UNITED STATES

DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

REGIONAL GEOHYDROLOGY OF THE NORTHERN LOUISIANA SALT-DOME BASIN, PART IV, HYDRAULIC CHARACTERISTICS OF THE WILCOX-CARRIZO AQUIFER

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FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM (SI)

OF UNITS

Multiply	By	To obtain
foot (ft)	0.3048	meter (m)
foot per day (ft/d)	0.3048	meter per day (m/d)
foot squared per day (ft^2/d)	0.09290	meter squared per day (m^2/d)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
	$3.785X10^{-3}$	cubic meter per minute (m^3/min)
inch (in.)	25.40	millimeter (mm)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)

To convert temperature in degree Celsius (°C) to degree Fahrenheit (°F), multiply by 9/5 and add 32.

To convert permeability in millidarcies to hydraulic conductivity in feet per day for water at 60°F, multiply by 0.00244.

REGIONAL GEOHYDROLOGY OF THE NORTHERN LOUISIANA SALT-DOME BASIN, PART IV, HYDRAULIC CHARACTERISTICS OF THE WILCOX-CARRIZO AQUIFER

By Gary N. Ryals

ABSTRACT

This report, which describes the hydraulic characteristics of the Wilcox-Carrizo aquifer, is the fourth in a series of reports describing the regional geohydrology of the northern Louisiana salt-dome basin.

The Wilcox Group of Paleocene and Eocene age and the Carrizo Sand of Eocene age comprise the Wilcox-Carrizo aquifer. Results of 25 aquifer tests and permeability determinations from 43 sidewall cores show that the hydraulic characteristics of the aquifer are variable. Values of hydraulic conductivity determined from aquifer tests of the Wilcox ranged from less than 1 to 35 feet per day. One aquifer test of the Carrizo showed a hydraulic conductivity of about 8 feet per day. Studies of the Carrizo showed that hydraulic conductivity increased as sand-bed thickness increased. Hydraulic conductivity averaged 29 feet per day for sand beds 25 to 100 feet in thickness and 40 feet per day for sand beds 100 to 200 feet in thickness. Based on the aquifer tests and sidewall core analyses, hydraulic conductivity does not increase with increased thickness for the Wilcox part of the aquifer. Permeabilities determined from sidewall cores ranged from less than 1 to more than 3,000 millidarcies (less than 0.002 to more than 7.3 feet per day). Additional data are needed to adequately define the regional variability of the hydraulic characteristics of the Wilcox-Carrizo aquifer.

INTRODUCTION

The Department of Energy (DOE) in 1976 began an expanded waste-management program for both defense and commercially produced radioactive waste. The National Waste Terminal Storage (NWTS) program is an effort by DOE to locate and develop sites in various parts of the country for disposal or storage of commercially produced radionuclides in deeply buried geologic formations. As part of the program, the Vacherie salt dome in the northern Louisiana salt-dome basin (fig. 1) is being studied to determine the dome's suitability as a repository. In Louisiana, a major part of the U.S. Geological Survey's participation in the NWTS Program, in cooperation with DOE, has been to describe the regional geo-hydrology of the northern Louisiana salt-dome basin. A series of reports

Figure 1.--Location of northern Louisiana salt-dome basin.

has been prepared by the Geological Survey; each report focuses on a specific aspect of the regional geohydrology. Previous reports presented, (1) a conceptual ground-water flow model (Ryals, 1982), (2) geohydrologic maps of the basin (Ryals, 1983a), and (3) potentiometric data (Ryals, 1983b). This is the fourth report in the series and presents the hydraulic characteristics of the Wilcox-Carrizo aquifer. The hydraulic characteristics of other geohydrologic units in the salt-dome basin are described in reports by Hosman (1978), Payne (1968, 1970, 1972, and 1975), and Ryals (1982).

The northern Louisiana salt-dome basin has an area of about 3,000 mi^2 and includes all or parts of 11 parishes in north-central and northwestern Louisiana. The area of interest for this report (fig. 1) is considerably larger than the northern Louisiana salt-dome basin, as most of the aquifers have regional extent, and ground-water flow within the basin follows regional patterns.

BRIEF DESCRIPTION OF THE WILCOX-CARRIZO AQUIFER

The Wilcox-Carrizo aquifer is comprised of the Wilcox Group of Paleocene and Eocene age and the Carrizo Sand of Eocene age (table 1). The Wilcox Group consists of interbedded fine-grained sand, clay, and silt and contains varying amounts of lignite. The Carrizo Sand consists of fine to medium sand. The Carrizo Sand was deposited over an eroded and irregular surface of the Wilcox. Because of nondeposition or erosion over some highs, the Carrizo Sand is discontinuous. The Wilcox is hydraulically interconnected with the overlying Carrizo; therefore, the Wilcox and Carrizo are considered to be a single hydrologic unit. The Wilcox-Carrizo deposits generally dip and thicken to the southeast. The combined thickness of the two units ranges from about 500 to 3,000 feet in the salt-dome basin. The Wilcox Group is the most important part of the aquifer, as the Carrizo Sand ranges in thickness from 0 to a maximum of about 150 feet in the basin. Sand content of the combined sequence varies but generally is less than 60 percent.

The Wilcox-Carrizo aquifer crops out in northwestern Louisiana. In the subsurface the aquifer is confined by the underlying Midway Group and the overlying Cane River Formation (table 1). In general, water moves from recharge areas in the outcrop downdip to discharge areas in the subsurface. However, in part of the outcrop area water discharges from the aquifer into alluvial deposits in the Red River Valley. For regional hydrologic studies of the Wilcox-Carrizo aquifer, the principal area of interest lies between the Red River and discharge areas in the subsurface to the east and southeast.

Table 1.--Generalized post-Cretaceous stratigraphic column for the northern Louisiana salt-dome basin and vicinity

System	Series	Group	Formation	Hydrologic unit
Quaternary	Holocene and Pleistocene		Terrace and alluvial deposits	Terrace and alluvial aquifers
Tertiary	Eocene	Claiborne	Cockfield Formation	Cockfield aquifer
			Cook Mountain Formation	Confining layer
			Sparta Sand	Sparta aquifer
			Cane River Formation	Confining layer
			Carrizo Sand	Wilcox-Carrizo aquifer
		Wilcox	Undivided	
	Paleocene	Midway	Undivided	Confining layer[1/]

[1/]Confining layer below Wilcox-Carrizo aquifer also includes units of Cretaceous age.

HYDRAULIC CHARACTERISTICS OF THE WILCOX-CARRIZO AQUIFER

Available Data

Aquifer tests of the Wilcox-Carrizo aquifer are mostly in northwestern Louisiana and in the western part of the salt-dome basin, where the aquifer contains freshwater. Most of the aquifer tests have been made in conjunction with the development of public-supply systems in northwestern Louisiana. The location and results of eighteen aquifer tests, using production wells and test wells associated with public-supply systems in the principal area of interest, are shown on plate 1. The modified Theis nonequilibrium and Theis recovery methods (Lohman, 1979) were used to analyze the tests. The aquifer-test data are in the files of the U.S. Geological Survey, Alexandria, La. Gaydos and others (1973), Newcome and others (1963), Newcome and Page (1962), Page and May (1964), Page and others (1963), and Page and Pree' (1964) describe the local hydraulic characteristics of the aquifer in northwestern Louisiana.

Between October 1979 and September 1980 a total of 16 test wells were completed at five sites in Louisiana (pl. 1) as part of the NWTS Program. Seven of the wells were screened in the Wilcox-Carrizo aquifer. Percussion sidewall cores were obtained from the Wilcox-Carrizo interval at each of the five test-drilling sites. Plate 2 shows the electric logs of the Wilcox-Carrizo aquifer at each site, screen intervals of the seven test wells, values of hydraulic conductivity determined from aquifer tests, and permeability values determined from 43 sidewall cores. The test-drilling program in 1979-80 is described in Ryals (1982) and Office of Nuclear Waste Isolation (1982a, b, c, d, e, f).

The sidewall cores were analyzed by Core Laboratories, Inc., New Orleans, La., and the permeability data were provided by Law Engineering Testing Company (written commun., 1981). Permeability determinations were made with an air permeameter. In some instances an insufficient amount of core was recovered to measure permeability. For these samples, permeabilities were determined empirically using parameters such as porosity, saturated-sample density, and grain size. Core Laboratories reports that air permeabilities determined from percussion sidewall cores are (1) generally higher than the actual permeability for material with a permeability of less than about 20 millidarcies and (2) are generally lower than the actual permeability for material with a permeability of greater than about 20 millidarcies. Fracturing and shattering of the sample material upon bullet impact results in higher permeabilities in the low ranges. In the high ranges, the permeabilities are reduced because of partial blocking of flow paths through the pores by drilling mud and by changes in sand-grain alignment. Even though the permeabilities determined from sidewall cores are not precise, the determinations give an order of magnitude and an indication of the variability of permeability.

Coefficient of Storage

In or near the outcrop of the Wilcox-Carrizo aquifer, water may be unconfined (water-table conditions) or confined (artesian conditions) because this part of the aquifer consists of alternating clay and sand beds. In these areas the storage coefficient may be as great as $1x10^{-1}$ for water-table conditions. However, no coefficients of storage have been determined from aquifer tests where water-table conditions prevail. In downdip areas, water in the aquifer is confined. Therefore, the storage coefficient probably ranges about $1x10^{-4}$ to $1x10^{-1}$. Page and May (1964) report a storage coefficient of $5x10^{-4}$ from an aquifer test in Bossier Parish. Newcome and others (1963) report storage coefficients of $7x10^{-4}$ and $6x10^{-5}$ from aquifer tests in Natchitoches Parish. In De Soto Parish, Page and Pree' (1964) report storage coefficients of $9x10^{-5}$ and $2.4x10^{-4}$.

Hydraulic Conductivity

Payne (1968, 1970, 1972, and 1975) found that hydraulic conductivity increased as the thickness of individual sand beds increased in the Claiborne Group, which includes the Carrizo Sand (table 1). Payne postulated that the increase in hydraulic conductivity with increased sand thickness is related to the environment of deposition. Sands of the Claiborne Group probably were deposited in stream channels or along or near shore. Payne noted that the thicker sands would lie along the lines where velocities would have been relatively high. Thus, the thicker sand beds would consist of better sorted and coarser sand than the thinner sands along the margins of channels. For the Carrizo, Payne (1975) found the hydraulic conductivity averaged 29 ft/d for sand beds 25 to 100 ft thick and 40 ft/d for sand beds 100 to 200 ft in thickness. The test well in the upper part of the Wilcox-Carrizo aquifer at site LH-7 (shown on pl. 2) is screened in the Carrizo part of the aquifer. An aquifer test of this interval showed the hydraulic conductivity to be about 8 ft/d, which is somewhat lower than the average of 29 ft/d for a sand bed less than 100 ft thick.

Hydraulic conductivity does not appear to increase with increased sand-bed thickness for the Wilcox part of the Wilcox-Carrizo aquifer. Except for the aquifer test (LH-7) of the Carrizo mentioned in the previous paragraph, all the aquifer-test results given on plates 1 and 2 are for sand beds of the Wilcox Group. The values of hydraulic conductivity shown on plate 1 range from about 1 to 35 ft/d and average about 10 ft/d. The aquifer tests were performed on public-supply wells and test wells, which generally are screened in the more permeable sand beds. Therefore, the aquifer-test results probably represent the upper limit of the range of hydraulic conductivity for the Wilcox. The test-drilling program in 1979-80 provided general aquifer testing of the Wilcox-Carrizo. Sites LVH-6, LH-7, and LRH-13 are near salt domes (pls. 1 and 2). Data collected from these sites are probably more indicative of near-dome hydrology than of regional hydrology. However, the data from these three sites and two regional sites (LH-2 and LH-17) show the variability of the Wilcox. Permeabilities determined from sidewall cores (pl. 2) range from less than 1 to more than 3,000 millidarcies (less than 0.002 to more than 7.3 ft/d). Values of hydraulic conductivity from aquifer tests of six sand intervals range from 0.1 to 8 ft/d and average about 4 ft/d (pl. 2). The sand intervals of the aquifer tests given on plates 1 and 2 range from 11 to 152 ft in thickness. No correlation of sand thickness and hydraulic conductivity is apparent from a comparison of the data shown on the two plates.

The Wilcox interval is a complex sequence of deltaic deposits, which may account for the variability of the hydraulic conductivity. Hydrologic data for the Wilcox are available only for the northwestern part of the study area; thus, additional data are needed, especially downdip, to establish the range of values of hydraulic conductivity for the Wilcox. Downdip in some areas, electrical logs of the Wilcox interval show massive sand beds for which no aquifer-test data are available. A transmissivity map of the Wilcox-Carrizo aquifer, which is needed for modeling, can be constructed when the regional variability of the hydraulic conductivity of the Wilcox sand beds is established.

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