THE ROLE OF GROUND-WATER RESERVOIR MANAGEMENT IN THE COMPREHENSIVE DEVELOPMENT OF THE WATER RESOURCES OF THE SOUTH PLATTE RIVER BASIN

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Prepared for presentation at the 120th meeting of the Missouri Basin Inter-agency Committee, August 3, 1961, Fort Collins, Colorado

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My assignment today is to inform you of current research which should
be of considerable value in carrying out the objectives of the theme of this
meeting - the Comprehensive Development of the Water Resources of the
South Platte Basin. The ultimate goal of this research is to determine how
to make maximum use of the natural ground-water reservoirs in conjunction
with surface-water supplies, in such basins as the South Platte.

Funds were appropriated to the Colorado Department of Natural
Resources during the last legislative session to begin this study. The
Director of Natural Resources has divided the funds between the U.S.
Geological Survey and Colorado State University. Also active in the planning
and guidance of this project are the State Engineer and his staff, the Colorado
Ground Water Commission, and the Colorado Water Conservation Board.

Before discussing the research project, it would be well to first present
some background information.

Surface-Water Development

When the early settler of little more than a century ago made his way up
the South Platte Valley towards the Rocky Mountains, he found a stream
system still largely controlled by nature. He soon learned that although
the South Platte and its major tributaries carried an abundance of water in
the spring, the flows often were insufficient in the late summer and fall.
He also probably noted that the South Platte lost water as it proceeded across
the dry plains, making the more reliable water supplies available near the
mountains.

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However, the natural regime of the stream system was rapidly changed as more and more ditches were constructed to divert water from the river and spread it on adjoining lands. The Colorado Doctrine of Prior Appropriation adopted in 1876, a landmark in water law, provided an incentive for rapid development of the surface-water resources.

It soon became obvious to the early irrigators that reservoirs were needed not only to store excess water in the spring for use in the fall, but for longer term storage to bridge across periods of several years of deficient runoff. By the early 1900's many surface reservoirs were in use.

All through this period of irrigation development very few realized that below their lands was a natural reservoir of great magnitude and immense potential value. This reservoir was constructed many thousands of years earlier by the South Platte River itself. The South Platte is a consequent stream that resulted from the uplift of the Rocky Mountains during the late Cretaceous and early Tertiary periods. During the early Tertiary, severe erosion removed great thicknesses of the Cretaceous sediments. Later, during the early part of the Pleistocene epoch, the South Platte River and its major tributaries incised deep channels in the underlying bedrock material. The Pleistocene glaciations caused several cycles of erosion and deposition, resulting in as many as six distinguishable terraces along the river. Filling of the Quaternary channels with worked and re-worked sands and gravels provided the facilities for the present-day ground-water reservoirs which underlie a major portion of the irrigated areas in the South Platte Valley.

The early settlers tapped these reservoirs with wells to provide water for their households and livestock, but little thought was given to use ground water for irrigation until much later. Even though use was not made of the underground reservoirs purposely, the early irrigators benefited from them. The new ditches and reservoirs leaked much water, and excessive amounts of water was often applied to the land in years of abundant runoff. Certainly, much land would have become water-logged and useless if it had not been for the permeable alluvial sediments furnishing excellent internal drainage. Records show that the water table rose as much as 50 feet in some areas during the first 20 years of irrigation, but water-logging was minor because of rapid internal drainage back to the river.

Soon, instead of a "losing" stream, the South Platte became a "gaining" stream due to ground-water "return flow." This tended to make more water available to the lower river during late summer and fall. Today many water rights on the lower river are dependent upon this "return flow." Professor L. G. Carpenter, who later became State Engineer, began making measurements of the return flow as early as 1889. Ralph Parshall made a study of it on the lower South Platte in the 1920's and it has been measured periodically by the State Engineer throughout this period. From all
indications the "return flow" reached an equilibrium by 1930 of some 1,000,000 acre-feet per year. Because of this re-use of water, the total diversions by all ditches in the South Platte Basin average more than twice the average annual runoff from the mountain watershed.

Ground-Water Development

Partly out of necessity during the drought years of the early thirties, and also made possible by more efficient pumps and the advent of electrical power, drilling of wells for irrigation became big business. Many of these wells merely supplemented ditch water. Others were drilled in areas above canals such as the Beaver Creek and Bijou Creek Valleys. Those drilled below canals receive recharge every year, while those above canals draw upon storage which accumulated over many thousands of years.

Today, over 5200 irrigation wells tap the alluvial ground-water reservoirs adjacent to the South Platte and its tributaries. At least 4000 of these are below canals and within three miles of the river. As much as 1,000,000 acre-feet are pumped from the 5200 irrigation wells annually. The well water often makes the difference between a mediocre and a good crop, and during drought years such as 1954 and 1956 it saved the Valley from disastrous crop failure.

The Problem

Thus, surface water and ground water, although intimately interrelated physically, have been developed separately from one another. Through necessity the surface water was developed by cooperative action and financing by groups and organizations. On the contrary, ground-water supplies have been developed somewhat haphazardly by individual initiative and financing. Laws and customs have also developed separately. Therefore, instead of coordinated use of the two related sources of water, serious conflicts have developed. Those irrigators who cannot obtain wells look unfavorably upon the use of ground water and subsequent reduction of river flow by well pumpers who are 40 to 80 years junior to them in time. But the well owners generally take the philosophy that the water under their land is their property, and many are opposed to any degree of control or regulation.

It has been estimated that there is some 25,000,000 acre-feet of ground water storage capacity in the South Platte Basin. If only 1/5 of this could be used for planned cyclical storage it would add considerably to a total water plan for the system. Because of the immense storage possibilities, the value of the ground water, the impending conflicts of interest and the direct hydraulic connection to surface supplies, the conjunctive operation of the ground-water reservoirs with surface-water supplies must be considered in any comprehensive development plan. In fact, it is doubtful if comprehensive development can be accomplished without considering the ground-water factor.
Several advantages can be cited for use of ground-water storage. These include:

(1) No construction costs.
(2) No loss of capacity due to silting.
(3) No land flooded.
(4) Protection from evaporation losses.
(5) Protection from contamination, such as radio-active fallout.

There are, of course, a number of problems peculiar to ground-water storage. These include:

(1) The boundaries, capacity and operational characteristics are more difficult to determine than for a surface reservoir.
(2) Measurement of the amount of water in storage at any time is not generally as simple as reading one gage height.
(3) Outflow occurs at many points (wells) rather than at the spillway, thus administration and control is a greater problem.

What Research is Needed?

In order to manipulate ground-water storage intelligently, we must know and understand the basic interrelationships of surface water and ground water. That is, we must know what affect the use of one will have on the quantity, quality and distribution of the other. Thus, the earlier phases of the study will be devoted to defining these interrelationships through field investigations and the analysis of historical records.

After the interrelationships of surface water and ground water are determined in the various reaches of the river, an electric analog model will probably be constructed to simulate the hydraulic characteristics of the basin. Because of the complexities involved, exact mathematical relationships will be difficult to apply. The electric analog approach offers the best tool for predicting the effects of various water supply, use and operational procedures. With this tool, an operational plan for an one hundred-year period can be tested in a matter of minutes.

What Might a Conjunctive Use Plan Include?

Planned management and operation of ground-water reservoirs in conjunction with surface-water supplies would probably include:

(1) Heavy reliance upon ground water during years of deficient runoff.
(2) Artificial recharge facilities to replace pumped ground water during years of favorable runoff.
(3) Planned long term storage in ground-water aquifers where geologic conditions make it possible. This may involve transfer of water from surface reservoirs to underground reservoirs during fall and winter months to provide maximum catchment capacity in the spring.

(4) Because of the storage manipulations already mentioned, the ground-water reservoir cannot be kept full and thus will not always provide "return flow" to the river. Thus many ditches may have to be served by pumps when surface water is not available.

Legal, Economic and Social Problems

It can be readily seen that a conjunctive-use management plan may be scientifically sound, but quite incompatible with present institutional frameworks. These legal and social customs resist change, but if it is possible to show that water supplies can be stabilized and increased, and that conflicts can be alleviated, then a well planned educational program should win acceptance. Up until now these institutional frameworks have been built in an atmosphere of water-supply development. Emphasis must now be shifted to one of management.