A PROGRESS REPORT ON DETERMINING THE EFFECTS OF PUMPING FROM THE CAMBRIAN-ORDOVICIAN AQUIFER IN THE AUDRAIN COUNTY AREA

by

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A PROGRESS REPORT ON DETERMINING THE EFFECTS OF PUMPING FROM THE CAMBRIAN-ORDOVICIAN AQUIFER IN THE AUDRAIN COUNTY AREA, MISSOURI

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INTRODUCTION

The Missouri Department of Natural Resources, Division of Geology and Land Survey in cooperation with the U.S. Geological Survey has begun a study to determine the quantity and quality of water available for irrigation in the Audrain County area. It is also the purpose of this study to determine the effects that an increased withdrawal of ground water from the Cambrian-Ordovician aquifer will have on the water level in the aquifer and to evaluate the potential for saltwater encroachment that may ensue from lowering of water levels.

The possibility of increased withdrawal of ground water from the Cambrian-Ordovician aquifer in the Audrain County area has caused concern that such withdrawal may adversely affect water levels of wells in the area, and the quality of water from the aquifer. For example, the use of water from the Cambrian-Ordovician aquifer by towns in Audrain County has increased from about 0.9 in 1962 to a little over 1.8 million gallons per day (mgd) in 1977 (Census of Public Water Supplies in Missouri, 1962[1], 1977[2]). The major portions of this water (93-95 percent) is withdrawn by the City of Mexico. In addition to this withdrawal for public supply, there are several self-supplied industrial and commercial users of water from the Cambrian-Ordovician. A more recent development (since about 1975) has been the installation of irrigation wells that tap this aquifer in areas where surface impoundments either were not feasible or where ground water provided a more dependable supply.

The Missouri Department of Natural Resources, Division of Geology and Land Survey has a continuous water level recorder in an unused well at Vandalia. The depth to water in this well in January 1971 was 178.1 feet, indicating the low water level for that period. By June 1976 the low water level was 181.5. At this time, an increase in ground water usage in the area was shown by marked decrease in water levels, declining to a low of 189.3 in July 1978.

At the present (1979) there are 24 irrigation wells in the Audrain County area that tap the Cambrian-Ordovician aquifer. In this area, in order to supply the amount of water needed for an irrigation system, it is necessary to drill wells to a depth of 1,200-1,400 feet. Most of these wells have yields of 800-1,000 gallons per minute. There is some concern that heavy pumping of water from the Cambrian-Ordovician aquifer will lower water levels making it necessary to lower the pump and in extreme cases drill the well deeper.

The water in this aquifer is saline (total dissolved-solids concentration exceeds 1,000 milligrams per liter (mg/l)) north of Audrain County. If water levels in the Cambrian-Ordovician aquifer are significantly lowered, it is possible that poorer quality water may move into the Audrain County area.

In the area covered by this report, the major water-bearing horizon below the Potosi Dolomite is the Lamotte Sandstone. The State Penitentiary Well #3A at the State Prison in Jefferson City was drilled

into the Lamotte to a depth of 1,570 feet. Approximately 100 feet of Lamotte was penetrated.

Water samples were taken as drilling progressed with the first sample being taken and analyzed at a depth of 600 feet in the Eminence Dolomite. The water at this depth had a total dissolved-solids concentration of 340 mg/l and the chlorides were 8.1 mg/l. The analysis in the Pototsi Dolomite at a depth of 812 feet had a total dissolved-solids concentration of 331 mg/l and the chlorides were 13.1 mg/l. A sample taken from the Lamotte Sandstone at a depth of 1,540 feet has an increase of total dissolved solids to 620 mg/l with the chlorides increasing to 89.6 mg/l. At the depth of 1,570 feet the total dissolved solids were 552 mg/l and the chlorides were 98.6 mg/l.

With the water in the Lamotte Sandstone (approximately 500 feet below the Potosi) being more mineralized than in the Potosi, there is the distinct possibility that heavy and continued pumping could induce encroachment both horizontally and vertically. This is known to have happened in the city wells at St. Peters in St. Charles County, and at Warrensburg in Johnson County. The wells at St. Peters increased in mineralization by encroachment of mineralized water due to heavy pumping. The wells were finally abandoned and wells were then constructed in the Mississippi River alluvium east of town.

HYDROGEOLOGIC SETTING

The study area consists of Audrain County and parts of adjacent counties and is located in the southern part of the glaciated area of northern Missouri. The local topographic relief is not great, being less than 100 ft. in the vicinity of Mexico, Missouri.

Over 70 percent of the area drains north into tributaries of the Salt River. About 20 percent of the eastern part of the area is drained by tributaries of the Cuivre River. The Salt River and Cuivre River drainage systems are tributary to the Mississippi River, which is about 36 miles east of the area. The extreme southern part of the area drains to the south into the Missouri River.

The regional dip (slope) of the Cambrian-Ordovician aquifer in this area is shown by a structure contour map using the top of the Roubidoux Formation as the datum (fig. 1). Regional dip is only a few degrees in a northerly direction. Steeply dipping beds are restricted to the immediate vicinity of faults.

Description of the Aquifers and Confining Beds

Most of the area is covered by glacial drift consisting of pebbly clay with minor amounts of sand and gravel. Along some streams this glacial material has been removed and the underlying rocks of Pennsylvanian age are exposed. In a few areas erosion has exposed the older rocks of Mississippian age.

The maximum total thickness of consolidated sedimentary rocks underlying the glacial drift in Audrain County is about 2,600 feet. A generalized geohydrologic section for the area is given in table 1.

Water level measurements in wells indicate that there are two aquifers of regional extent. The geologic formations from the St. Peter Sandstone down to and including the Potosi Dolomite constitute the Cambrian-Ordovician aquifer of this report. The other aquifer in this area is made up of limestones of Mississippian age, primarily the Burlington-Keokuk Limestone.

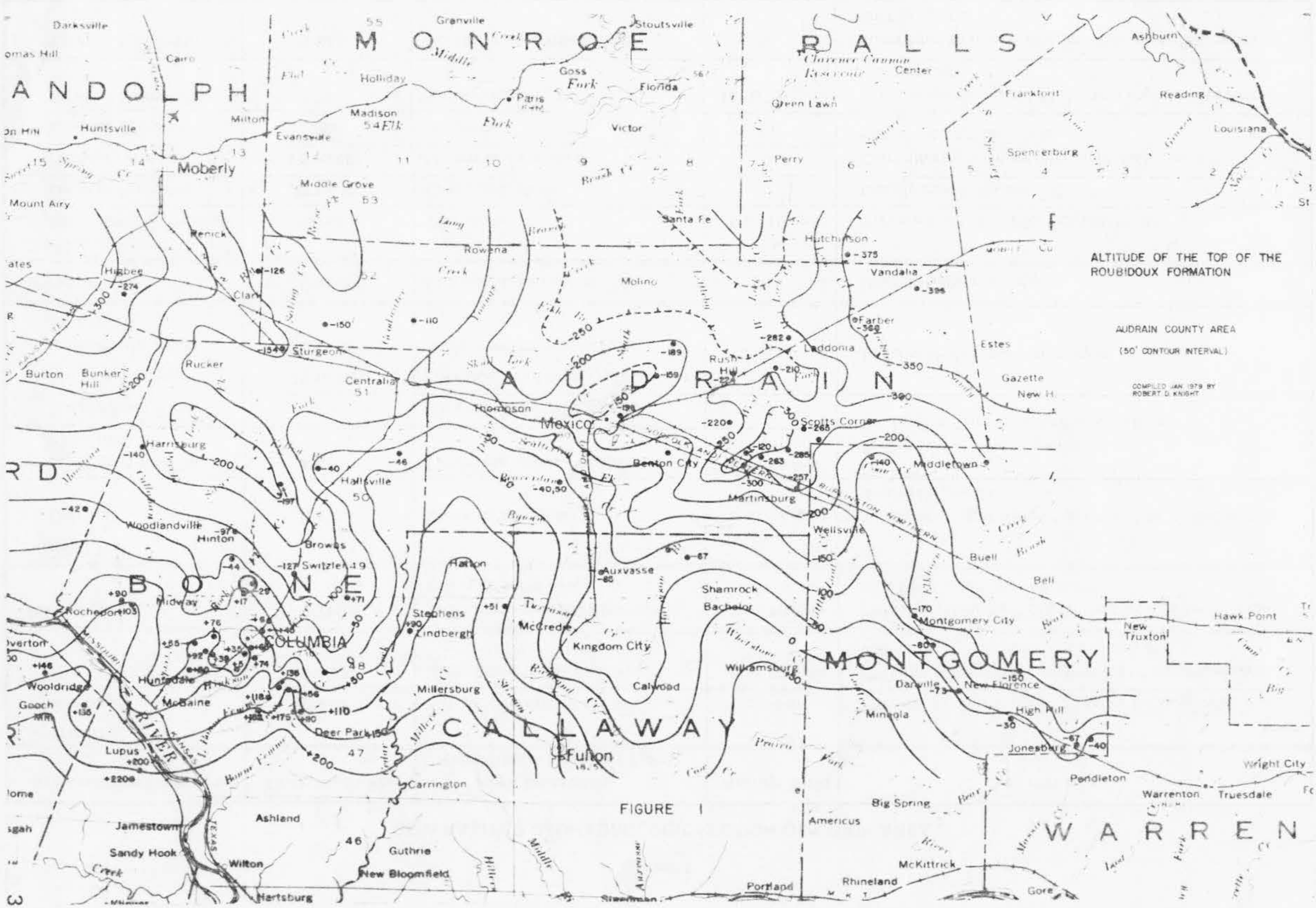

Figure 1. *Altitude of the top of the Roubidoux Formation.*

Table 1

GENERALIZED GEOHYDROLOGIC SECTION OF STUDY AREA

System Series Formation	Thickness in Feet	Rock Description (Predominate Lithology First)	Average Yield	Remarks
Quaternary				
Residuum	0-25±	Silt, sand, gravel, and clay	0 to seep	Provides small quantities of water for dug wells.
Glacial Drift	0-100±	Sand, gravel, clay, and silt	0 to 10 gpm	Well yields dependent on amount of contained sand and gravel; usually cased out in this area.
Pennsylvanian	0-175±	Shale, sandstone, limestone, silt, clay, and some coal	0 to 10 gpm	Production usually from sandstone; may be mineralized (high sulphate, high iron).
Mississippian				
Detrital	0-40±	Chert (broken), clay	0 to 5± gpm	Yields small quantities of poor quality, turbid water; should be cased out.
Burlington-Koekuk Limestone	150±	Limestone, chert, dolomite	5 to 15 gpm	Production affected by draught. Low yields — unimportant as an aquifer.
Sedalia Formation	20±	Silty limestone and dolomite,	0	
Chouteau Group	25 to 75±	Limestone, dolomites, some chert	0	Locally, shale is confining layer.
lower Mississippian formations	20 to 50±	Shale, sandstone, limestone	0	
Devonian	20 to 75±	Limestone, sandstone	0	Unimportant as aquifer.
Ordovician (Middle)				
Kimmswick Formation	0-75±	Limestone	5 to 10 gpm	Yields are sufficient for household use.
Decorah Formation	20 to 30±	Limestone, shaly	0	Locally confining layer.
Plattin Formation	25 to 40±	Dolomite, limestone	0	Confining layer; most high yield wells cased in Plattin Formation.
Joachim Dolomite	25±	Dolomite	0	
St. Peter Sandstone	0-75±	Sandstone	10 to 25 gpm	Good water production for home use; small industry and farm use.
Everton Formation	0-40±	Dolomite, sandstone, shale	0	Sometimes shale will cave in wells necessitating use of liner or casing.

Table 1 *cont.* . . . . .

System Series Formation	Thickness in Feet	Rock Description (Predominate Lithology First)	Average Yield	Remarks
Ordovician (Lower)				
Powell Dolomite	0-75±	Dolomite, chert, shale	0 to 10 gpm	Generally unimportant as an aquifer; may be used locally.
Cotter Dolomite	250±	Dolomite, sand, chert	0 to 10 gpm	
Jefferson City Dolomite	150±	Dolomite, chert, sandstone	0 to 25 gpm+	This unit can be a good producer locally, if sufficient porosity and permeability are present.
Roubidoux Formation	100 to 125±	Chert, sand, dolomite	50 to 200 gpm+	Good producer for small towns and industry.
Gasconade Dolomite	200 to 300±	Dolomite, chert, sandstone	300 to 500 gpm+	Excellent producers for towns, cities, industry, irrigation.
Cambrian				
Eminence Dolomite	75 to 125±	Dolomite	400 to 700 gpm+	Excellent producer. Could be mineralized in north and west part of area.
Potosi Dolomite	50 to 75±	Dolomite	700 to 1100 gpm	Excellent producer.
Pre-Potosi formations	1000±	Dolomite, silt, shale, sandstone	0	Non producing. High yield wells drilled into this interval to completely penetrate the Potosi but no wells completely penetrate this interval. May be locally mineralized.
Precambrian		Igneous and metamorphic		Unimportant as a source of water.

Water-level measurements in wells that tap the two different aquifers show the head in the Mississippian aquifer to be as much as 150 ft. higher than the head in the Cambrian-Ordovician aquifer. Consequently, the Cambrian-Ordovician aquifer probably receives some recharge from the Mississippian aquifer. Water levels in wells that tap formations below rocks of Mississippian age but above the St. Peter Sandstone display water levels intermediate between the two aquifers. Local aquifers of limited areal extent and small yield probably are present in sandy portions of the glacial drift and also in the rocks of Pennsylvanian age.

There are no producing wells in the Audrain County area that penetrate formations below the Potosi Dolomite. Consequently, the hydrogeologic characteristics of formations below the Potosi Dolomite are unknown. If the geologic formations underlying the Potosi Dolomite contain saline water, and if the head is greater in the pre-Potosi formations than in the overlying Cambrian-Ordovician aquifer, the pre-Potosi formations could become a source of saltwater contamination.

Recharge, Discharge, and Movement of Ground Water

Recharge to the Cambrian-Ordovician aquifer from precipitation is impeded by the glacial drift (predominantly a pebbly clay), and the underlying Pennsylvanian formations (predominantly shale).

Direction of movement of water in the Cambrian-Ordovician aquifer in the Audrain County area is shown in figure 2. The major feature shown by the potentiometric map (fig. 2) is the cone of depression (inverted cone) formed by pumping from the City of Mexico water wells.

There was very little irrigation during the 1978 growing season. Consequently, figure 2 does not show any significant lowering of water levels that can be attributed to irrigation pumpage. Discharge from the Cambrian-Ordovician aquifer is from wells and from outflow probably along the eastern and southern margins of the area.

Quality of Ground Water

The total dissolved-solids and sodium concentrations in water from the Cambrian-Ordovician aquifer in Audrain and adjacent counties are shown in figures 3 and 4, respectively. Figures 3 and 4 show that the total dissolved-solids and sodium concentrations in the water increase toward the north.

A possible indication of upward leakage of poor quality water from geologic formations underlying the Cambrian-Ordovician aquifer is suggested by the slightly higher values for total dissolved-solids and sodium concentrations (figs. 3 and 4) in the vicinity of Columbia, Fulton, and Montgomery City where large amounts of ground water are pumped. There is, however, no indication of this occurring in the immediate vicinity of Mexico.

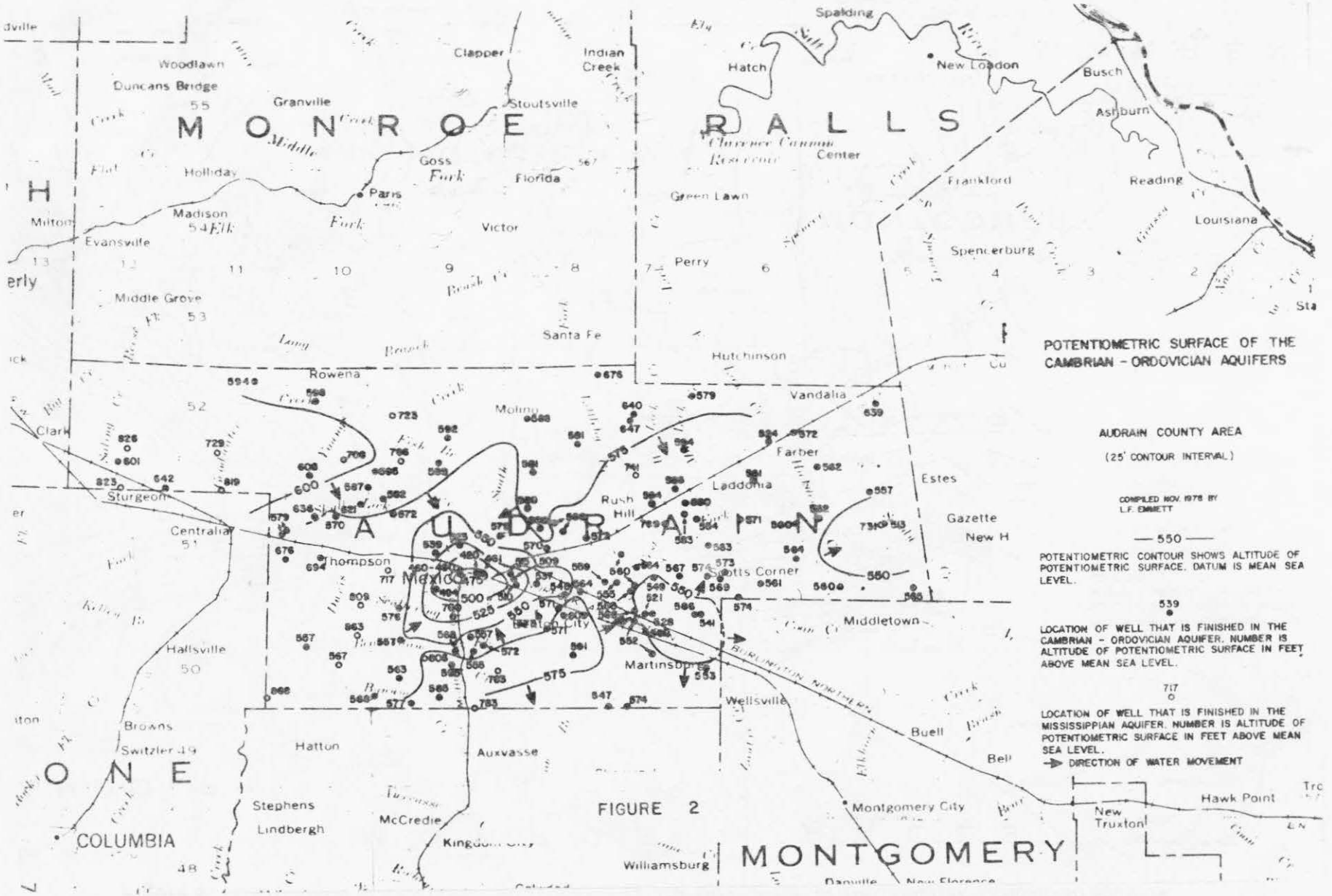

FIGURE 2

Figure 2. *Potentiometric surface of the Cambrian-Ordovician aquifers.*

Figure 3. *Distribution of total dissolved solids concentration in water in the Cambrian-Ordovician aquifers.*

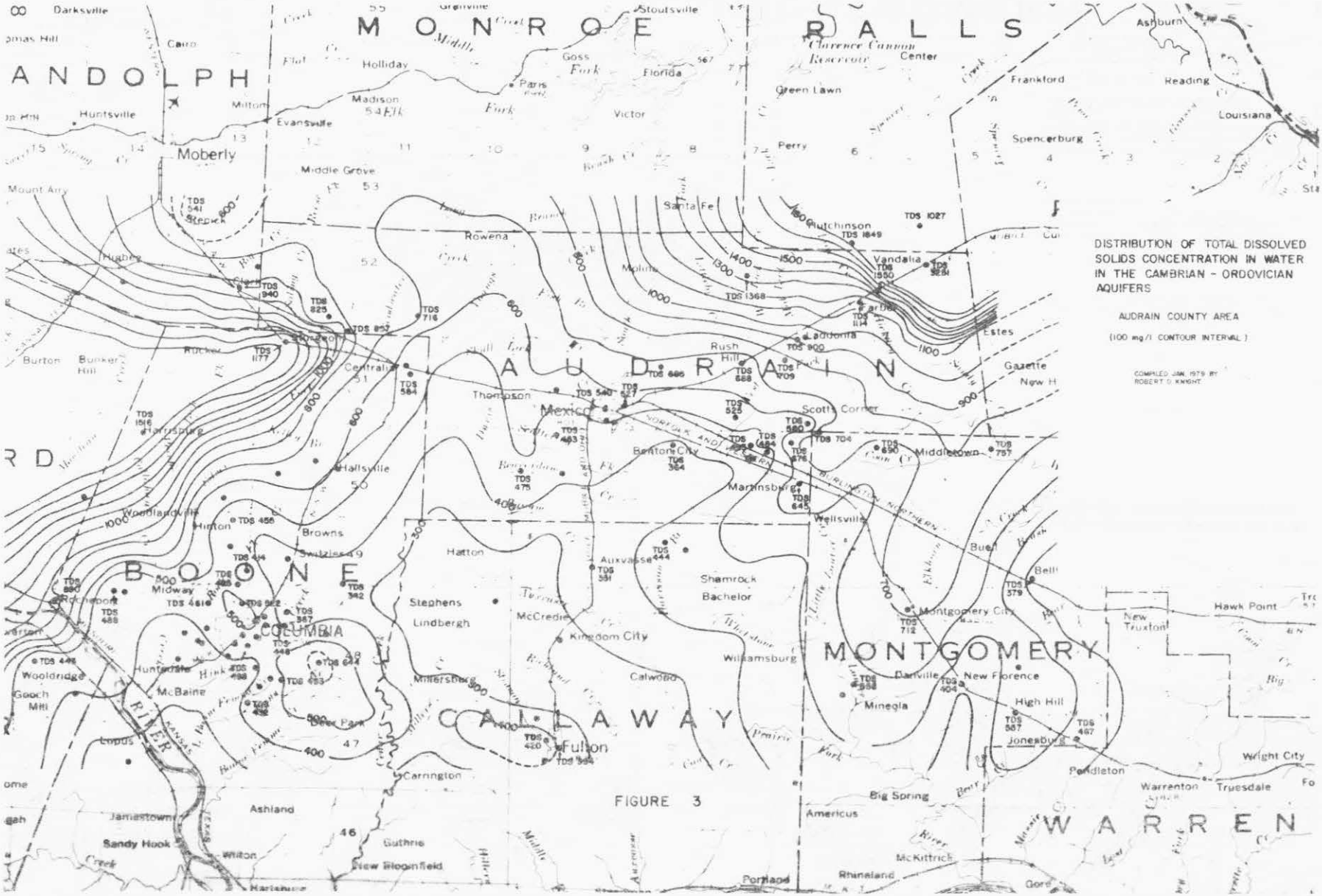

Figure 4. *Distribution of sodium concentration in water in the Cambrian-Ordovician aquifers.*

CONCLUSIONS AND PLANS FOR FURTHER STUDY

A review of chemical analyses of water from municipal wells in the Audrain County area from 1934 to the present does not show a change in chemical quality of the water with time. However, because of the potential increase in groundwater withdrawal from the Cambrian-Ordovician aquifer, and the subsequent potential for saltwater encroachment, it is desirable to continue periodic sampling of water quality from irrigation wells, public-supply wells, and selected domestic wells.

As shown in figure 2, pumping from the Cambrian-Ordovician aquifer has caused a cone of depression to form in the potentiometric surfce. Additional pumping from the aquifer, either from existing or new wells, will result in lowering of the potentiometric surface. The amount of lowering and consequent configuration of the potentiometric surface will be dependent on the aquifer characteristics, the amount of water pumped, and the location and spacing of the pumped wells.

Computer simulation techniques will be used to help understand how the groundwater system operates, and to guide the collection of additional data.

Data needed include:

1. An inventory of all large-capacity wells and the amount of water pumped.
2. Water-level measurements in wells; data to be used to construct maps showing the configuration of the groundwater surface before and after summer pumpage. These maps will show the effects pumping has on the water level in the Cambrian-Ordovician aquifer.
3. Determination of aquifer characteristics. These values must be determined from aquifer tests, or from the potentiometric maps, and a knowledge of the amount of water pumped.
4. Map showing elevation of the top of the Cambrian-Ordovician aquifer.
5. Map showing distribution and thickness of the Pennsylvanian and glacial drift confining the Cambrian-Ordovician aquifer.

The completion and results of this study are planned for September 1980. The Missouri Department of Natural Resources, Division of Geology and Land Survey will publish this as a Water Resources Report and this will be available from their office at Rolla, Missouri.

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