GROUND WATER EXTRACTION TRENDS IN FOREST AND LAMAR COUNTIES, MISSISSIPPI

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INTRODUCTION

Purpose and Scope

The primary purpose of this research is to document and describe, using computer graphics methods, the local and regional historical drawdown of piezometric surfaces in Forrest and Lamar Counties, Mississippi. The secondary purpose was to further our understanding of the geologic framework of the aquifers in this region. These studies were undertaken because of increased urbanization and industrialization in this region of south Mississippi, and the evidence that ground-water levels in this area are declining (Wasson, 1986). The studies presented here are a part of a more comprehensive investigation dealing with the development of predictive (groundwater) models for the aquifers of Forrest, Lamar, and Jones Counties.

AQUIFER CHARACTERISTICS

Stratigraphy

The Neogene aquifer system consists of a southerly dipping body of interbedded lutites (silts and clayey silts), sands, sandstones, sandy gravels, and gravelly sands which outcrop south of Jackson where they exhibit thicknesses of several hundred feet and which extend to the south where they exhibit thicknesses of several thousand feet at the Mississippi Gulf Coast. From oldest to youngest, the aquifer system consists of the Catahoula, Hattiesburg, Pascagoula, and Citronelle Formations. The youngest unit, the Citronelle Formation, may be as old as Miocene but is usually considered to be Plio-Pleistocene in age. Most of our knowledge of the stratigraphy and lithology of these units has been derived from examination of outcrops which, due to their highly weathered condition, do not provide adequate information, and from data taken from borehole geophysical logs of water wells and petroleum test wells; there are very few detailed observations made from subsurface samples (Kirby, 1985). Surface and subsurface data have shown that this sequence of sediments is further characterized by lateral and vertical facies change, typical of fluvial depositional environments, which means that lithologic units exhibit limited lateral and vertical continuity. The definition of discrete and continuous hydrogeologic units in such an inhomogeneous body is, therefore, difficult (Gerald, 1986). Facies relations within the aquifer system in northern Forrest County are shown in Figure 1.

Lithology and Hydrologic Properties

The lithologies or sediment types encountered in this aquifer system are diverse in composition and the sediments are usually not lithified. Generally, fine to medium quartz sand is the most common sediment type present and this material is that in which most of the water wells are constructed. Somewhat subordinant in distribution to these sands is lutite, a moderately graded mixture of clayey silt with minor sand. The lutite, where present, is the aquiclude or aquitard of this aquifer system. Gravels are next in abundance and, although usually found within a few hundred meters of the surface, they may occur locally at greater depths (Brown, 1944). The larger clasts in the gravels are usually composed of chert. The hydrologic properties of those sands in which wells have been constructed and pumping tests conducted are also diverse. For example, transmissibility values vary from 15,000 to 200,000 gallons per day per foot, and values of storage coefficient vary from 0.0001 to 0.0006 (Shows et al., 1966; Taylor et al., 1968; Shows, 1970; and Newcome, 1971 and 1975).

Hydrogeologic Characterization Problems

There are significant difficulties in establishing meaningful stratigraphic correlations between aquifer bodies, regionally and even between near-by wells. The inability to correlate aquifer sands results in imperfectly defined hydrogeologic units, vague notions of the limits of the aquifer boundary conditions, and poor definitions of the physical properties of the aquifers and their confining units. Correlation and boundary condition problems may be explained by the following: 1) these sediments originated in fluvial depositional environments which, in turn, are characterized by extensive facies changes and, thereby, lack lateral and vertical continuity; also, these sediments do not contain fossils or other internal signatures which could be used for correlation purposes and they have not been adequately mapped at the surface; 2) there are insufficient borehole geophysical logs of deep wells; 3) continuous cores are not available, and lithologic data, derived primarily from wash borings, do not adequately represent the materials encountered in the borehole since the clays and gravels will be underestimated; and 4) vertical control for water wells is, in many cases, poor since ground elevations are not given on drillers logs.

METHODOLOGY

Data Acquisition

The data used in this investigation consisted of published information describing pumping tests and water level (piezometric surface) measurements and unpublished information such as drillers and borehole geophysical logs. These unpublished water well data were obtained from the USGS and BLWR, and borehole geophysical logs were provided by the USGS and BG. Pumping test, drilling, and water level data provided temporal information on well location, elevation of screened interval, water level, and drawdown; and the borehole geophysical logs provided information on the nature of the sediments in which the water wells were constructed. Data from approximately 1,500 water wells were acquired of which approximately 65 had borehole geophysical logs. All water wells were plotted on USGS 7 1/2 minute topographic maps for the purpose of verifying the accuracy of location, and for determining ground elevation, and the latitude and longitude (geographic coordinates) of the well. Three north-south and two east-west lithologic cross-sections were prepared using the borehole geophysical logs for the purpose of defining and understanding the framework of the aquifer system.

Development of the Data Base

A commercially available data base software was used to store and collate the water well data. The information entered into the data base for each water well included: geographic coordinates, depths of screen, piezometric surface, transmissivity (if known), and year the piezometric surface was determined. The data stored in the data base could be sorted on the basis of year, depth, location or other parameter of interest. During this phase of the investigation, the well location data, given by geographic coordinates, was converted, by computer to Universal Transverse Mercator (UTM) grid system, and then storing the UTM coordinates in the data base. In this study, we needed to sort piezometric surface data by year or period of time in order to plot piezometric surface contour maps for the year or period of interest.

DATA ANALYSIS

Hydrogeology

The first step in the analysis was the identification of discrete aquifer bodies on the basis of the water well data and the comparison of these bodies with information derived from the lithologic cross-sections. This identification and comparison proved to be very difficult due to the great range of

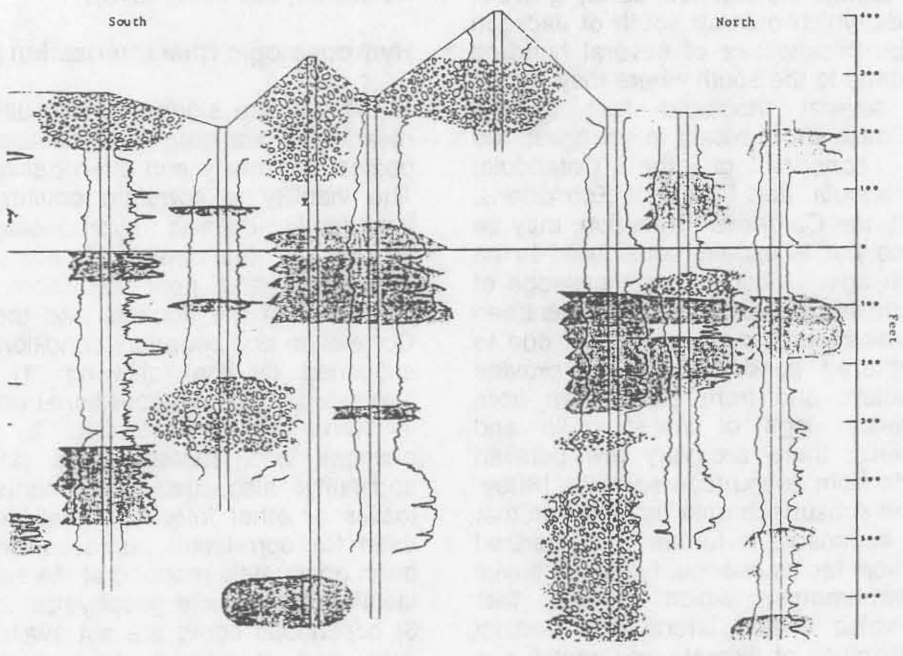

Figure 1. North-south geologic cross-section through northern Forrest County. Horizontal scale: 1 inch = 3 miles

water well depths, as well as the lithologic inhomogeneity of the sediments. There was no clear-cut distinction, which could be carried over a few miles, between aquifer and aquiclude. Even so, a histogram showing number of wells versus depth was constructed from which one could identify two relatively discrete aquifers, one deep and one shallow, separated by a thin discontinuous zone penetrated by very few wells (Figure 2). These two aquifers are considered to be subsets of the aquifer system; also, note that approximately two-thirds of the water wells are constructed in the shallow aquifer. The deep aquifer is in the Catahoula Formation, and the shallow aquifer is in the Hattiesburg and Citronelle Formations. The disproportionate distribution of wells in the two aquifers derives from the fact that most of the earlier wells are in the shallow aquifer and the more recent ones are in the deeper one. We must stress that the basis for this two-aquifer subdivision is more statistical than hydrogeologic.

The deep aquifer extended in elevation from 800 feet below mean sea level (msl) to 30 feet above msl. The shallow aquifer ranged in elevation from 75 to 375 feet above msl. The thin zone between aquifers is represented by fine-grained materials and may be considered an aquitard. The shallow aquifer is overlain locally by either coarse- or fine-grained material, and locally is interconnected with the surface. The lateral and vertical continuity of both aquifer and aquitard were variable and the data suggest that these aquifers, particularly the shallow one, are semiconfined and interconnected.

The second step in the analysis consisted of evaluating the temporal sufficiency of the water well data. The data base was sorted by year to determine the availability of piezometric surface data for years and/or periods of years. The sort revealed that, prior to the early 1960's, there was an insufficient number of water wells in this region for the development of piezometric surface maps for this period; also, the data showed that, from the early 1960's to the present, periods of years, rather than individual years, should be selected in order to maximize available data for a given period of time. The time periods selected were: 1960-1967, 1968-1969, 1970-1972, 1973-1976, 1977-1979, 1980-1981, 1982-1983, and 1984-1987.

Regional Drawdown Trends

The maximum and minimum piezometric surface elevations given in the data base for the shallow and deep aquifers, respectively, for the eight periods of time are tabulated below. The maximum piezometric surface elevations generally occur in areas of minor pumping and are, generally, beyond the radii of influence of wells, whereas the minimum elevations occur in areas of significant drawdown.

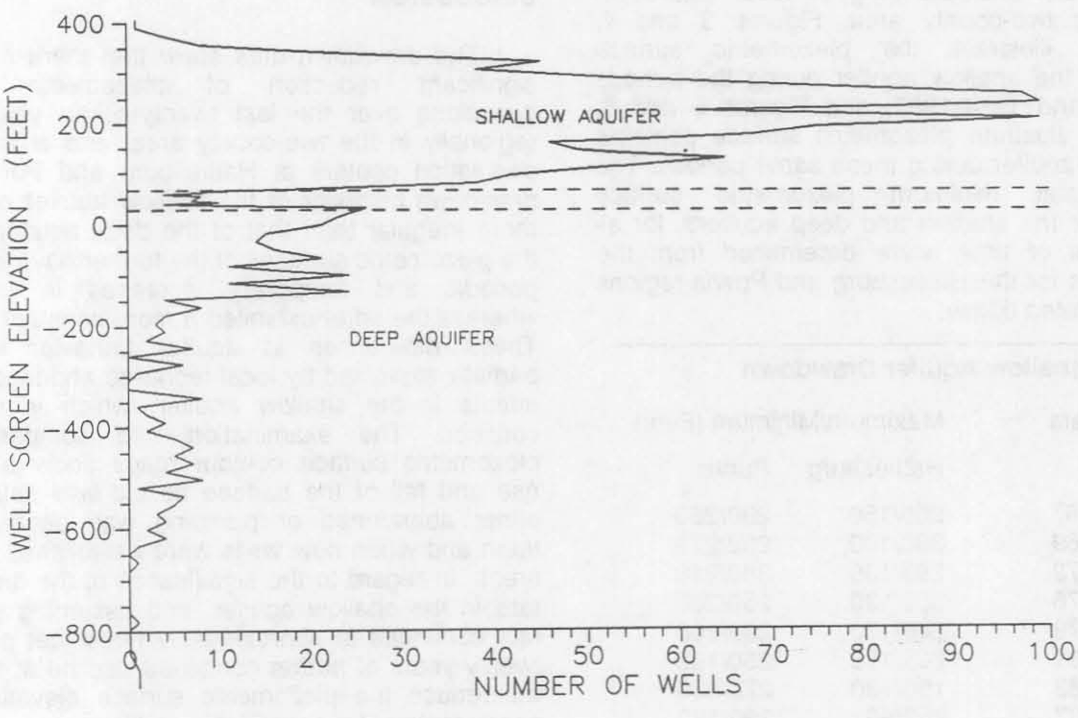

Figure 2. Histogram of water well screened interval versus number of wells showing approximate boundaries of the deep and shallow aquifers.

Piezometric Surface Elevations

Years	Shallow	Deep
	Maximum/Minimum (Feet)	
60-67	379/133	250/64
68-69	380/115	232/106
70-72	416/118	243/61
73-76	391/128	247/57
77-79	360/128	250/55
80-81	332/124	269/71
82-83	316/122	259/65
84-87	287/70	209/63

The data tabulated above show that the maximum elevations of the shallow and deep aquifers have decreased 92 and 41 feet, respectively, over the 27-year period; the data also show that the drawdown was not always negative and that there were increases in piezometric surface elevations for both aquifers during certain periods.

Local Drawdown Trends at Hattiesburg and Purvis

Computer-generated piezometric surface contour maps were compiled using commercially available and data-base compatible software for each time period given above, and for each aquifer. The comparison of temporally successive maps resulted in the understanding of local drawdown rates in this two-county area. Figures 3 and 4, respectively, illustrate the piezometric surface contours for the shallow aquifer during the periods 1960-1967, and 1984-1987; and Figures 5 and 6, respectively, illustrate piezometric surface contours for the deep aquifer during these same periods. The maximum and minimum piezometric surface elevations for the shallow and deep aquifers, for all eight periods of time, were determined from the contour maps for the Hattiesburg and Purvis regions and are tabulated below.

Shallow Aquifer Drawdown

Years	Maximum/Minimum (Feet)	
	Hattiesburg	Purvis
60-67	250/150	290/250
68-69	300/130	290/270
70-72	285/130	340/210
73-76	300/130	250/200
77-79	240/150	290/200
80-81	265/155	250/195
82-83	190/130	270/230
84-87	250/90	260/180

Deep Aquifer Drawdown

Years	Maximum/Minimum (Feet)	
	Hattiesburg	Purvis
60-67	185/160	190/150
68-69	165/80	150/135
70-72	140/80	140/115
73-76	140/90	130/95
77-79	140/90	145/110
80-81	130/80	130/110
82-83	140/90	180/145
84-87	135/75	120/75

The tabulation for the shallow aquifer shows that the maximum piezometric surface elevation at Hattiesburg has experienced both positive and negative changes, and the most recent elevation is the same as that of 1960-1967; however, the minimum elevation has decreased by 60 feet. At Purvis, the maximum and minimum elevations, respectively, have declined by 30 and 70 feet. The decline of the maximum surface elevation at Hattiesburg has been more-or-less regular and has resulted in a net loss of 50 feet since the 1960's; the minimum surface elevation has declined 85 feet during the same period. At Purvis, the maximum and minimum drawdowns, respectively, are 70 and 75 feet.

DISCUSSION

The drawdown data show that there has been significant reduction of piezometric surface elevations over the last twenty-seven years, both regionally in the two-county area, and at the major population centers at Hattiesburg and Purvis. The drawdown behavior of the shallow aquifer has been more irregular than that of the deep aquifer, in that the piezometric surfaces of the former have exhibited periodic and temporary increases in elevation, whereas the latter exhibited a more constant decline. These differences in aquifer behavior may be partially explained by local recharge and topographic effects in the shallow aquifer, which is not fully confined. The examination and comparison of piezometric surface contour maps show a distinct rise and fall of the surface as old well fields were either abandoned or pumping was decreased in them and when new wells were established in other areas. In regard to the significance of the drawdown rate in the shallow aquifer, and assuming that this rate continues at approximately three feet per year, twenty years of further continued decline at this rate will reduce the piezometric surface elevation very nearly to that of the top of this aquifer.

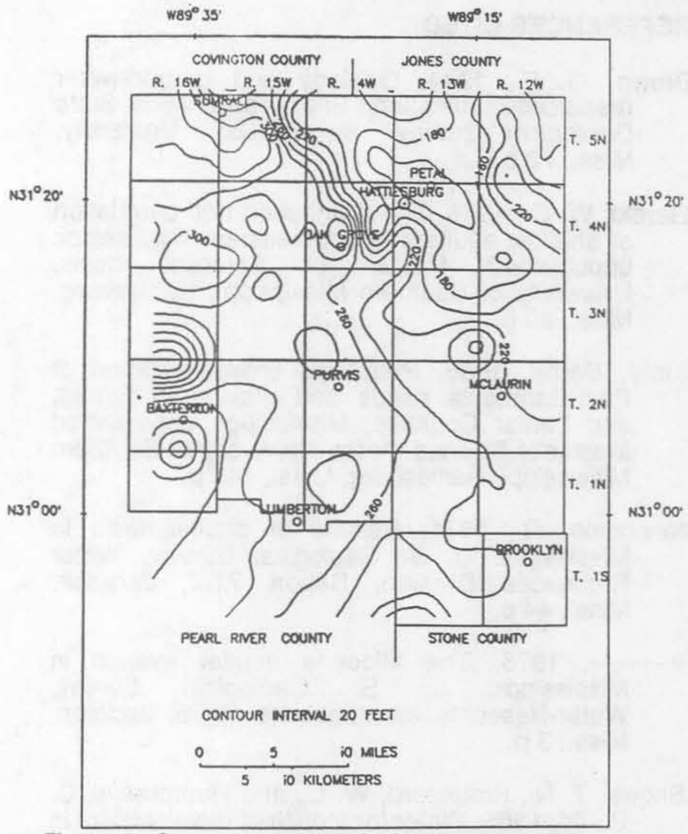

Figure 3. Computer-generated piezometric surface contour map for the shallow aquifer during the period 1960-1967.

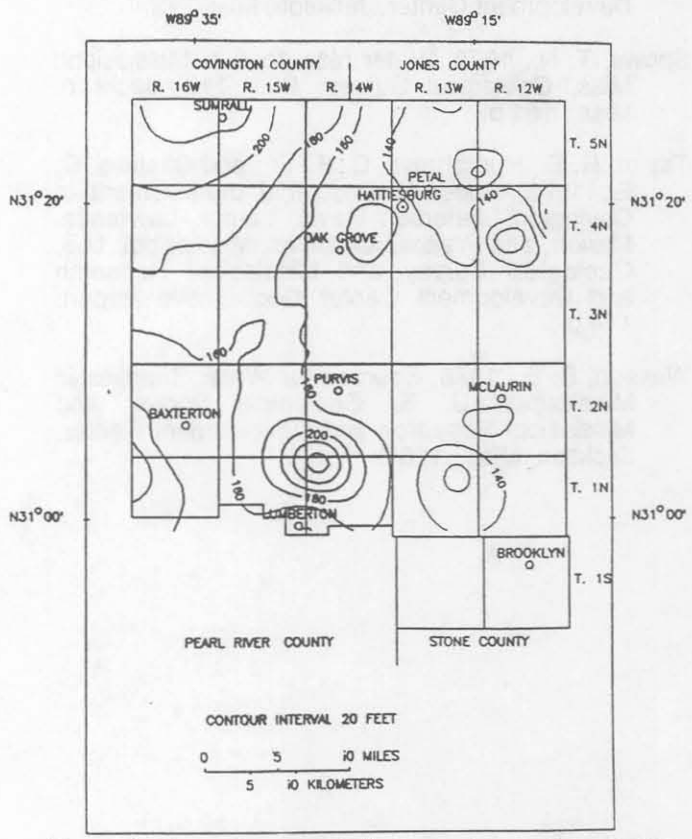

Figure 4. Computer-generated piezometric surface contour map for the shallow aquifer during the period 1984-1987.

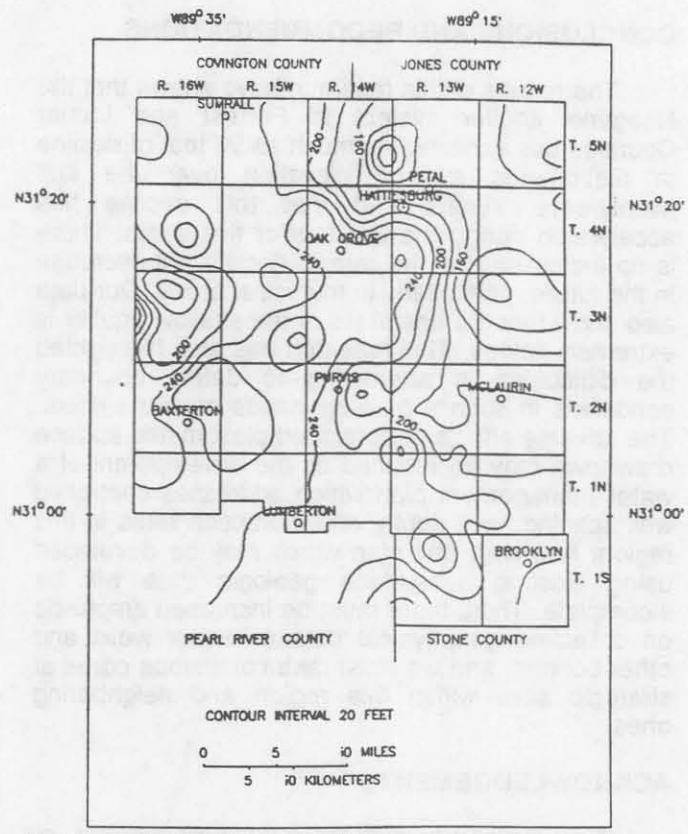

Figure 5. Computer-generated piezometric surface contour map for the deep aquifer during the period 1960-1967.

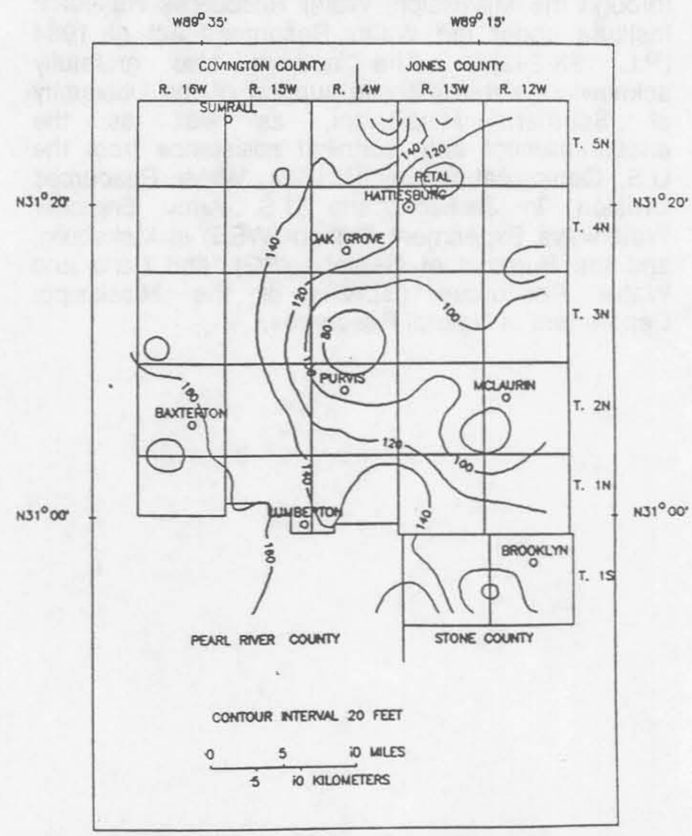

Figure 6. Computer-generated piezometric surface contour map for the deep aquifer during the period 1984-1987.

CONCLUSIONS AND RECOMMENDATIONS

The results of this research have shown that the Neogene aquifer system in Forrest and Lamar Counties has exhibited as much as 90 feet of decline in piezometric surface elevation over the last twenty-seven years and that this decline has accelerated during the last four or five years. There is no indication that the rate of decline will decrease in the future, particularly in municipal areas. Our data also show that the useful life of the shallow aquifer is extremely limited. This research has also highlighted the difficulties in attempting to define boundary conditions in such a heterogeneous aquifer system. The adverse effects of continued piezometric surface drawdown may be reduced by the development of a water management plan which addresses controlled well spacing, well depth, and extraction rates in this region; however, any plan which may be developed using existing subsurface geologic data will be incomplete. Thus, there must be increased emphasis on collecting geophysical data on water wells and other borings, and we must take continuous cores at strategic sites within this region and neighboring ones.

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