TUPELO AND CORINTH - - EXAMPLES OF GROUNDWATER MANAGEMENT PRACTICES IN TWO NORTHEASTERN MISSISSIPPI COMMUNITIES

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INTRODUCTION

Purpose

Tupelo and Corinth are metropolitan centers in northeastern Mississippi that have in recent decades experienced significant population and industrial growth with accompanying increases in water use. Long-term declines in water levels in public water-supply wells at Tupelo, in Lee County, and at Corinth, in Alcorn County, resulted in serious concerns in each community for the viability of water supplies to sustain high growth rates. The methods by which these communities have each dealt with water-supply concerns provide interesting and useful lessons in water management.

Total ground-water withdrawal in Lee County increased from about 8 million gallons per day (MGD) in 1967 to 9.5 MGD in 1980 to more than 11 MGD in 1990. Most of this pumpage was from the Eutaw-McShan and Gordo aquifers and was centered in the Tupelo area. A result of this heavy and long-term demand was the development of a large cone of depression in the potentiometric surface. At the turn of the century, wells located in topographically low elevations at Tupelo flowed above land surface. By the late 1980s, however, static water levels near the center of the cone of depression had probably declined to elevations at or near the top of the Eutaw aquifer. Concerns about the long-term viability of the aquifer as a source of water led to the construction of a water treatment plant, pumping facility, and an 18-mile pipeline to supply water to the city from the Tombigbee River in Itawamba County.

In September 1991, the city of Tupelo shut off most of its wells and began using the surface-water source. By the fall of 1992, a reduction of about 6 to 7 million gallons per day in the total pumpage rate in Lee County had been made. An investigation was undertaken by the Mississippi Office of Land and Water Resources to monitor the recovery in potentiometric levels in the Tupelo/Lee County area that was expected to result from the cessation of pumpage from Tupelo's wells and from wells at two industrial parks north and south of the city. This report presents the data concerning water-level changes observed during the first four years of the study.

In Alcorn County, total pumpage from the Paleozoic aquifer, the principal water-supply source for the area, increased from about 1 MGD in 1960 to more than 4 MGD by 1975, and current withdrawal rates remain above that level. Corinth has been the largest pumping center in the county, and the city is the principal user of water from the Paleozoic aquifer in northeastern Mississippi. A relatively sharp decline in water levels in one observation well from 1962 to 1974 at Corinth, along with frustration in well siting due to variability in the Paleozoic aquifer, resulted in concerns for the viability of the water supply (Wasson and Tharpe 1975; Shindala et al. 1984). Water levels in most of Corinth's wells have shown modest recoveries in recent years but remain at elevations that are about 100 feet lower than in the early part of this century. This report summarizes changes that have occurred in the Paleozoic potentiometric surface in Alcorn County and outlines the major factors influencing those changes.

Methods

Most of the water-level measurements reported here were made with either a chalked steel tape or with an electric tape. Wells measured vary considerably in diameter and depth. Owners include municipalities, water associations, government agencies, and private homeowners. The Corinth Gas and Water Department has provided quarterly water-level measurements since 1990. Automated water-level monitoring equipment provided water levels at Corinth from observation well G57 until 1989 and from G135 since May 1994. Ground-level

elevations (altitudes) were approximated from U.S. Geological Survey 7 ½ minute topographic maps.

The on-going study of water levels in the Tupelo/Lee County project has involved the measurement of 39 wells, including one well in extreme eastern Pontotoc County. Occasionally, measurements could not be made on a few wells due to various difficulties, and two wells were dropped from the study in 1993. Water levels were measured in May 1991 in anticipation of Tupelo shutting off most of its wells in June; however, delays in the completion of the surface-water supply system resulted in the wells being shut off in September 1991. The May 1991 measurements and resulting potentiometric map (Figure 1) constitute the "baseline" data for comparative purposes in this study. Water-level data for previous years are available, however, for selected wells in the county. Twelve widely-distributed wells were measured monthly from October 1991 until April 1992; the remaining wells were measured quarterly during that period. All the wells were measured in May and July 1992. Beginning in October 1992 and continuing to the present, all wells in the study have been measured semi-annually in April and October. The monitoring of water levels on this basis is planned to continue until 1997, though conditions may call for modification of the schedule or changes in the network of wells.

It should be noted that although the situation at Tupelo has provided an interesting study, it is not a completely controlled recovery-phase aquifer test. It was necessary for four of Tupelo's wells (G59, G61, G95, and H115, all located outside of central Tupelo) to be utilized (pumped) for about 11 months after the other 19 city wells were shut off. All of Tupelo's wells are pumped briefly each month to maintain a standby system for the city. Wells in the Tupelo-Lee Industrial Park South (including two wells monitored in this study) continued to be pumped until July 1992, and wells in the Turner Industrial Park on the north side of Tupelo were used until October 1992. Moreover, many wells in the surrounding area, principally at Mooreville, Verona, Saltillo, Plantersville, City Point, Auburn, Shannon, Nettleton, and elsewhere, continue to pump from the Eutaw-McShan and Gordo aquifers. Water levels from the still-active wells should not be considered true static water levels because those wells cannot be turned off for a considerable length of time for measurement.

TUPELO/LEE COUNTY POTENTIOMETRIC STUDY

Hydrogeology

Loosely consolidated sediments of the Upper Cretaceous Gordo Formation, the Eutaw and McShan Formations, and the Selma Group unconformably overlie Paleozoic sedimentary rocks in Lee County. The Cretaceous strata dip to the west at about 30 feet per mile. The principal aquifers in the area are composed of sand beds in the Eutaw and McShan Formations (Eutaw-McShan aquifer) and sand and gravel deposits in the Gordo Formation of the Tuscaloosa Group (Gordo aquifer). Principal overlying confining units are composed of clays, marls, and chalks of the Mooreville Chalk and the Demopolis Chalk of the Selma Group. Low-porosity and impermeable Paleozoic rocks provide lower confinement in Lee County. The Coffee Sand aquifer occurs between the Mooreville and Demopolis confining units and provides ground water in the northern half of the county, primarily to small diameter home wells.

The combined thickness of the Eutaw and McShan Formations in the vicinity of Tupelo is about 250 feet. The Gordo thickness ranges from about 100 feet at Tupelo to more than 200 feet in the southern part of Lee County. The average transmissivity and 1-day specific capacity of the Eutaw-McShan aquifer derived from 21 aquifer tests in Lee County are approximately 1,164 feet squared per day and 3.4 gallons per minute per foot, respectively (Slack and Darden 1991). The average transmissivity and specific capacity of the Gordo aquifer, determined from 10 aquifer tests in Lee County, are 4,056 feet squared per day and 6.1 gallons per minute per foot, respectively.

All of the wells used in this study are screened in the Eutaw-McShan aquifer or the Gordo aquifer (or both). Some wells have split (dual) screen intervals and others have screens that overlap the contact between the two aquifers. The thickness of the confining clay beds and thus the degree of hydraulic separation between the Eutaw-McShan and Gordo aquifers is highly variable but is generally not significant in the northern two-thirds of the study area. As a result, potentiometric levels in the two aquifers commonly show only small differences in the central and northern parts of Lee County. Water levels from all wells in the study, except four that are screened entirely in the Gordo aquifer (H42, L19, L108, and O14), were used to construct the potentiometric maps presented in this report.

Potentiometric Data and Interpretations

Monitoring of water levels in the Eutaw-McShan and Gordo aquifers in the Tupelo/Lee county area for more than four years following the conversion by Tupelo to surface water has thus far documented a significant rise in the potentiometric surface. This recovery has occurred in spite of the continued pumpage of wells from surrounding communities that adversely affects the overall rise in water levels. The recovery of Eutaw-McShan aquifer water levels is readily apparent by comparing the May 1991 potentiometric map (Figure 1) with the potentiometric map of October 1995 (Figure 2). (Note that the contour interval for the May 1991 map is 20 feet, whereas the contour interval for the October 1995 map is 10 feet). An east-west profile (cross section) of key wells in Tupelo (Figure 3) also illustrates the recovery and shows that the rate of recovery has slowed in recent years. Much of the recovery occurred in the first year of the study, with water levels in a few wells rising more than 80 feet in the first 7 months after being shut off. Water levels in the 17 measured wells owned by the city of Tupelo have recovered approximately 112 feet per well on average since May 1991. The greatest amount of recovery of the potentiometric surface has been in the central cone of depression, but static water levels have risen 20 feet or more as far away as Saltillo and in southern Lee County (Figure 4).

The potentiometric data documenting a significant rise in water levels in only four years demonstrate the relatively modest transmissivities and storage coefficients of the confined aquifers in the area and illustrates the sensitivity of the aquifers to recharge. Water levels in wells in central and eastern Tupelo and to the east of the city had been drawn down to the top of the aquifer by the late 1980s. Recovery was rapid due to the relative close proximity to the recharge (outcrop) area in extreme eastern Lee County and in Itawamba County.

CORINTH/ALCORN COUNTY POTENTIOMETRIC STUDY

Hydrogeology

In Alcorn County, sedimentary rocks of Paleozoic age are unconformably overlain in ascending order by loosely consolidated sediments of the Upper Cretaceous Eutaw Formation, Coffee Sand, and Demopolis Chalk. Paleozoic strata occur only in the subsurface in Alcorn County but crop out to the east in northern Tishomingo County, primarily along the shores of Pickwick Lake. The Upper Cretaceous strata and the unconformity at the top of the Paleozoic rocks dip to the west at about 30 feet per mile. The top of the Paleozoic rocks is generally found at depths of between 300 and 500 feet in the general vicinity of Corinth. Paleozoic strata generally dip southward at rates of about 25 to 50 feet per mile (Jennings 1994). Water-bearing sand beds in the overlying Eutaw Formation are screened at the town of Rienzi in southern Alcorn County and are used for home well purposes in the eastern part of the county. The general lack of permeable sands in the Eutaw across much of the area, however, along with the generally high iron content of the ground water commonly discourages the unit's use as an aquifer (Boswell et al. 1963). Clay beds in the Eutaw Formation provide upper confinement for the underlying Paleozoic aquifer. The Coffee Sand overlies the Eutaw Formation and is used as an aquifer, especially in western and southwestern Alcorn County.

White to light gray Paleozoic chert constitutes the principal aquifer at Corinth and for the Kossuth, Farmington, and Alcorn Water Associations in Alcorn County. Paleozoic rocks are also used as the primary aquifer in northern Tishomingo County, principally at Iuka and Burnsville. The subcropping rock comprising the aquifer at Corinth is of probable Devonian age and is underlain by lower porosity and permeability Silurian and Ordovician limestones that progressively become the subcropping rock units in a northwesterly direction from the city in western Alcorn County (Jennings 1994). Although excellent wells producing over 1,000 gallons per minute have been made in the chert at Corinth and elsewhere, the unit exhibits significant variability in its hydraulic characteristics; transmissivity calculated from 11 aquifer tests in Alcorn County ranges from 1,280 to 12,800 feet squared per day (4,110 average) and specific capacity from 3.2 to 23.0 gallons per minute per foot (8.9 average) (Slack and Darden 1991). Although this variability has imparted some notoriety on the aquifer, the generally excellent water quality characteristics and higher yields with greater available drawdown has made the aquifer the one of choice for Corinth and the surrounding communities.

Potentiometric Levels and Pumpage

Predevelopment water levels for the Paleozoic aquifer were likely at elevations of about 420 feet above sea level at Corinth, more than 100 feet higher than today. Two wells drilled in 1915 at Corinth apparently were the first to use the Paleozoic aquifer in the county (Stephenson et al. 1928), though mention is made by Crider and Johnson (1906) of an earlier well penetrating the upper part of the Paleozoic stratigraphic section in the city.

In the 1950s, pumpage at Corinth began to exceed 40 million gallons per month in high-demand summer months (Boswell et al. 1963), but the city utilized the Coffee Sand as well as the Paleozoic aquifer. Beginning in about 1960 or 1961, Corinth began to supply all its needs from three wells (G4, G5, and G18) screened in the Paleozoic chert. Groundwater withdrawal rates from the Paleozoic aquifer accelerated in the 1960s and early 1970s, reaching about 4 MGD by the mid-1970s (Boswell et al. 1963; Newcome and Callahan 1964; Wasson and Tharpe 1975; Callahan 1979). In 1967, Corinth also began selling water to surrounding communities, first to Farmington and later adding Kossuth as a customer. Concomitant with this pumpage increase, beginning in 1962 Corinth increased the number of Paleozoic wells, going from three to nine wells by early 1973. All of Corinth's new wells drilled during that period were sited within 7,500 feet of the older city wells at the water plant (wells G4 and G5). Three Paleozoic wells were completed by Alcorn Water Association in late 1972 and early 1973 at Glen and Biggersville, but total pumpage from those wells was relatively minor compared to that of Corinth and was at a considerable distance from the city.

Relatively rapid declines in water levels during the 1960s and early 1970s were exhibited in well G18 and in well G57, an observation well located in the industrial park south of highway 72 and one mile south of the water plant (Figure 5). One large facility in the industrial park required about 1 to 1.5 MGD of the total pumpage during that time, and most of that water was supplied from the three wells nearest well G57 (Lilly 1996). Lower transmissive and storage properties of the aquifer in the industrial park area (Newcome and Callahan 1964) are also factors in the decline of water levels in well G57. By 1973, a large and steep cone of depression had developed on the potentiometric surface in the Corinth area (Wasson and Tharpe 1973).

Although the average daily total ground-water withdrawal from the Paleozoic aquifer in Alcorn County has continued to increase, albeit at a much lower rate of growth than occurred in the period 1960 to 1975, water levels in many of Corinth's wells have shown modest recoveries since the mid-1970s (Figure 5). Beginning in August 1973 and continuing to the present, Corinth has spread its pumpage by drilling and completing wells southeast, northeast, and southwest of the old pumping center; three wells are more than four miles from well G5 near the old water plant. The development of Paleozoic wells by Kossuth, Farmington, and Alcorn Water Associations in the period from 1972 to the present resulted in the self-sufficiency of those communities. Thus, as shown in Figure 5, pumpage within a 2-mile radius of well G57 decreased to early 1960s levels by 1995 and water levels were allowed to recover. The most recently mapped Paleozoic aquifer potentiometric surface in Alcorn County (Figure 6) shows cones of depression in Corinth and at Kossuth. Compared to the steep cone of depression mapped in 1973 (Wasson and Tharpe 1975) and in 1978 (Wasson 1979), the current (1996) potentiometric surface shows a more widespread but less steeply inclined depression. The potentiometric decline in the Kossuth area in recent years (Jennings and Phillips 1994) is a function of the relatively poor aquifer characteristics in that area and is likely related to the wedging out of the Devonian chert in a northwesterly direction across the county.

In addition, the close monitoring of tank water levels, pumpage, and well water levels by the Corinth Gas and Water Department has greatly improved the available information. Corinth has utilized a supervisory control and data acquisition (SCADA) system since 1990 to monitor tank water levels and an interconnected system of wells to manage pumpage to their five storage tanks. Coupled with the quarterly measurement of static water levels in all their wells, this automated system allows better management of the water supply. Pumpage is rotated or shifted periodically to different primary wells, constantly allowing recovery periods for all wells. As a result, water levels in individual wells in recent years have shown significant short-term fluctuations, but they have remained relatively stable when considered on a long-term basis. The Office of Land and Water Resources is currently measuring water levels daily with pressure transducer equipment in one observation well in an effort to gather more detailed potentiometric data.

CONCLUSIONS

Water levels in Tupelo's wells have recovered approximately 112 feet on average since the city and the industrial parks converted to a surface-water source. Static water levels in all 39 wells used in the study conducted by the Office of Land and Water Resources have risen as a result of the cessation of 6 to 7 MGD pumpage from the aquifer. The rise in the potentiometric surface of the Eutaw-McShan aquifer has essentially eliminated the well-defined cone of depression that existed in 1991 prior to shutting off the wells. The magnitude and speed of the recovery of water levels provides evidence of the relatively low transmissive and storage properties of the aquifer and evidence of the proximity of the recharge area. This on-going study has

also provided information pertinent to the future management of ground-water resources of the area.

The rapid and serious decline in Paleozoic aquifer water levels at Corinth in the 1960s and early 1970s resulted from several factors including: the total reliance of Corinth on the Paleozoic aquifer beginning in 1960-61; significant increase in pumpage rate from about 1 MGD in 1960 to about 4 MGD by 1975, including the sale of water to surrounding communities; the construction of six new Paleozoic wells, all located within a two-mile radius of the principal observation well (G57); relatively poor aquifer transmissive and storage characteristics in part of the industrial park area where much of the heavy pumpage occurred. The general recovery of water levels in many of Corinth's wells resulted primarily from the spreading of the pumpage from the aquifer over a much broader area. Corinth not only increased its well spacing and spread its pumpage, but surrounding communities that were purchasing water from Corinth developed their own wells. The recovery occurred in spite of an overall increase in ground-water withdrawal rate from the aquifer in the county. Corinth's total average pumping rate was about 2.8 MGD in 1995, whereas pumpage from the aquifer in the county averaged about 4.3 MGD. The close monitoring of pumping volumes and water levels by the Corinth Gas and Water Department ensures that water-management decisions are based on factual information.

Acknowledgments

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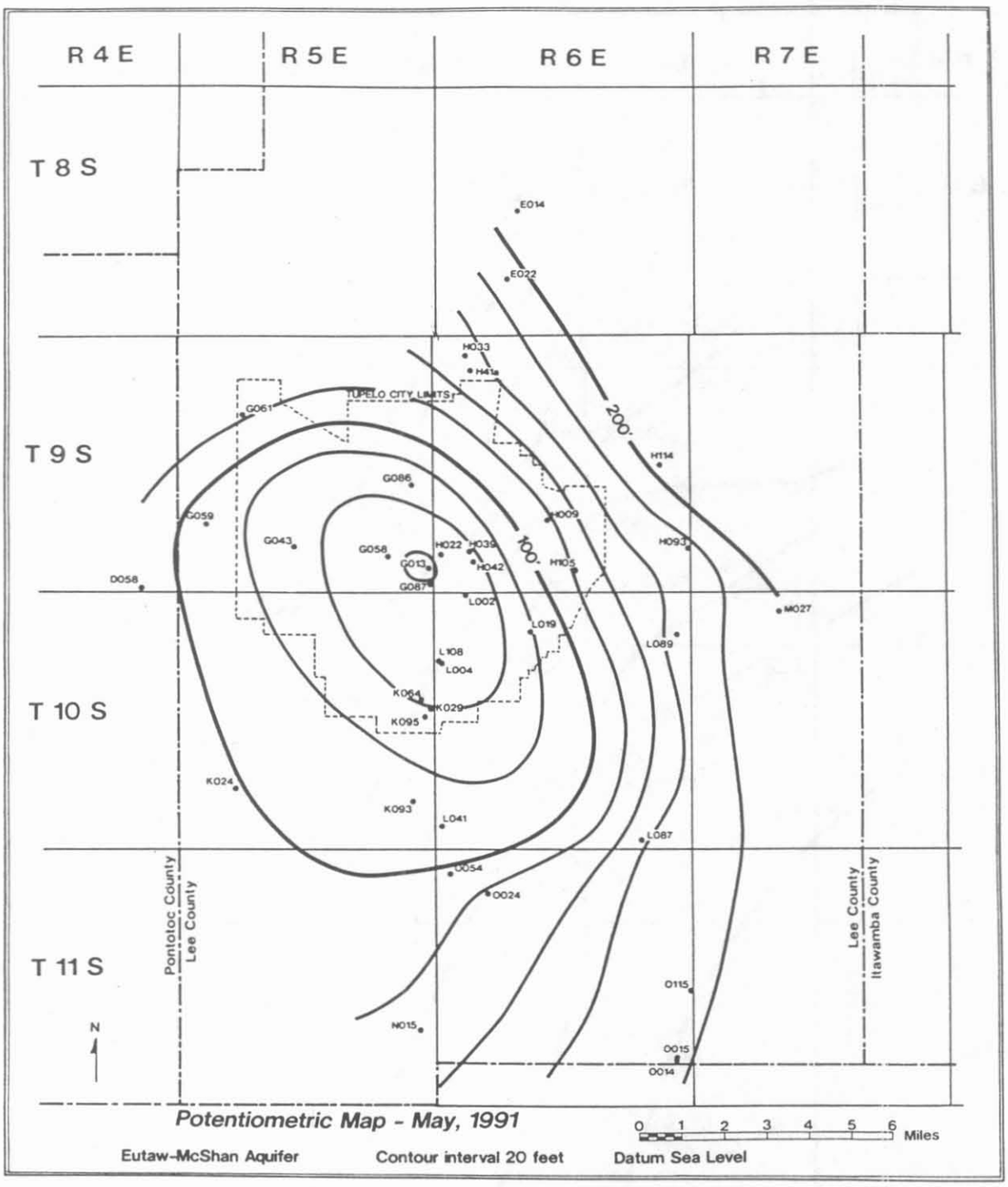

Figure 1: Potentiometric map - May,1991, Eutaw-McShan aquifer, Tupelo/Lee County, MS. Note contour interval of 20 feet.

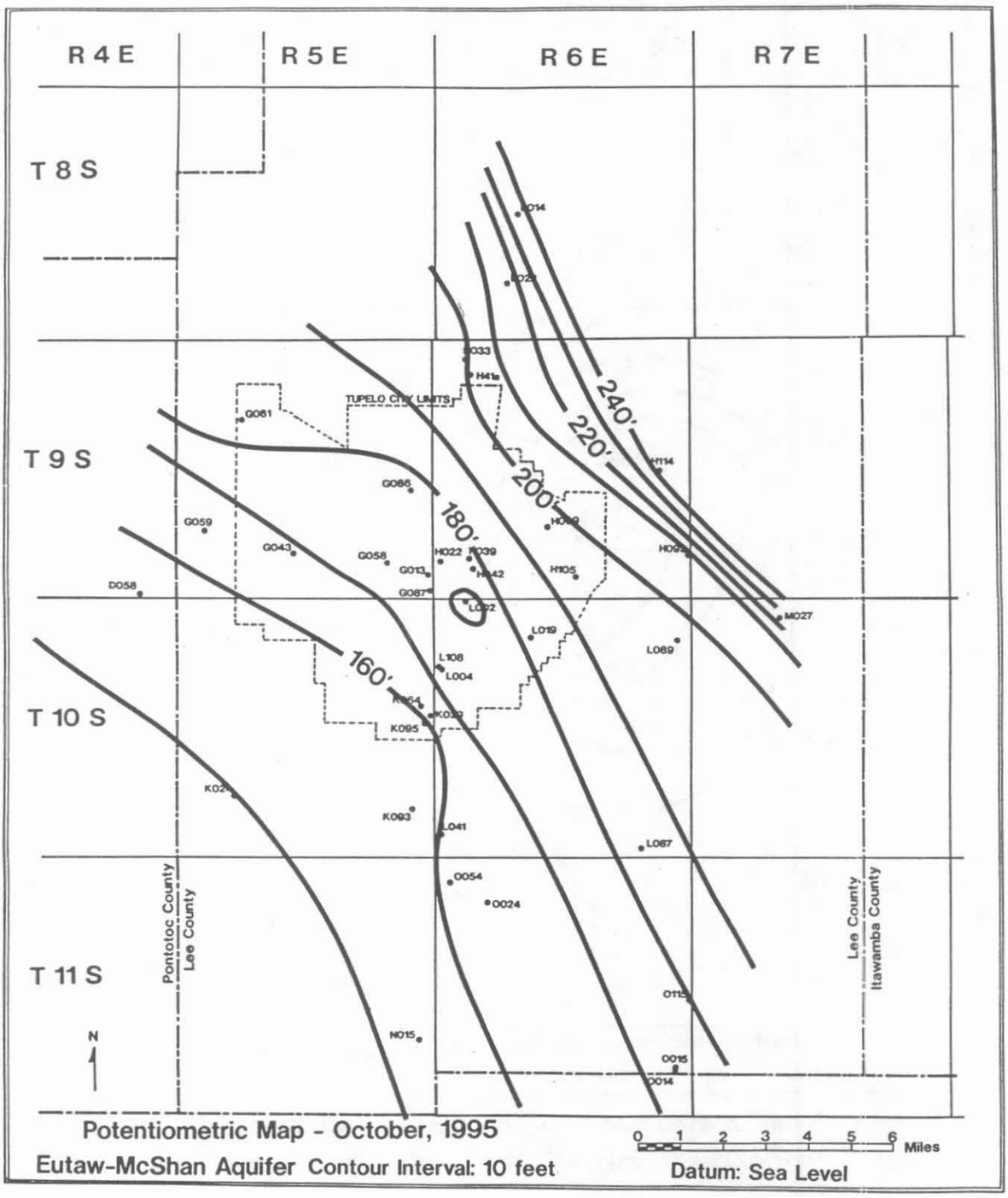

Figure 2: Potentiometric map - October, 1995, Eutaw-McShan aquifer, Tupelo/Lee County, MS. Note contour interval of 10 feet.

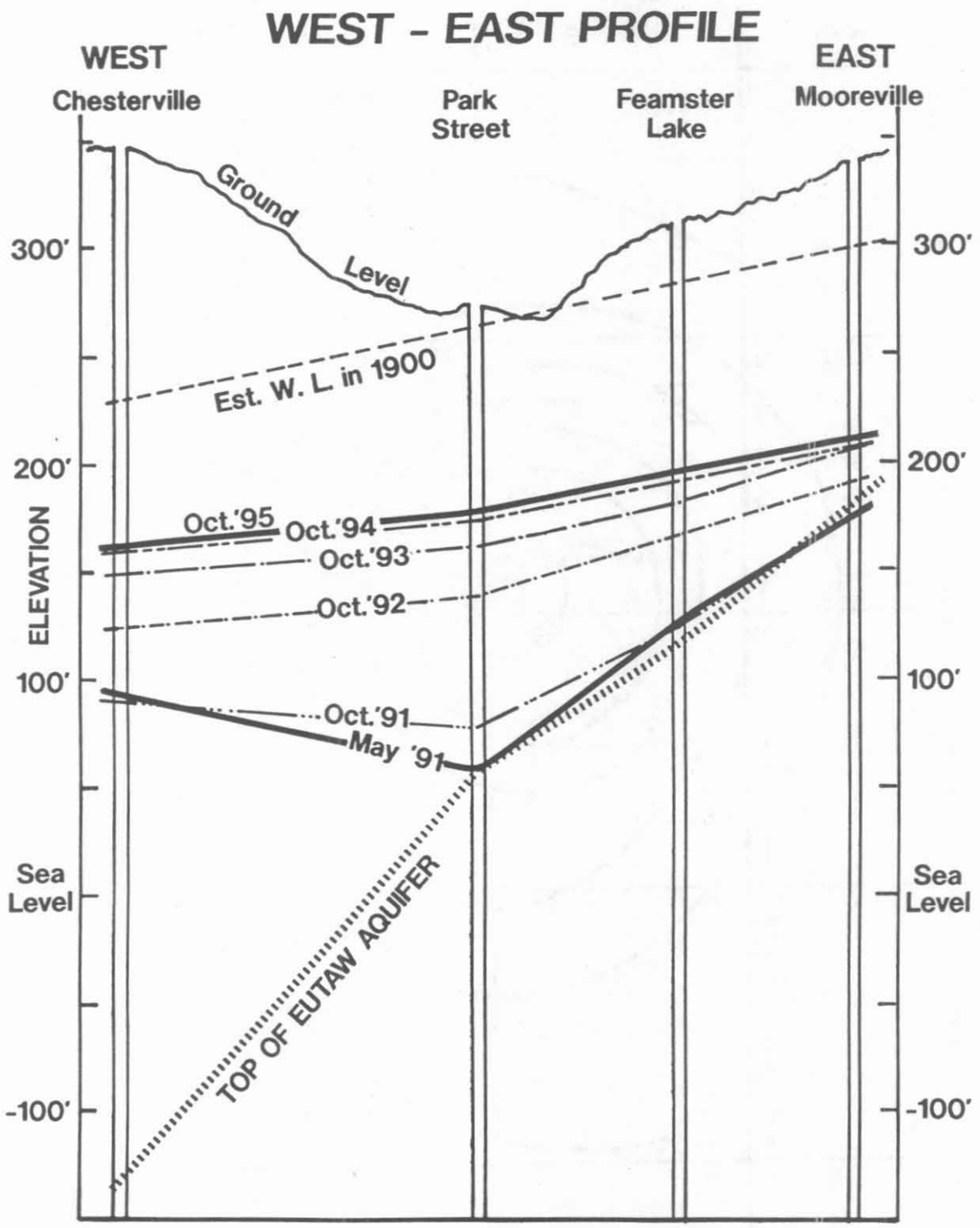

Figure 3: Profile (cross section) across the Tupelo area showing the rise in water levels. See Figure 4 for location of profile line.

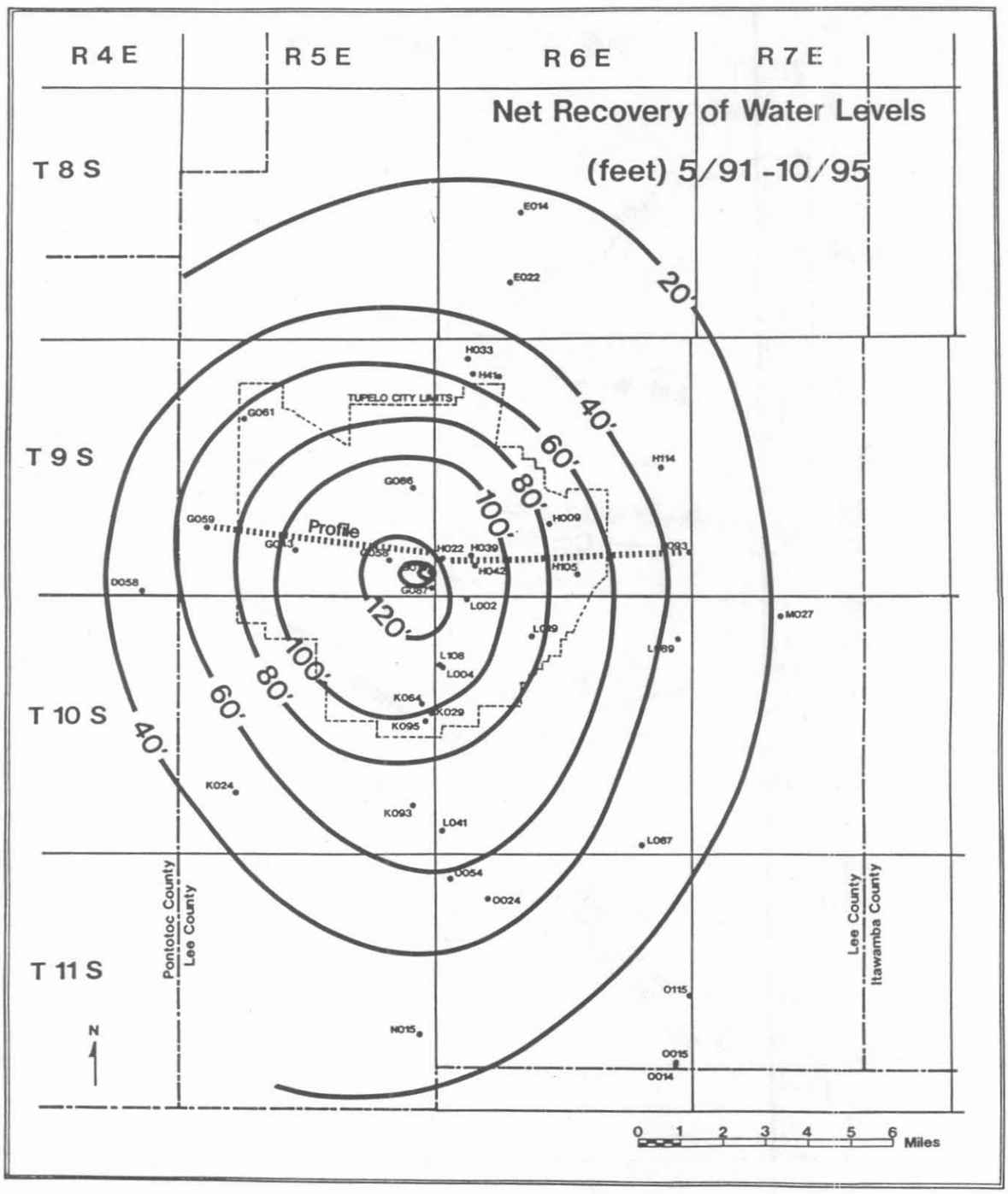

Figure 4: Net recovery of water levels, Eutaw-McShan aquifer, May, 1991 to October, 1995.

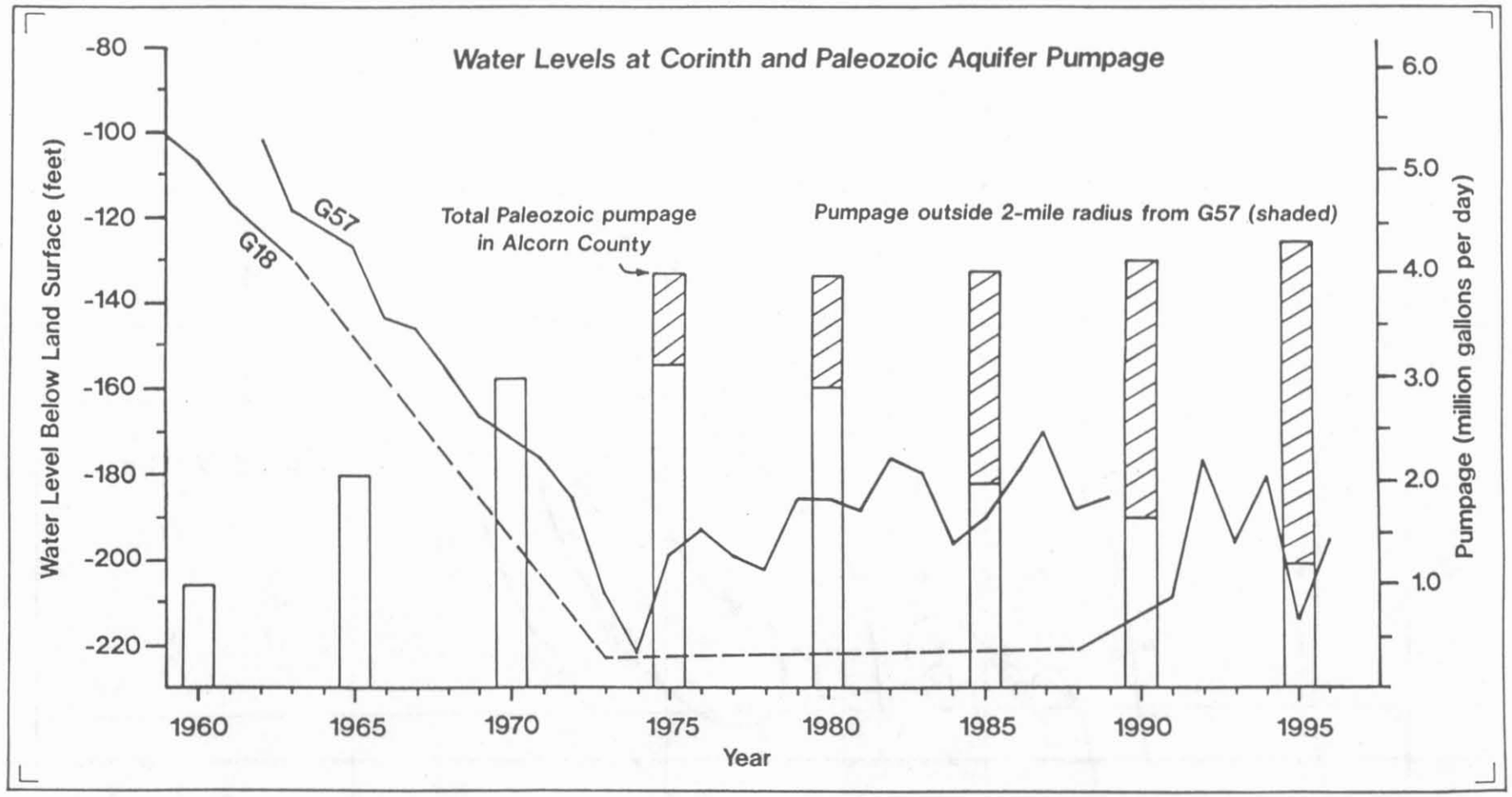

Figure 5: Hydrographs of observation well G57 and well G18 at Corinth and average total daily pumpage rates from the Paleozoic aquifer in Alcorn County, MS. Nearly all the withdrawal from the aquifer prior to 1974 was from wells within a 2-mile radius from G57. Only selected (fall) measurements shown when multiple measurements exist for a year.

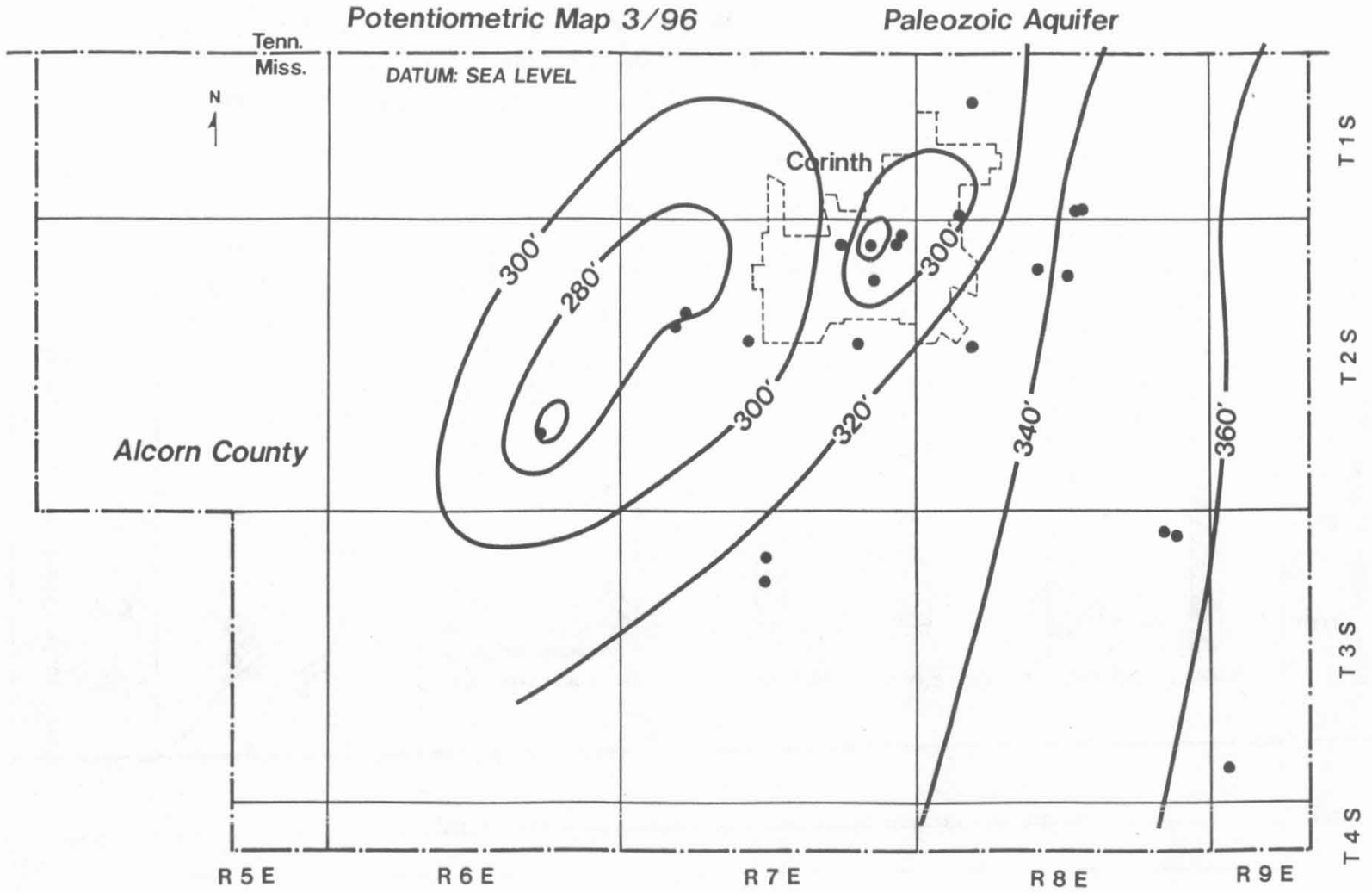

Figure 6: Potentiometric map, March, 1996, Paleozoic aquifer in Alcorn County, MS.