WRC NEWSLETTER

VOL. 2 NO. 2 January, 1987

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FREQUENCY OF SIGNIFICANT RECHARGE TO THE OGALLALA AQUIFER FROM PLAYA LAKES

Since the dawn of history the High Plains region of Texas has possessed three significant natural resources and a highly variable climate. The resources are petroleum deposits, shallow groundwater of generally excellent quality, and fertile soil.

It was well into this century, however, before the extent of the petroleum and groundwater was realized and until pumping techniques were perfected to the degree that irrigation using groundwater was rendered feasible.

At the moment, market prices are wreaking havoc on both petroleum and agriculture and the constraints of economic feasibility are severe. For the longer term, however, it seems evident that the values of both petroleum and water will again rise, and that studies now to optimize recovery factors for both liquids, and to replenish the supply of water by means of artificial recharge, precipitation enhancement, and secondary recovery are of vital long-term importance to the region.

Dr. B.J. Claborn, Dr. Lloyd V. Urban, and Ms. Sharon E. Oppel published the results of a study of one phase of the poorly understood phenomenon of natural recharge in a WRC report: "Frequency of Significant Recharge to the Ogallala Aquifer from Playa Lakes" in July 1985. By analyzing the hydrological records of twenty-two playa lakes well distributed over the Panhandle and South Plains, they determined that from thirty to fifty percent of the runoff has been recharged by natural means through the ring-shaped areas outside of the assumed impermeable clay bottoms of the lakes. The balance, fifty to seventy percent, of the inflow to a playa lake is now lost to evaporation. This volume is available for artificial recharge to the aquifer.

The following background of the study is quoted, with a few minor deletions, from the report.

INTRODUCTION

By far the greater portion of the storm drainage on the High Plains of Texas is to local playa lakes. These natural surface depressions occur with a frequenc of 1 to 2 per square mile and range in size from a few acres at a shallow depth to a few of over 200 acres and 10 to 20 feet in depth. These lakes are characterized by a naturally occurring liner of almost impermeable clay or clay/silt. In general, the larger lakes are located in the northern portion of the region. The general slope of the land surface is from northwest to southeast; consequently, the drainage area for most lakes is located north and west of the lake with a very short (quarter to half mile) region to the southeast. With sufficient runoff, the shallower lakes fill to overflowing and drain to the next lake down slope.

Because the lakes are sometimes inundated, and may remain so for a considerable period of time due to their clay bottoms, farmers have not been able to fully utilize the land for production. Some have used the lake bottoms for pasture for a few head of cattle; others have used bench leveling to reclaim as much of the land as practicable. A few have drilled wells near, or in, the lakes in attempts to drain the water quickly into the underground aquifer. Almost without exception, these efforts met with failure because of the high silt content of the lake water. The silt quickly clogged the pore space in the aquifer resulting in very slow injection rates. Other operators have constructed pits in the lake to concentrate the water into a smaller area. Recharge initially occurred from the pits, but they too clogged and the rate of drainage became unsatisfactory.

PREVIOUS RECHARGE RESEARCH

Efforts by various researchers to recharge playa

lake water as a water conservation measure date back at least to 1955 and continue to the present. Recharge through wells has been the most popular method although pits have also been used. The problem of silt has plagued all investigators. Removal of the silt from the face of the well bore by pumping after a period of injection has not been completely effective, with the result that the well gradually loses its recharge capability. The recharge rate from a pit also has been shown to decrease with time; however, it is possible, between recharge events, to mechanically remove the silt from the bottom and sides of the pit and thus restore the recharge capacity. While this is a technically feasible measure, it is expensive and thus it does not appear likely to be widely adopted by the farmer. In 1976 Johnson and Crawford reported satisfactory results using playa lake water in a pressure injection experiment at pressures of 50 to 80 psi. With current costs of energy this method cannot be justified economically for agricultural applications.

THE CASE FOR NATURAL RECHARGE

It has been observed by both farmers and playa lake researchers that the water level in a lake recedes rapidly immediately after a large runoff event, then much more slowly as the lake reaches a shallower depth. This phenomenon is due to the geological constitution of the lake basin. As described previously, the bottom of the lake is comprised of a clay--typically, Randall Clay--sometimes to a depth of 30 or more feet. On proceeding upslope, the clay liner becomes thinner and finally feathers out. Whenever the runoff is sufficient to bring the water level above the clay liner, recharge can occur through the surrounding soil profile which is typically a silty sand or silty loam. Thus, the infiltration rate is initially large; however, after the water level recedes back into the clay liner zone, very little, if any, recharge takes place. Water level declines, thereafter, correspond very well to evaporation from a free surface. Wood and Osterkamp recently suggested that a considerable volume of water is recharged naturally through the zone immediately above the clay liner. Their thesis was supported by water level observations and by the chemistry of soil extracts from this region. These facts suggest the possibility that there is not sufficient water remaining in the playa lake after the rapid infiltration period to warrant continued research efforts into practicable means of artificial recharge. The quantification of the amount available for artificial recharge was the focus of this research.

The body of the report is primarily devoted to an analysis of the reliability of the data used. The sources of possible error are attributed to several factors:

1. Rainfall records from non-recording gauges sometimes contain errors, particularly timing errors.
2. The empirical rainfall-runoff relations developed by the U.S. Soil Conservation Service are unreliable when applied to arid or semi-arid regions.
3. The lakes were assumed to be empty each time a runoff event occurred. This would cause the amount of water available for natural recharge to be underestimated.
4. Planimetering of the available small-scale maps (1:24000) introduced some error.

"In spite of the uncertainties listed above, this study has shown that a considerable portion of the runoff into the playa lakes is ultimately evaporated back to the atmosphere and thus would be available for artificial recharge into the Ogallala Aquifer."

RESEARCH CONTINUES

Urban and Claborn are continuing their research in artificial recharge with a large scale test/demonstration facility located near Shallowater, Texas. Data and information collected during the late summer rains of 1986 indicate that high quality filtered recharge water can be produced in significant quantities. The three filter units installed produced flow rates in excess of 30, 70, and 100 gpm, respectively.

The results of these experiences are being analyzed and will be incorporated into a preliminary design manual for recharge facility construction. The guide should be available in late 1987.

T. LINDSAY BAKER UNEARTHS AND PUBLISHES REPORTS OF EXPLORATIONS OF THE HEADWATERS OF RED RIVER, TEXAS

Dr. T. Lindsay Baker, Curator of Agriculture and Technology of the Panhandle-Plains Historical Museum, Canyon, Texas, and former affiliate of the WRC on many projects while he headed the History of Engineering Program at Texas Tech, has discovered and published in the Panhandle-Plains Historical Review, 1985, two documents describing a topographic and scientific

survey and exploration of the headwaters region of the Red River (Palo Duro Canyon vicinity) conducted in May and June, 1876. The first of these, the "Official Report" by Lt. E. H. Ruffner, was printed only in an obscure government document in 1877. The second, a diary by Carl Julius Adolph Hunnius, a civilian surveyor and draftsman who accompanied the expedition, remained in private hands for almost a century before reaching the Spencer Research Library at the University of Kansas in 1971.

The region had been explored and traversed by numerous parties for more than two decades before Ruffner led his expedition to obtain a detailed report of the land and water resources of the Central Panhandle region.

Ruffner's comments on the water supply include the following:

"As there had been little or no rain during the early spring, and as we had very little during our trip, the ponds or drain basins that are everywhere on the plains had no water in them, though they were evidently wet during some part of each year." [p. 11]

"The quivering heat and the disagreeable odor [of Tule Creek] make the passage up its bed even for three miles at five o'clock in the morning anything but pleasant." [p. 15]

His basic conclusion was that "...whatever may be the future of the country the needs for it are not apparent as yet, and with the miles and miles of fair grazing land in the Indian Territory and in Kansas as yet unflocked with peaceful herds I see no reason for speculating on the use of the Staked Plains." [p. 17]

As can be judged from the following excerpts of Hunnius' diary, Baker carefully preserved the original spelling and punctuation.

May 22 [p. 76-77]: "...the west wind set in and the dust and flying sand was awfull... Dr. Mendenhalls red shirt shrunk awfull. I found him washing it in the creek. he thinks it is a horrible place we are staying ... such a dirty camp will make the cleanest man careless and slopy."

June 10 [p. 91]: "The pool or pond here is very deep and one may find water here at all time. it is not running and tastes very brackish but it is water and wet."

June 12 [p. 98]: "Woke from a sensation like being in rain about 2-1/2 A.M. this morning and so it was. Raining and strong wind from the North very chilly, 52° Farenheit. we made coffee as quick we could by the storm, packed up and started at 3:30 A.M. it was a very cold ride... After arrival in Camp, heard that our Mess is in a most poor condition, in fact nothing left to eat so I laid down and slept dinner away."

June 13 [p. 94]: "There is no dust, of which latter we had any amount in former camps.. The Creek is not very wide but has running water, color of which is pretty red, and tastes alkali, but not so bad as Tule Creek... Moore, my rod carrier, is sick (diaorrhea),..."

Baker, a historian, saw in his discovery two documents that complemented each other in a way rarely encountered in primary resources recording the history of the American West. A hydrologist is most impressed by the inherent inhospitality of the High Plains of Texas if it were not for the beneficial contribution of the Ogallala Aquifer.

KATHLEEN M. TRAUTH AWARDED PORTER MEMORIAL FELLOWSHIP BY TEXAS SECTION, A.S.C.E.

The trustees of the J. Walter Porter Memorial Fund have selected Kathleen M. Trauth as one of the two Civil Engineering graduate students in Texas to receive fellowships for the current school year.

After graduation from The Ohio State University in 1983 with a bachelor's degree in Civil Engineering, Ms. Trauth entered graduate school at Texas Tech. Here she serves as a teaching assistant in fluid mechanics classes and laboratories in the Civil Engineering Department and as a research assistant in the Water Resources Center. Her contributions in the WRC research have included participation in a team that developed guidelines for environmental analyses of solar bowl technology.

For her master's degree, received in 1985, she wrote a thesis entitled "Municipal Water Resources Audit --- A Planning Strategy for Arid/Semi-Arid Areas." Readers of this newsletter will recall discussions in the April and July issues, 1986, of the practical applications of this concept in some of the five municipalities that have employed it to date.

Her research for her doctoral thesis investigates the identification and quantification of the barriers to the implementation of municipal water conservation programs and the means of surmounting them. Her experiences with the "nuts and bolts" of the Audit where it has been used, and in the reluctance to employing it in some other localities --- where political, economic, technical or cultural obstacles exist or where the municipal records

are totally inadequate (as is too often the case in smaller towns) --- has provided her with a unique background for investigating the means available to a civil engineer for operating most effectively in providing optimum water and wastewater services within the constraints of the locality.

Ms. Trauth has visited extensively with municipal councils and operators of utilities and has acquired a down-to-earth understanding of her problem which presages well for her thesis becoming a valuable contribution to practice. Plans exist for joint publication of the results by the WRC and another agency at the state or national level to make them more widely available.

Ms. Trauth has her Engineer in Training Certificate, and is a member of the American Society of Civil Engineers, Chi Epsilon, and Tau Beta Pi.

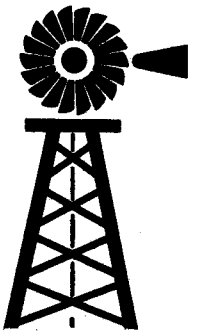
DR. ANDREW STONE PRESENTS SEMINAR

Stopping over at the Water Resources Center on a round-the-world tour in which he was seeking information on the management of salinity in irrigation water, Dr. Andrew Stone of Rhodes University, Grahamstown, South Africa, presented a seminar on November 3.

He described the construction in the early 1970's of the Verwoerd Dam on the Orange River and of the Orange-Fish tunnel, 51.5 miles long, which conveys 1800 cubic feet per second of water to the Fish River. The additional water in the Fish River has led to a substantial increase in the amount of irrigation water applied in its drainage basin. This, in turn, has led to penetration of the applied water into deeper formations with detrimental increases in salinity, particularly in the lower portion of the valley where return flows are recycled.

Stone had visited Dr. T. Lindsay Baker in Canyon, particularly on the subject of windmills in which Baker is an outstanding authority, and was accompanied by Baker to Tech. En route, he was shown many of the features of High Plains agricultural practices.

He departed for Southern California en route home by way of Australia.



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