil Cohen, himself only a year in office as Chief Hydrologist, cited the current dynamic state of flux of both budgets and programs. He pointed out that the rapid-fire changes made the short-term views and predictions necessary to good, reliable planning very difficult. Phil set forth some positive steps already being taken to facilitate decision making and action. These included: (a) improved communications, (b) improved career and personnel management, and (c) improved administration of programs and research. We have seen many actions in these directions over the past 4 years with some positive, identifiable results. By and large, these subjects were examined again in some detail during the past 4 days.

During the past 4 years we have continued on the fast track we were riding at the time of the Ocean City conference. All of you have been on the firing line at some time during that period and are well aware of the pace and pressures. It has been a time in which the Survey has sought to adapt to the new administration's policies, while at the same time holding steadfastly to our time-honored scientific role and responsibilities. All of this of course, was conducted under the budgetary and personnel constraints that have become a part of our way of life.

Let us examine our accomplishments and trends in budget, personnel, and programs over the past 4 years.

The process of demonstrating accomplishments and progress in our business is not easy. At Ocean City, I passed out four sheets that itemized in some detail what we deemed to be our most significant accomplishments since the previous conference. They were in fact, a summarized version of hundreds of items submitted by the Regional and Reston offices, whose total contributions amounted to a stack of 82 pages. The handouts were an effective way to document the great range of the Division's water research, investigation, and data activities of that period.

Similar but more detailed tabulations of recent accomplishments have been included in the special publication titled "Water Resources Activities of the Geological Survey, 1985". I have adopted that publication as an alternative to the handouts used at Ocean City. Copies of the publication were provided to District and Regional offices last spring. Undoubtedly you are familiar with it. Again, the number of activities and substantive

accomplishments—spanning research; field studies; methodologies and laboratories; information management and communications; organization, planning, and administration; etc.—provide assurance that we are moving ahead productively. The listings are only samplings but they add up to a well-rounded program that indicates that we are not only on the fast track, but on the right track.

Money and people are our two basic resources, so let's look at budget and personnel trends over the past 10 or 15 years and their significance.

We have had a fourfold rise in budget since 1970, but the relentless effects of inflation have reduced the buying power of those dollars. Expressed in constant 1972 dollars, we have enjoyed only a minor rise in funds. These effects are pervasive, and, consciously or unconsciously they have had strong influences on the discussions and workshop deliberations this week.

The actual appropriated dollars would make us appear to be affluent, and I suppose in some respects we might be so considered in comparison with the budget fate suffered by many Federal agencies in recent years. The anticipation of reduced funding for FY 1982 hovered over our Ocean City meeting and was a prominent topic of discussion. This concern was justified. However, the data also show that, once again, we rode out a storm successfully.

Important trends in our funding sources have taken place over the past 10-year period. From 1975 to 1985, the gross total from all sources rose 142 percent in actual dollars but only 27 percent in constant dollars adjusted to the 1972 base. However, the bulk of this rise took place before 1981.

Proportions of funding from the six listed sources have remained roughly similar through the years covered 1975-1985. There is one obvious variance, however—the increased proportion of the Federal Program in 1981 and to a lesser degree in 1985. Most of the dollar increase from 1975 to 1985 took place before 1981, reflecting the proportionately large growth of our Federal Program activities during the first part of the 10-year span, and the slowing of that growth in more recent years. The principal compensating increase took place in the Other Federal Agency program. Of interest also is the percentage increase between 1981 and 1985 in unmatched cooperative program offerings. Also note the emergence in 1985 of the Research Institute and Research Grant Programs.

Overall, the proportions of funds derived from the various sources have not changed markedly since 1981. However, the impacts of the decreased energy-hydrology fundings, accrual of the State Water Research Institute and Grants Program, and several other changes in sources of funding during the 4 years since Ocean City are worthy of mention.

With regard to the personnel situation, in Ocean City I referred to the fast-moving changes that included a 100-percent turnover in District Chiefs between the Albuquerque and the Ocean City meetings. All senior Bureau and Division officers from the Director to Division leaders were newly installed as well. We were confronted with the problems and challenges, especially in regard to continuity and communications, inherent in such a wholesale change in senior personnel. You will recall that there had been an especially big surge in WRD retirements during the period 1979-1981, just before Ocean City. Thank goodness we have had no such massive turnover in subsequent years, permitting the Division to devote considerable management effort toward consolidation and improvements in communications and cooperation among our Division and offices. And, we have had to learn how to cope with what have become permanent, institutionalized personnel ceilings.

At Ocean City, staffing handicaps imposed by personnel ceilings were viewed as a major impediment to the maintenance of quality and productivity. I think we all recognize now that ceilings are here to stay, and that we must approach our planning and programming accordingly. Staffing will continue to be one of the greatest challenges to our management abilities.

Although the comparisons of 1981 and 1985 sources of funds indicate that our money continues to come predominantly from our established, traditional sources, new and larger investigational and management responsibilities have necessitated substantial organizational and program changes, especially at headquarters. Those responsibilities and the steps being taken to shoulder them have been examined and discussed throughout the course of this conference.

As you know, WRD Memorandum No. 85.134, issued September 16, 1985, announced the implementation of the reorganization of WRD Headquarters functions, and the reapportionment of functional responsibilities among Division officers and staff. As noted in the memorandum, the most sweeping changes being in the Office of the Assistant Chief Hydrologist for Research and External Coordination (ACH/R&EC) and the Office of Assistant Chief Hydrologist for Program Coordination and Technical Support (ACH/PC&TS), and subordinate Branches to accommodate new, revised, or continuing functions.

The new organizational chart accompanying the memorandum contains many differences from the old one, reflecting not only the magnitude of the organizational change instituted, but also the many new and changing program responsibilities we have shouldered.

For example, water-quality issues have headed the list of cooperative program priorities since 1982. At present, nearly three-fourths of the investigations in the cooperative program, in part or entirely, address water-quality concerns. Of these, one in four focuses principally on hazardous-substances contamination of surface or ground water. Thus, the emphasis on water quality or problems of contamination continues to grow significantly. I like to think that our success in accommodating that dramatic, new public program demonstrates the responsiveness of the cooperative program and our Division programming machinery to the Nation's fluctuating water-information requirements.

This week has been a productive learning experience for me, and I suspect for everyone here. But the real measure of our smarts at the conclusion of the meeting is the confidence with which we are prepared to plan for the future. That is, to forecast the future as a consequence of (a) changing water problems; (b) changing political and social issues associated with water; and accordingly, (c) changing responsibilities and functions of the Division. Those three influences on our activities, of course, were the underlying goal in the design of the conference agenda.

I believe that our deliberations have given us reasonably dependable estimates of what lies ahead and how we should prepare for it. Our keynote speaker, Abel Wolman, displaying the same perceptiveness and wisdom that commanded our colleagues' attention 31 years ago in Chicago, set us in a thinking mode from the start.

Abel urged us to do more with our data, to assimilate and try to understand it, and to try to convey our understanding to others. Wolman described this in terms of the "whole body" concept.

The Assistant Secretary, through Nancy Lopez, provided insights on the directions the Administration and the Department are headed that have significance to our programs and plans.

Likewise, the Director outlined his perception of the Survey of the future, and the roles of water and the Division in that plan. He reemphasized the message from Dr. Wolman exhorting us to communicate the results of our work more fully to the public, as well as to the traditional users of our data, and to assure that results of our work are relevant and timely.

Then the Chief Hydrologist laid out challenges and opportunities for the Division. He set forth seven "givens" on which to base our workshop, panel, and seminar deliberations. He also provided his assessment of the influences these precepts would have on the Division's future.

Herb Snyder, Jerry Orlob, Roger Revelle, and John

Bredehoeft added scientific and technical aspects to the outlook. Herb Snyder emphasized the importance of anticipating how the data we collect will be used to meet future water issues. Jerry Orlob looked at WRD in general and our role in the future through the eyes of the consultant. Roger Revelle gave us a great deal to think about in terms of the possible future supply of water as it may be affected by the greenhouse effect. John Bredehoeft pointed out that the future of the Division is in the hands of the younger men and women here at this conference—that they can have any kind of Division they want—and stated his belief that if we continue as a scientific Division, other problems will fall into place.

Over the past several days our work groups, panels, and seminars have delved into all elements of Division organization, personnel, and technical and management activities. The observations and conclusions of this informed and experienced gathering collectively provide a powerful base of information on which to anticipate the future. We now have in hand a wealth of conclusions, all of them important to the shaping of our organization and its goals and programs. Let me assure you that the Division leaders will consider each of the recommendations emanating from this 1985 National Conference and will respond to each.

In closing, let me express our thanks to the Committee that planned our conference. This group included Tom Buchanan, Stan Sauer, Jim Daniel, Ed Imhoff, Roger Wolff, Marshall Moss, and Gordon Bennett. John Conomos and the staff of the Western Region and the California District did a superb job in organizing and arranging this conference. Special thanks are due Andy and Gail Spieker for our Monday evening festivities; Ben and Mai Jones for their overall help and support; Andy Spieker, Bill Hardt, and Julie Schulenberg for the field trip arrangements; Martha Zaccor and Gloria Barnes for registration and planning; Jerre McClelland and the California District folks for their support, especially logistics in the San Diego area; Irene Girard for the spouses program; and the ladies who handled all of our secretarial needs during these past 5 days—Martha Zaccor, Connie Handewith, Gloria Barnes, Linda Meadows, Kathy Wilson, Doris Johnston, and Irene Girard.

And, most of all, thanks are due to each of you for your participation in this highly successful conference. Well done!

Permit me to make three final points:

1. We have reaffirmed our desire for the Water Resources Division to be a scientific organization and a world-class organization that is responsive to the Nation's needs for water data and information and that produces relevant and timely reports in an unbiased, dispassionate way.

2. The future Chief Hydrologist is in this room and, I predict, the future Director is here also. The future of the Division is in your hands. You will determine what our organization will be!

3. As I close my career with the Geological Survey, I know that I have been fortunate beyond any hopes I may have had early in my professional career—fortunate in being allowed to undertake challenging technical and management assignments throughout my 37 years with the Geological Survey—and fortunate to have been associated with men and women of high integrity. Such is the nature of the people in our Division. This integrity, coupled with the high technical excellence of our people, assures that the Division truly is in good hands—in your hands. On a personal note, I want to thank Phil Cohen for his support and understanding over the last 6 years when we have worked so closely together. This has been the most exciting and challenging period of my career.

And now I officially close this 1985 National Conference of the U.S. Geological Survey's Water Resources Division, and wish you all Godspeed and the very best in the challenging years ahead.

HYDROGEOLOGIC FIELD TRIP TO SOUTHERN CALIFORNIA

Conference attendees participated in a field trip on November 20, 1985, to examine some of the more interesting hydrologic and geologic features of southern California. The weather was nearly perfect: typical, brilliant southern California sunshine, with only a smattering of smog in the inland areas. Among the features observed were lower Mission Valley of the San Diego River, the Peninsular Ranges, Lake Elsinore, Prado Dam and the Santa Ana River Canyon, artificial recharge facilities and Water Factory of the Orange County Water District, the Long Beach–San Pedro harbor area, the Palos Verdes Peninsula, and Mission San Juan Capistrano.

Lake Elsinore State Park

Lake Elsinore is the terminus of the San Jacinto River. The lake has a drainage area of 768 mi^2, elevation of 1,234 feet, and an area of 4 mi^2. The outlet is at 1,265 feet, and is to the north through Temescal Wash, which drains into the Santa Ana River above Prado Dam. The level of Lake Elsinore has fluctuated widely, from dryness to overflow. The lake was practically dry in 1810-12, 1859, 1881-82, 1951, and much of 1954-64. Water from the Colorado River has been imported, beginning in 1965, to maintain water in the lake for recreational use. Since that time, a lake area of 6 mi^2 has been maintained. Before the 1980 flood, outflow was known only in 1872, 1883-84, and 1916-17; outflow probably occurred also in 1862.

Warner Basin (Santa Ana River Lake) and Santa Ana Spreading Facilities

The Orange County ground-water basin underlies one of the most highly urbanized areas of the United States. Ground-water pumpage has ranged from about 150,000 to 250,000 acre-ft/yr. As southern California has a semi-arid climate, with average yearly rainfall in Orange County of about 13.5 inches, overdraft of ground-water basins is common. Pumpage often exceeds natural recharge. Consequently, southern California, particularly Orange County, has become a world leader in methods of natural and artificial recharge of gound-water basins.

The Orange County Water District has been enhancing recharge of natural streamflow in the Santa Ana River by water-spreading operations since 1940. Water imported from the Colorado River since 1949, and from the State Water Project (northern California) since 1975 has been purchased from the Metropolitan Water District of southern California. These imported waters supplement the natural flow, help alleviate the basin overdraft, and allow for increased ground-water production. The quantity of imported water recharged to the aquifer ranges from 15,000 to more than 100,000 acre-ft/yr depending on the quantity of natural flow available for recharge in

the Santa Ana River, and the average water level in the basin. The water is permitted to flow into retention ponds excavated into the Santa Ana River channel. As the river channel is limited in area, several off-river recharge facilities have been built, mostly since 1960. The optimal rate of recharge to the aquifers from the ponds and other nearby ponds and lakes is about 4 feet per day. It decreases to only a few inches per day as silt and algae clog the bottom of the pits. Periodically, these pits are drained and the bottom scraped by bulldozers to remove fine-grained sediments to enhance the infiltration rates.

Orange County Water District—Water Factory 21

Water Factory 21 is capable of producing about 23,000 acre-ft. of potable water per year. The water treated by Water Factory 21 is municipal wastewater obtained from the nearby Orange County Sanitation District plant. This wastewater has received primary and secondary treatment. The reclaimed water produced at Water Factory 21 is injected into the groundwater basin through a series of 23 multi-point injection wells. These wells are located along a line about 2 1/5 miles across the Santa Ana Gap, an area subject to saltwater intrusion. The wells are perforated in four separate aquifers to create a ground-water mound. The wells are located on 600-foot centers and are capable of injecting as much as 250 gal/min. each. Downgradient about 2 miles from the injection barrier wells is a series of extraction wells used to create a depression in the water table and enhance the effects of the barrier.

To meet injection water-quality criteria, the reclamation system requires several advanced treatment operations. They include lime clarification with sludge recalcining, ammonia stripping, recarbonation, breakpoint chlorination, mixed-media filtration, activated-carbon absorption, post chlorination, and reverse-osmosis demineralization. The reclaimed wastewater must be of extremely high quality, with specific conductance less than 900 μS/cm., because the injected water will be withdrawn for domestic, industrial, and irrigation uses.

Point Vicente Interpretive Center

Point Vicente is a whale watching center, owned by the city of Rancho Palos Verdes, and site of the Point Vicente lighthouse. It is on the Palos Verdes Peninsula, a slightly oblong northwest-trending ridge that separates the Long Beach-San Pedro harbor area to the southeast, from Santa Monica Bay to the north. The surface of the peninsula consists of a remarkable display of 13 marine terraces, several of which can be seen from Point Vicente. Because of the peninsula's high elevation, the marine terraces, and a relatively smog-free climate, spectacular views of the Pacific Ocean can be seen in all directions. As a consequence, the Palos Verdes Peninsula has become one of California's prime residential areas.

Just before arriving at Point Vicente, the field trip route crosses the Portuguese Bend landslide area, an ancient landslide that has been reactivated by highway construction. More than 130 homes have been destroyed or abandoned, as a result of movement of this landslide.

San Juan Capistrano

Mission San Juan Capistrano was founded by Father Junipero Serra in 1776. It is the third in the series of 22 missions established by the Franciscan Fathers along a 600-mile trail that extended up the California coast from San Diego to Sonoma. The trail between the missions was known as El Camino Real—"The King's Highway"—and is closely paralleled by U.S. Highway 101. Mission San Juan Capistrano is unusual in that it consisted of three churches. The main stone church, one of the most elaborate of the entire mission trail, was destroyed by an earthquake in 1812. A new church, just north of the original site, is now nearing completion.

Perhaps the most famous event at San Juan Capistrano is the annual return of the swallows on St. Joseph's Day, March 19th. The swallows spend their summers at San Juan and their winters in Argentina. They return on the same day without fail, and were late only once, in 1935, when a storm blew them off course. Biologists are uncertain as to why the birds are so unerringly accurate. The most prevalent theories involve their detection of the changing lengths of days.

PARTICIPANTS

Donald R. Albin
District Chief, Minnesota

Gary S. Anderson
Office Chief, Virginia

David H. Appel
District Chief, West Virginia

Jeffrey T. Armbruster
District Chief, Georgia

Ted Arnow
District Chief, Utah

Robert C. Averett
Special Assistant to the Chief Hydrologist, Lakewood, Colorado

Robert A. Baker
Regional Research Hydrologist, Southeastern Region

Daniel P. Bauer
District Chief, Missouri

Paul R. Beauchemin
Program Officer, Reston

Gordon D. Bennett
Senior Staff Scientist, Reston

James P. Bennett
Regional Research Hydrologist, Northeastern Region

Donald L. Bingham
Chief, Syosset Subdistrict, New York

James F. Blakey
District Chief, Colorado

Richard M. Bloyd
District Chief, Wyoming

C. William Boning
District Chief, Texas

John D. Bredehoeft
Research Hydrologist, Western Region

Thomas J. Buchanan
Assistant Chief Hydrologist for Operations, Reston

James S. Burton
Water Research Program Manager, Reston

Edward Callender
Research Advisor, Geochemistry, Northeastern Region

Frank T. Carlson
Chief, Branch of Water Institute Programs, Reston

Philip J. Carpenter
Office Chief, Washington

William J. Carswell, Jr.
Office Chief, Nevada

Rodney N. Cherry
District Chief, South Carolina

Alfred Clebsch, Jr.
Regional Hydrologist, Central Region

David E. Click
District Chief, Pennsylvania

James E. Cloern
Research Scientist, Western Region

Donald L. Coffin
Program Officer, Central Region

Philip Cohen
Chief Hydrologist, Reston

T. John Conomos
Regional Hydrologist, Western Region

James L. Cook
Regional Hydrologist, Southeastern Region

Derrill J. Cowing
Office Chief, Maine

T. Ray Cummings
District Chief, Michigan

James F. Daniel
Assistant Chief Hydrologist for Scientific Information Management, Reston

James A. Davis
Research Geochemist, Western Region

G. Louis Ducret, Jr.
Chief, Miami Subdistrict, Florida

Saundra S. Duncan
Chief, Central Laboratory, Arvada, Colorado

John F. Elder
Research Biologist, Florida

Philip A. Emery
District Chief, Alaska

William W. Emmett
Research Advisor, Geomorphology and Sediment Transport, Central Region

Richard E. Fidler
District Chief, South Dakota

John N. Fischer
Assistant Chief Hydrologist for Program Coordination and Technical Support, Reston

Herbert J. Freiberger
District Chief, Mid-Atlantic District

Marvin O. Fretwell
Office Chief, Oregon

Michael H. Frimpter
Office Chief, Massachusetts

E. E. "Gene" Gann
District Chief, Arkansas

John R. George
Program Officer, Southeastern Region

David Grason
Office Chief, Maryland

Phillip E. Greeson
Assistant Regional Hydrologist, Southeastern Region

Larry R. Hays
District Chief, Tennessee

John D. Hem
Research Chemist, Western Region

Steven M. Hindall
District Chief, Ohio

Robert M. Hirsch
Chief, Branch of Systems Analysis, Reston

Ernest F. Hubbard, Jr.
District Chief, Idaho-Nevada District

Edgar A. Imhoff
Chief, Office of Water Data Coordination, Reston

James H. Irwin
District Chief, Oklahoma

Ivan C. James II
District Chief, New England District

Raymond A. Jensen
Chief, Water Resources Scientific Information Center, Reston

Harvey E. Jobson
Research Hydrologist, Mississippi

Benjamin L. Jones
Assistant Regional Hydrologist, Western Region

J. Ronald Jones
Chief, Branch of Computer Technology, Reston

Irwin H. Kantrowitz
District Chief, Florida

Stanley F. Kapustka
District Chief, Hawaii

William M. Kastner
District Chief, Nebraska

Joel O. Kimrey
Chief, Tampa Subdistrict, Florida

John M. Klein, Jr.
District Chief, Iowa

Alfred L. Knight
District Chief, Kentucky

Robert L. Knutilla
District Chief, New Mexico

Leonard F. Konikow
Research Advisor, Ground Water, Northeastern Region

Leslie B. Laird
District Chief, Pacific Northwest District

Solomon M. Lang
Senior Staff Scientist, Reston

R. Hal Langford
Associate Chief Hydrologist, Reston

Denis R. LeBlanc
Hydrologist, Massachusetts Office

Jerry A. Leenheer
Research Chemist, Central Region

Samuel N. Luoma
Regional Research Hydrologist, Western Region

Robert D. MacNish
District Chief, Arizona

Gail E. Mallard
Hydrologist, Office of Water Quality, Reston

Larry A. Martens
District Chief, New York

Nicholas C. Matalas
Research Hydrologist, Reston

Jerald F. McCain
Program Officer, Northeastern Region

E. Jerre McClelland
Acting District Chief, California

Stuart W. McKenzie
Hydrologist, Oregon Office

John P. Monis, Jr.
Assistant Regional Hydrologist, Central Region

David W. Moody
Chief, Office of National Water Summary and Long Range Planning, Reston

L. Grady Moore
District Chief, North Dakota

John E. Moore
Chief, Branch of Scientific Publications, Reston

Joe A. Moreland
District Chief, Montana

Marshall E. Moss
Assistant Chief Hydrologist, Research and External Coordination, Reston

Vernon W. Norman
District Chief, Wisconsin

Garald G. Parker, Jr.
District Chief, Mississippi

C. A. "Jerry" Pascale
District Chief, Alabama

Eugene P. Patten
Chief, Office of Ground Water, Reston

Richard W. Paulson
Chief, Branch of Instrumentation, Reston

R. J. Pickering
Chief, Office of Atmospheric Deposition, Reston

Douglas R. Posson
Chief, DIS Program, Reston

Ferdinand Quinones
District Chief, Caribbean District

Thomas E. Reilly
Hydrologist, Office of Ground Water, Reston

David A. Rickert
Chief, Office of Water Quality, Reston

Joseph S. Rosenshein
District Chief, Kansas

Jacob Rubin
Research Soil Scientist, Western Region

Stanley P. Sauer
Regional Hydrologist, Northeastern Region

Francis T. Schaefer
Assistant Regional Hydrologist, Northeastern Region

Verne R. Schneider
Chief, Office of Surface Water, Reston

Andrew M. Spieker
Staff Hydrologist, Western Region

Dennis K. Stewart
District Chief, Indiana

Chester E. Thomas, Jr.
Office Chief, Connecticut

Donald C. Thorstenson
Research Geochemist, Northeastern Region

Michael E. Thurman
Regional Research Hydrologist, Central Region

Larry G. Toler
District Chief, Illinois

James F. Turner
District Chief, North Carolina

Donald E. Vaupel
District Chief, New Jersey

C. Russell Wagner
Chief, Hydrologic Instrumentation Facility, Mississippi

Roger G. Wolff
Chief, Office of Hydrologic Research, Reston

Thomas H. Yorke
Chief, Tampa Subdistrict, Florida

Loren E. Young
Program Officer, Western Region

GUESTS

James E. Biesecker
Assistant Director for Information Systems,
U.S. Geological Survey

Joseph F. Coates
President, J. F. Coates, Inc., Washington, D.C.

John J. Dragonetti
Assistant Director for Intergovernmental Affairs,
U.S. Geological Survey

Robert M. Hamilton
Chief Geologist, U.S. Geological Survey

Nancy Lopez
Staff Assistant, Office of the Assistant Secretary for
Water and Science, U.S. Department of the Interior

Gerald T. Orlob
University of California, Davis, California

Dallas L. Peck
Director, U.S. Geological Survey

Roger Revelle
University of California, San Diego, California

J. Herbert Snyder
University of California, Davis, California

Lowell Starr
Chief, National Mapping Division, U.S. Geological Survey

Raymond Watts
Acting Assistant Director for Research, U.S. Geological Survey

Abel Wolman
The Johns Hopkins University, Baltimore, Maryland

CONFERENCE STAFF

California District
Gil Bertoldi
R. R. "Phil" Contreras
Connie Handewith
Greg Lines
Peter Martin
Jerre McClelland
Mike Roque
Roy Schroeder
Julie Schulenberg

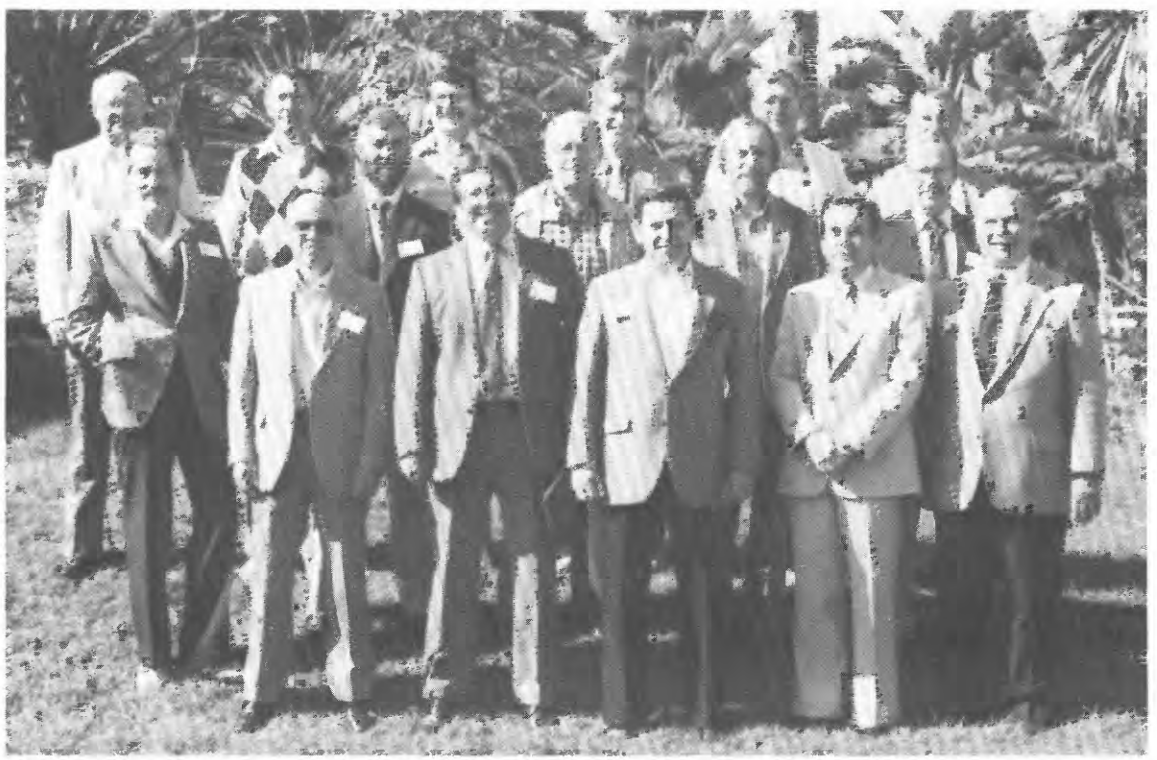
Western Region
Gloria Barnes
Martha Zaccor

Reston Office
Irene Girard
Doris Johnston
Linda Meadows
Kathy Wilson

Field Trip Leaders
Bill Hardt
Red Longfield
Dick Moyle
Andy Spieker

Senior Staff

Pickering Daniel Schneider Patten Imhoff Moss Buchanan Wolff
Conomos Cook Langford Cohen Clebsch Sauer Rickert



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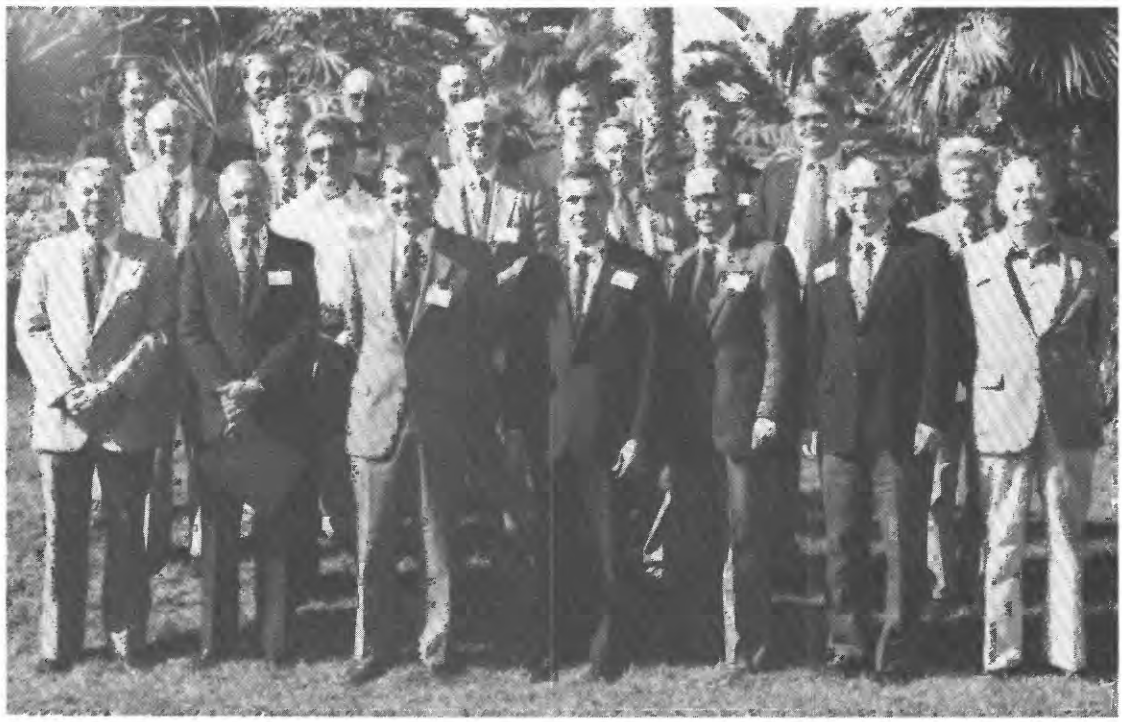

Northeastern Region

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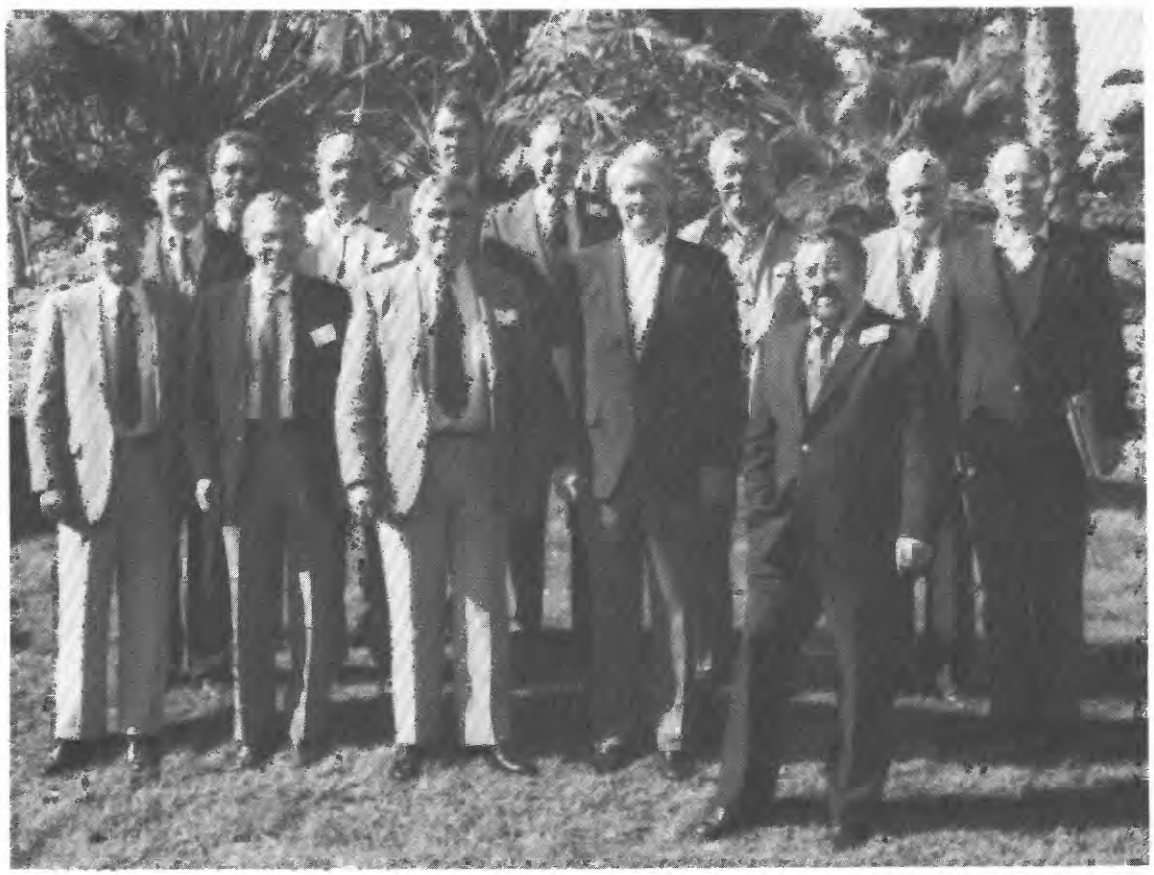
Toler Frieberger Albin Vaupel Martens Anderson Frimpter
Thomas Cummings Sauer Appel Stewert Click Schaefer



Western Region

Carswell Hubbard
Spieker MacNish McClelland Kapustka Carpenter
Emery Young Conomos Laird Fretwell
Jones









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