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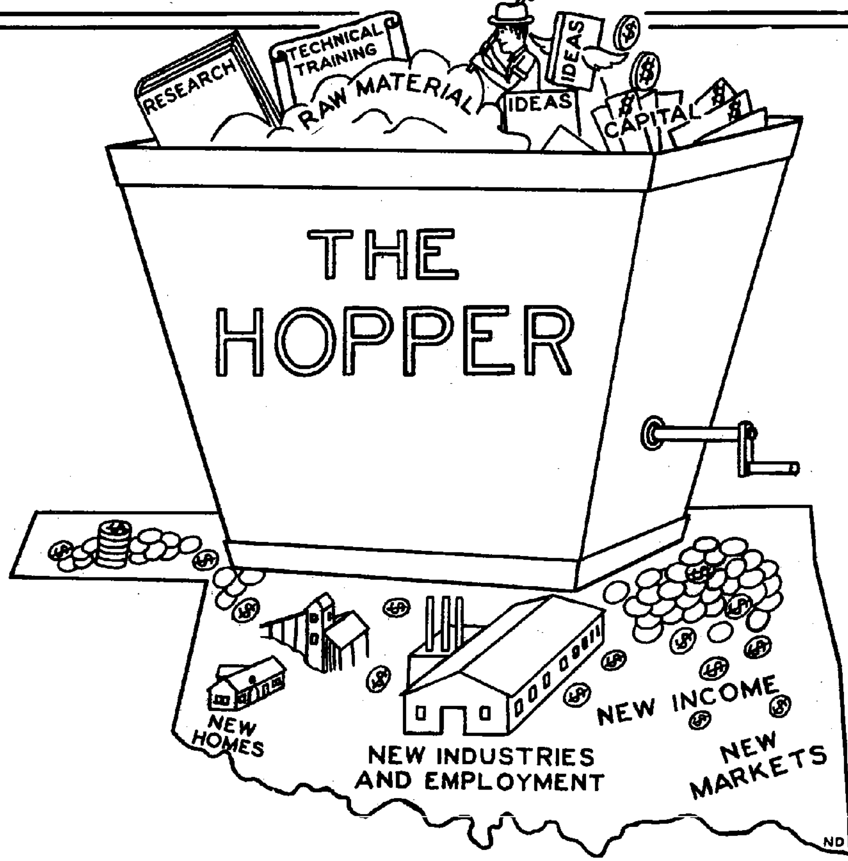

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GROUND-WATER PUMPAGE AND WATER LEVELS IN THE OKLAHOMA PANHANDLE 1/

By Stuart L. Schoff 2/

One of the largest reservoirs of ground water in Oklahoma is a thick deposit of sediments, largely unconsolidated, that is distributed widely in the Oklahoma Panhandle (Beaver, Cimarron, and Texas Counties). Its opportunities for replenishment do not match its capacity, however, and large-scale development could lead to overpumping. The Oklahoma Geological Survey and the U. S. Geological Survey have been studying the ground-water resources of the area since 1937. The most recent publication resulting from this study gives a brief summary of the status of deep-well irrigation.3/

Municipal Pumpage Increases

Records furnished by the Southwestern Public Service Co. show that 22 percent more ground water was pumped in 1952 than in 1951 to meet the water needs of seven towns in the Panhandle counties.

3/ Schoff, S. L., 1950, Deep-well irrigation in Oklahoma Panhandle: THE HOPPER, vol. 10, no. 8, p. 76 (Oklahoma Geol. Survey, mimeographed).

The present paper reports an inventory of ground-water pumpage and observations of ground-water levels.

1/ Publication authorized by Director, U. S. Geological Survey.

2/ District Geologist, Ground Water Branch, Water Resources Division, U. S. Geological Survey, Norman, Okla.

The largest increase occurred at Beaver and was 31 percent. Other increases, expressed in percentage, were that for Guymon (27), Texhoma (21), Boise City (8) and Forgan (8). Hooker, Goodwell, and Tyrone have municipally owned water systems for which records of pumpage are not available. The water pumped for these towns in 1952 is estimated as about 150 acre-feet, and the total pumpage for all municipalities in the Panhandle counties is estimated as about 2,265 acre-feet. Water pumped for industrial use is not accurately measured but is estimated to have been about 570 acre-feet in 1952.

Irrigation Expands

A complete inventory of irrigation pumpage in the Oklahoma Panhandle - the first since the end of World War II - has shown a substantial increase in use of ground water for irrigation. The summer of 1952 was hot and dry, and some of the older irrigation wells were pumped far more than in immediately preceding years. Wells completed in 1951 and 1952 added substantially to the total quantity of water pumped. The new inventory showed that in 1952 about 18,000 acre-feet of water was pumped from 69 wells for the irrigation of about 7,640 acres. Texas County led with 13,000 acre-feet pumped from 28 wells for the irrigation of 5,640 acres. Cimarron County was second with nearly 3,500 acre-feet of water pumped from 20 wells for the irrigation of 1,395 acres. Beaver County was third with about 1,800 acre-feet of water pumped from 21 wells for the irrigation of 613 acres. The average number of acres irrigated per well was 201 in Texas County, 70 in Cimarron County, and 29 in Beaver County, and the average number of acre-feet of water pumped per well was 459 in Texas County, 173 in Cimarron County, and 85 in Beaver County.

For all purposes - municipal, industrial, and irrigation - about 21,000 acre-feet of water was pumped from wells in the Panhandle in 1952.

In addition to the pumping from wells, several irrigators were pumping from sloughs, large open pits dug on the flood plains of creeks, or directly from rivers and creeks. As runoff was very low during the growing season even the water taken directly from streams was mainly the effluent seepage of ground water. More than 2,000 acres was irrigated from the Cimarron River in Cimarron County, and about 255 acres was irrigated from several streams, or from sloughs or pits adjacent to streams, in Beaver County. There was very little irrigation from such sources in Texas County. The water taken in this way in Beaver County is estimated as about 390 acre-feet.

Rise of Water Level

Depths to water have been measured in wells in Texas County since 1937 and in Beaver and Cimarron Counties since 1938. For the first several years the measurements were made every 2 or 3 months, but failed to show significant fluctuations and the frequency was reduced, first to twice a year and then to once a year. The observed wells have been divided into groups according to the aquifers tapped and average water levels have been calculated. For each County the different aquifer groups have been assigned a percentage value based on the area underlain by the aquifer, and a weighted average for the county has been calculated. The county averages then have been averaged together to obtain the average water level for the whole Panhandle.

The lowest average for the water levels in the Panhandle as a whole was recorded in November 1938, and there was little change until 1941, when a gradual rise began as a result of heavier precipitation. This rise has been accelerated in recent years, and the highest average was recorded in May 1953, notwithstanding a decline in precipitation and an increase in the pumping of ground water for irrigation. The average for 1953 was 6.9 feet higher than the record low, and if the recoverable water equals only 10 percent of the volume of rock saturated by the rising ground water, the increase in available ground water would amount to about 225,000 gallons per acre, or 144,000,000 gallons, on the average, for each square mile underlain by water-bearing formations.

The rise in ground-water levels has continued despite a decline in precipitation that threatens to turn into drought. This probably is because fluctuations of the water table lag considerably behind the climatic variations that cause them. The drought of the 1930's was broken and several years of fairly abundant rain passed before the water table rose significantly. Now, more than 2 years have passed since the return of dry weather, and it may be a year or two more before the effects appear at the water table. At Goodwell, near the middle of the Panhandle, the normal annual precipitation reported by the U. S. Weather Bureau is 16.94 inches, and the precipitation received in the last 5 years has been:

Year	Precipitation (inches)	Year	Precipitation (inches)
1948	24.02	1950	26.94
1949	22.25	1951	16.17
		1952	9.16

Change of Water Level by Formations

The sustained rise of water level has occurred in an extensive deposit of sand, gravel, silt, and clay which underlies the uplands. In reports on Texas and Cimarron Counties 4/, this deposit has been identified as the Ogallala formation. This is the principal aquifer in the Oklahoma Panhandle, as well as in the rest of the High Plains, and it is tapped by most of the municipal, irrigation, and industrial water wells.

By May 1953 the net rise of average water level in observation wells in this formation was 10.08 feet in Beaver County, 7.47 feet in Cimarron County, and 7.12 feet in Texas County. Meanwhile the water levels in wells tapping alluvium near streams and in wells tapping the red beds beneath the Ogallala formation had fluctuated through a narrower range and under the influence of imminent drought declined almost to where they were at the beginning of the record.

Effect of Irrigation Pumping

Most of the water-level measurements are made in unused wells far from cities, towns, or concentrations of irrigation wells, and they therefore reflect water-level fluctuations that are due primarily to natural causes. The storage capacity of the Ogallala formation is enormous, and the effects of heavy pumping in one area will not appear in remote localities for a long time. Hence,

4/ Schoff, S. L., 1939, Geology and ground-water resources of Texas County, Okla.: Oklahoma Geol. Survey Bull. 59.

________, and Stovall, J. W., 1943, Geology and ground water resources of Cimarron County, Okla.: Oklahoma Geol. Survey Bull. 64.

the effects of heavy pumping for irrigation in 1952 will not show up very soon in the average water levels.

Through May 1953 no obvious effects had appeared even in the observation wells nearest the areas of pumping. In Beaver County the two observed wells nearest to irrigation wells had relatively low water levels in May 1953, but the lowest for these wells had been recorded in previous years. In a well near Boise City, Cimarron County, where several municipal, irrigation, and commercial wells were pumped in 1952, the water level was about half way between the highest and lowest on record. And near Guymon, Texas County, the water in one well was much closer to the highest recorded level than to the lowest, and the water in another was at the highest level on record!

Average Change by Counties

The water levels in individual wells have not all reached record highs and lows at the same time, and the county averages therefore have shown considerable diversity. Thus, the lowest and the highest average ground-water levels for Beaver County were recorded in November 1938 and May 1952, respectively, and the rise of water level in 13.5 years was 7.64 feet; but the lowest and the highest for Cimarron County were recorded in July 1938 and May 1953, respectively, and the rise of water level in 14.8 years was 6.78 feet. The lowest and the highest average ground-water levels for Texas County were recorded in November 1939 and May 1953, respectively, and the rise in 13.5 years was 6.70 feet.

Replenishment

The record of water-level fluctuations can be considered encouraging because it shows that replenishment of the ground water takes place when precipitation is sufficient, but it does not prove that the ground-water supply is "unlimited" or "inexhaustible." The record in the Oklahoma Panhandle contrasts sharply with the record in the irrigated parts of the High Plains in Texas, where geological conditions are similar and the climate is not very different but irrigation is on a large scale. The withdrawal of ground water has obscured the effects of replenishment, and in some localities relatively large declines of water level have been recorded in a single year.

At best, the average annual replenishment in the Oklahoma Panhandle can be no more than a fraction of the annual precipitation, and a small fraction at that. Even if all the precipitation were to go into the ground, it would amount to less than 2 feet of water per acre, barely as much as the irrigators need per acre. From this it follows that the replenishment is not enough for the entire Panhandle to be irrigated indefinitely. The volume of water in storage plus the small annual replenishment would suffice for the irrigation of a small part of the area indefinitely, or the irrigation of a larger part of the area for only a certain period of time.

So far, the pumping appears not to have made an appreciable dent in the ground-water supply. Local decline of water level due to concentration of heavy pumping in limited areas seems likely to develop before general depletion of the reservoir.

LIGHTWEIGHT BUILDING MATERIAL

By A. L. Burwell

The use of lightweight building materials has increased remarkably in recent years. The metals, aluminum and magnesium, have been contributing factors since their weight is much less than the steel which it is replacing. Ceramic materials such as brick, tile, and glass have many excellent advantages but their use introduces a tremendous load. The weight of brick will be in the range of 110 to 130 pounds per cubic foot and glass will average somewhat more than 160 pounds. Concrete is a heavy mass, too. It will average over 140 pounds per cubic foot. Concrete has many advantages for construction of building, and it was to be expected that an effort would be made to reduce the weight of the finished product. One of the first efforts made use of cinders to replace the usual sand and gravel. Concrete made with cinders has a weight of approximately 100 pounds per cubic foot. This was a step in the right direction.

As far back as 1919 the records show that a Mr. Hayde erected a plant to produce a lightweight concrete aggregate by rapidly heating certain clay or shale to a high temperature in a rotary kiln. The product was named Haydite, and similar material made from shale by this method is termed Haydite, today. Not until about 40 years later did the idea of using lightweight aggregate really take hold. Some natural lightweight materials were utilized, principally pumics and scoria. Processed materials came onto the market. Shales were expanded in the rotary kilns, and porous products were made from shales in sintering machines. Also, perlite, a volcanic rock, and volcanic ash, a volcanic glassy powder, were expanded and may be used in concrete compositions.

Contractors and architects soon realized the value and economy of lightweight structural materials. The saving in concrete and in steel, both structural beams and reinforcing bars, etc., was attractive. In addition, and of great consequence, were two other physical characteristics of concrete in which the lightweight aggregate was used, namely, - insulating and acoustical properties. To date, lightweight concrete block producers have been the largest consumers of lightweight aggregate. There is a growing use of the materials in pre-fabricated and pre-cast concrete beams and slabs. Recent investigations undertaken in North Carolina and in Kansas should lead the way to ceramic (that is, fired) products using clay or shale as the binder for the lightweight aggregate. Such products will possess certain advantages over the conventional concrete products, but the economics of the process remains to be proven by actual production and marketing of the products.

It is known that certain Oklahoma shales can be expanded or bloated to yield satisfactory lightweight aggregate. It is known, too, that many shales will not respond to the usual treatment. Preliminary experimental work in the Oklahoma Geological Survey laboratory indicate that clay shales relatively free from sand and limestone concretions are preferable. It has also been established that fresh unaltered shale will often bloat whereas the same material after exposure to the air and therefore oxidized will not, or only partially.

Few deposits of natural raw material that will bloat under the usual methods have been found in Central Oklahoma and the few that do are of recent origin geologically. In the eastern part of the state where rock of Pennsylvanian age occur, it is expected that shale from a number of formations will prove satisfactory. In the southern and western parts of the state where rocks of Cretaceous age occur it is expected that suitable rock will be found. In the parts of the state where Permian rocks crop out the situation is dubious. However, it has been said that most any shale can be bloated or expanded by the addition of specific materials which will lower the temperature at which the thermo-plastic stage exists or that will furnish the necessary gaseous material to cause the expansion.

A local supply of lightweight aggregate processed from local material should be a welcome addition to structural contractors and builders. The processing of Oklahoma mineral materials always is "good news" to us.

First operation for the production of expanded clay or shale in Oklahoma has recently started near Choctaw, east of Oklahoma City. This operation was started by the Oklahoma Lightweight Aggregate Co.