THE ROLE OF GROUND WATER IN THE UNITED STATES

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A conference may be defined as a meeting for an interchange of views, and it is with this definition in mind that I come to join you. For, in preparing this talk, it soon became evident to me that most of you in the Southwest are rather intimately acquainted with the ground-water resource, you have first-hand knowledge of many of the problems associated with its development, and you doubtless are as concerned with its wise management as is any similar group anywhere in the country. And so, I look forward not only to addressing you on a subject vital to all of us but, in turn, learning from you during this interchange of views today and tomorrow.

No doubt most of you are acquainted with the recently completed survey of the Nation's posture in the field of water by the Senate Select Committee on National Water Resources. The Committee's studies indicate that, if present trends continue, our demand for water, now on the order of 300 bgd (billion gallons per day), will increase by 1980 to 559 bgd, equivalent to 51 percent of average streamflow, and by 2000 to 888 bgd, or 81 percent of streamflow (U.S. Senate Select Committee on National Water Resources, 1961, p. 5). Because much of the water represented by the demand figures is returned to the streams and is available for reuse, these figures are not as frightening as they seem at first glance. Nevertheless, as a Nation we clearly face a serious water-supply problem. Already there are substantial areas of continuing water shortage in many of our western river basins. According to the Committee, full development of all the available water resources will be necessary by 1980 in 5 of the 22 water-resource regions if the projected increases in demand are to be met (idem, p. 9-11). These are the South Pacific, Colorado River, Great Basin, Upper Rio Grande-Pecos River, and Upper Missouri River regions. Of cource, the occasional water shortages that plague nearly all parts of the country are well known to all of us.

Are we going to be able to double our present supply by 1980 and triple it in less than 40 years to meet the predicted needs? Are we going to be able to balance regional supply and demand in a way that will be tolerable to us? And are we going to be able to eliminate or reduce in intensity the occasional water shortages that now plague us in most parts of the country?

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If we are to do so, there are two avenues we can consider: first, to add to our total water supply, and second, to make the most of what we have. If we had Aladdin's lamp today, we could simply rub the lamp, bring forth the genie, ask him to create for us the needed water supply, and so solve our problem. Science and technology are, indeed, a sort of Aladdin's lamp, and they hold forth the promise that by such techniques as desalting ocean water, purifying brackish water, modifying the weather, reducing evapotranspiration, and so on, we, in fact, may someday increase our total usable water supply. However, fulfillment of these promises is in the future--we cannot say when--and in the meantime our problems multiply.

Fortunately, the Nation as a whole is blessed with a bountiful supply of water. Our average runoff, which represents the upper limit of our manageable supply, is about 1,200 billion gallons daily (Langbein and others, 1949, p. 6). If we make the most of what we have--by maintaining the quality of the water to permit reuse, by routing it from areas of surplus to areas of deficiency, and by storing it at times of surplus to use at times of deficiency--we need not suffer for lack of water. In this direction much has been done, but much more remains to be done.

And this brings us to the theme of the conference--ground water. Ground water is difficult to define, difficult to describe, and difficult to comprehend. It is hidden and it cannot be measured directly. It is expensive to evaluate and difficult to manage (McGuinness, 1960, p. 9). Furthermore, its development often is accompanied by or followed by consequential problems that are difficult to predict and ofttimes costly to resolve.

Yet we have progressed far during the past decade or two, both in understanding ground water and in applying our knowledge to its development, use, and management. In general, we know the locations of our principal aquifers; we know the ground-water storage is enormous; and we know that recharge is substantial. We know something of the interrelation between ground water and surface water, and we have learned much about artificial recharge. We have developed test methods by which we can evaluate the hydrologic properties of our aquifers, and recently we have developed analog models which enable us to predict aquifer response to outside forces with a reliability limited only by the accuracy of the data used in setting up the models.

Also, during the past decade or two our use of ground water has increased greatly. In 1960 the total estimated withdrawal of ground water in the conterminous United States for all uses except hydropower was about 46 bgd (MacKichan and Kammerer, in press). Among the States, Texas was second in the use of ground water, Arizona third, and New Mexico ninth. Together these States pumped more than one-fourth of the total ground water used in the Nation.

The largest withdrawal of ground water was for irrigation--about 30 bgd. Arizona pumped 3 bgd, New Mexico 0.9 bgd, and Texas 7.7 bgd. More than one-third of the total for irrigation was pumped in these three States.

Industry supplied for its own use, including fuel-electric power generation, about 7 bgd. The largest withdrawals were in the East, but Arizona, New Mexico, and Texas together pumped 0.9 bgd--a substantial amount.

Ground water for public supply amounted to about 6 bgd, distributed roughly according to population. Among the States, Texas was the second largest user.

Rural use of ground water was only about 3 bgd, but this constituted most of the water derived for rural use from all sources. Altogether, in 1960 ground-water sources supplied about 1 in every 5 gallons of water withdrawn from all sources for all uses in the United States except waterpower.

The use of ground water has not been without problems, of which overdraft accompanied by increased pumping lifts and lowered yields, salt-water encroachment (not only in coastal areas but at some places inland as well), depletion of streamflow, and land subsidence are but a few. I could cite numerous specific examples, but I suspect that to you of the Southwest such examples are commonplace.

Now to the main purpose of this discussion--the role of ground water in helping us make the most of our water resources.

The first point I wish to emphasize is that ground water is not a separate and distinct resource. Rather it is a convenient term by which we distinguish water as it passes through or lingers in one part of the hydrologic environment from water as it passes through other parts of the environment. Except as, for a time, they can produce water that has accumulated over periods of many years, ground water reservoirs can add little to our total supply.

I do not mean to imply that the reserve stored in ground-water reservoirs is either small or unimportant. It has been estimated that the volume of ground water in storage in the United States above a depth of 2,500 feet is about 200 billion acre feet--equivalent to the total of all recharge during the last 160 years (Nace, 1958, p. 4-6). The stored reserve is enormous, and in places like the High Plains of Texas and some of the arid basins of the Southwest, where recharge is small, mining of this reserve has been a principal factor in developing and supporting the economy. Mining of ground water will continue to be important, but it offers no permanent solution to our water-supply problem. In the long run we must either furnish alternative sources of water for these areas of mining or change the character of the economy.

It is essential, therefore, that we do not permit the thought of ground water as a unique resource to dominate our thinking. Rather, we should emphasize the concept of aquifers as storage and distribution media, to be used as such either alone or in conjunction with streams and surface reservoirs. In this context our aquifers constitute a powerful management mechanism, which if fully employed should indeed help us to make the most of our water supply. Perhaps a few examples will illustrate the sort of uses I have in mind.

The Gallatin Valley in Montana is similar in many respects to many of the valleys in the Southwest. It occupies an intermontane basin in the Northern Rocky Mountain region. The valley floor is underlain by permeable alluvial deposits which form a large ground-water reservoir. Higher land along the sides of the valley is underlain by Tertiary strata of low permeability.

The climate of the valley is semiarid, but the Gallatin River, which flows across the valley, provides a source of water for irrigation. Because it is close to the river the land of the valley floor was irrigated first, and most of the earlier rights to use of water from the river are held in this area. Some of the later water rights permit irrigation of parts of the higher lands, but much of this area must be dry farmed. Land at the lower end of the valley floor is waterlogged and therefore is used mostly for pasture or forage crops.

Except for a reservoir on one of the small tributaries of the Gallatin River, there are no surface storage facilities. During the summer the river may be diverted completely, and water shortages are common for the lands irrigated under the later water rights.

Study of the Gallatin Valley (Hackett and others, 1960) suggests that the Gallatin River, its tributaries, a network of irrigation canals, and the ground-water reservoir could be managed together as a hydrologic system, utilizing the ground-water reservoir as the storage component. For instance, pumping of ground water for irrigation of the valley floor would permit some of the water from the river to be diverted for use on the higher lands along the sides of the valley. The spreading of water there would in turn provide recharge to the ground water-reservoir. And, the ground-water reservoir is in a position to intercept all return flow to the river. The discharge of the river during the winter and spring months is large enough to assure replenishment of the ground-water reservoir each year. It is possible that pumping from the ground-water reservoir might be useful also as a measure for controlling the waterlogging at the lower end of the valley.

An example from another part of the country is the valley of the Mattapoisett River, a short coastal stream which drains about 24 square miles in Massachusetts. Here the hydrologic system is a "watercourse" as that term is used by Thomas (1952, p. 10), consisting of the river and a closely associated ground-water reservoir.

In Massachusetts the annual runoff even during a dry year is relatively large and the potential water supply from even a small area is correspondingly large. During the summer months, however, the flow of a small stream such as the Mattapoisett sometimes becomes very low, and the water supply that can be sustained directly from the stream is limited accordingly. The ground-water reservoir consists of permeable glacial drift that partly fills a narrow preglacial valley in the impermeable bedrock of the area. The ground-water reservoir has a small storage capacity and can sustain large withdrawals for only a few months at a time.

In this situation the maximum yield from the annual water crop is possible only if the watercourse system is developed as a unit (Shaw and Petersen, 1960, p. 19-23). By placement of wells along the stream so as to induce infiltration from the stream, the stream can be utilized as a medium to collect water and in effect distribute it to the wells during the months when runoff is high. Then during the summer months when the runoff ordinarily is low, the ground-water reservoir can be utilized as a storage medium to sustain the withdrawals from the wells.

In many areas we do utilize our aquifers as storage and distribution media, and public authorities increasingly accept the need for developing an entire aquifer as a single unit. Nevertheless, the planned use of aquifers as components of larger hydrologic systems has been largely overlooked or neglected. With few exceptions, the planned use of aquifers as storage and distribution media has been neglected in the schemes for major river-basin developments.

We should remember that optimum use of aquifers as parts of larger hydrologic systems carries a price. We need first to identify and select the systems best suited to our purposes. We need, then, to analyze these systems in a manner that will yield us the widest choice of alternative measures for development and management and enable us to foresee the varied effects of development. Hydrologic data of all types are required. Many data are on hand but many remain to be gathered. In particular, data for aquifer description--suitable for use in setting up analog models--need to be gathered, and these data are especially expensive. Required also is research aimed at improving methods of analyzing hydrologic systems and at developing and testing methods of managing them.

We should remember too that time is of the essence, for as our demands grow and the stage of resources development approaches maturity we lose our freedom of action. We can either hasten to gather the facts and accelerate the research so that we may have a choice of alternatives and an opportunity to select the most palatable of the consequences, or delay until we have no choice but to react to the situation and accept the unplanned consequences.

We should bear in mind that preservation of the quality of the water as it passes through our aquifers is essential if they are to yield full value as tools to stretch our water supply. The problem of pollution of streams is well known and the need for corrective measures is generally accepted. We cannot permit deterioration of the water in our aquifers to become a problem on the same scale because remedial action may be effective only after a period of many years. Thus, constant vigilance, and prevention rather than cure, should be the order of the day.

We should bear in mind, too, that most problems are a natural consequence of the use of resources. We cannot avoid all problems, nor can we wave the magic wand and make them vanish. We can, however, by planning carefully and with full knowledge of the alternatives open to us, develop our water resources in such a way as to avoid or alleviate some of the more serious problems.

In summary, if we make the most of what we have--by reuse, routing, and storing our water supply and protecting the quality of our water from deterioration--we need not lack for water for some time to come. The vital role of aquifers in this scheme is as storage and distribution media to be used either alone or in conjunction with streams and surface reservoirs as parts of larger hydrologic systems. Let us collect the facts and do the research now, so that we may have the widest possible choice of alternatives in developing and managing the resources.

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