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Hydrologic Characteristics of Selected Alluvial Aquifers in the North Platte Natural Resources District, Western Nebraska

Water-Resources Investigations Report 01–4241

U.S. Department of the Interior
U.S. Geological Survey

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By G.V. Steele, J.C. Cannia, and K.G. Scripter

U.S. GEOLOGICAL SURVEY

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
	Length	
inch (in.)	25.4	centimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Area	
acre	4,047	square meter
square foot (ft^2)	0.09290	square meter
	Flow Rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
gallon per minute (gal/min)	0.06309	liter per second
foot per day (ft/d)	0.3048	meter per day
foot squared per day (ft^2/d)	0.09290	meter squared per day

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F = 1.8\ (°C) + 32$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C = (°F - 32) / 1.8$$

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Altitude, as used in this report, refers to distance above or below sea level.

Site Identification, as used in figures 2 through 14, and in tables 1 and 2.

This report uses two different methods of site identification. The first method, well site, uses the field identification number associated with the name of the municipality (for the pumping well) or the NPNRD original field identification for the observation well—such as Bayard and 23M–1, respectively. The second method, legal identification, is based on the land subdivisions in the Bureau of Land Management (BLM) survey of Nebraska. The number preceding N (north) indicates the township or tier, the numeral preceding W (west) indicates the range, and the numbers preceding the terminal letters indicate the section in which the well is located. The terminal letters designated A, B, C, and D denote the quarter section, the quarter-quarter section, the quarter-quarter-quarter section, and the quarter-quarter-quarter-quarter section. The designation is given in a counterclockwise direction beginning with "A" in the northeast corner of each subdivision. Each well also is assigned a terminal number "1" designating the order of inventory, and two or more wells are further distinguished by adding a sequential digit to the well number, assigned by order of inventory.

Hydrologic Characteristics of Selected Alluvial Aquifers in the North Platte Natural Resources District, Western Nebraska

By G.V. Steele, J.C. Cannia, and K.G. Scripter

Abstract

Between 1997 and 1998 the U.S. Geological Survey, in cooperation with the North Platte Natural Resources District, conducted constant-discharge aquifer tests at seven locations in the western part of the North Platte Natural Resources District—Bayard, Gering, Lyman, Minatare, Mitchell, Morrill, and Scottsbluff Airport. Hydraulic conductivity at the Bayard site ranged from 1.10×10^{1} to 1.33×10^{2} feet per day (ft/d), and values of specific yield ranged from 2.46×10 to 3.00×10^{-1}. Hydraulic conductivity at the Gering site ranged from 7.10×10^{1} to 8.40×10^{2} ft/d, and values of specific yield ranged from 5.00×10^{-2} to 2.55×10^{-1}. Hydraulic conductivity at the Lyman site ranged from 3.82×10^{1} to 3.24×10^{2} ft/d, and values of specific yield ranged from 1.00×10^{-2} to 1.14×10^{-1}. Hydraulic conductivity at the Minatare site ranged from 5.89×10^{1} to 6.33×10^{2} ft/d, and values of specific yield ranged from 1.47×10^{-2} to 2.50×10^{-1}. Hydraulic conductivity at the Mitchell site ranged from 1.85×10^{1} to 5.03×10^{2} ft/d, and values of specific yield for this site ranged from 1.70×10^{-1} to 3.20×10^{-1}. Hydraulic conductivity at the Morrill site ranged from 1.50×10^{1} to 5.89×10^{2} ft/d. Values of specific yield for this site ranged from 2.50×10^{-1} to 3.00×10^{-1}. Hydraulic conductivity at the Scottsbluff Airport site ranged from 1.96×10^{2} to 4.38×10^{2} ft/d, and values of specific yield ranged from 1.41×10^{-2} to 2.73×10^{-1}.

INTRODUCTION

Most public-supply wells in the North Platte Natural Resources District (NPNRD) produce water from alluvial aquifers. In order to assure adequate supplies of water and to manage the water resource effectively, water managers need information about the hydraulic properties of the alluvial aquifers. Some of the primary hydraulic properties of alluvial aquifers include hydraulic conductivity, transmissivity, storativity, and specific yield, which are discussed later in the report.

In 1997, the U.S. Geological Survey (USGS) entered into a 2-year cooperative agreement with the NPNRD to determine the hydraulic properties of seven sites in alluvial aquifers in the NPNRD (fig. 1). This study also helps resources managers gain an understanding of how the alluvial aquifers react to certain stresses. The study will improve understanding of the properties governing ground-water flow in the alluvial aquifers in the NPNRD.

Purpose and Scope

The purpose of this report is to present the results of seven aquifer tests conducted in the NPNRD during 1997–98. These results are presented in the form of data values and graphs. Results of the tests will enable water managers to understand the vulnerability of ground-water supplies to potential contamination.

Acknowledgments

The authors acknowledge the municipalities of Bayard, Gering, Lyman, Minatare, Mitchell, Morrill,

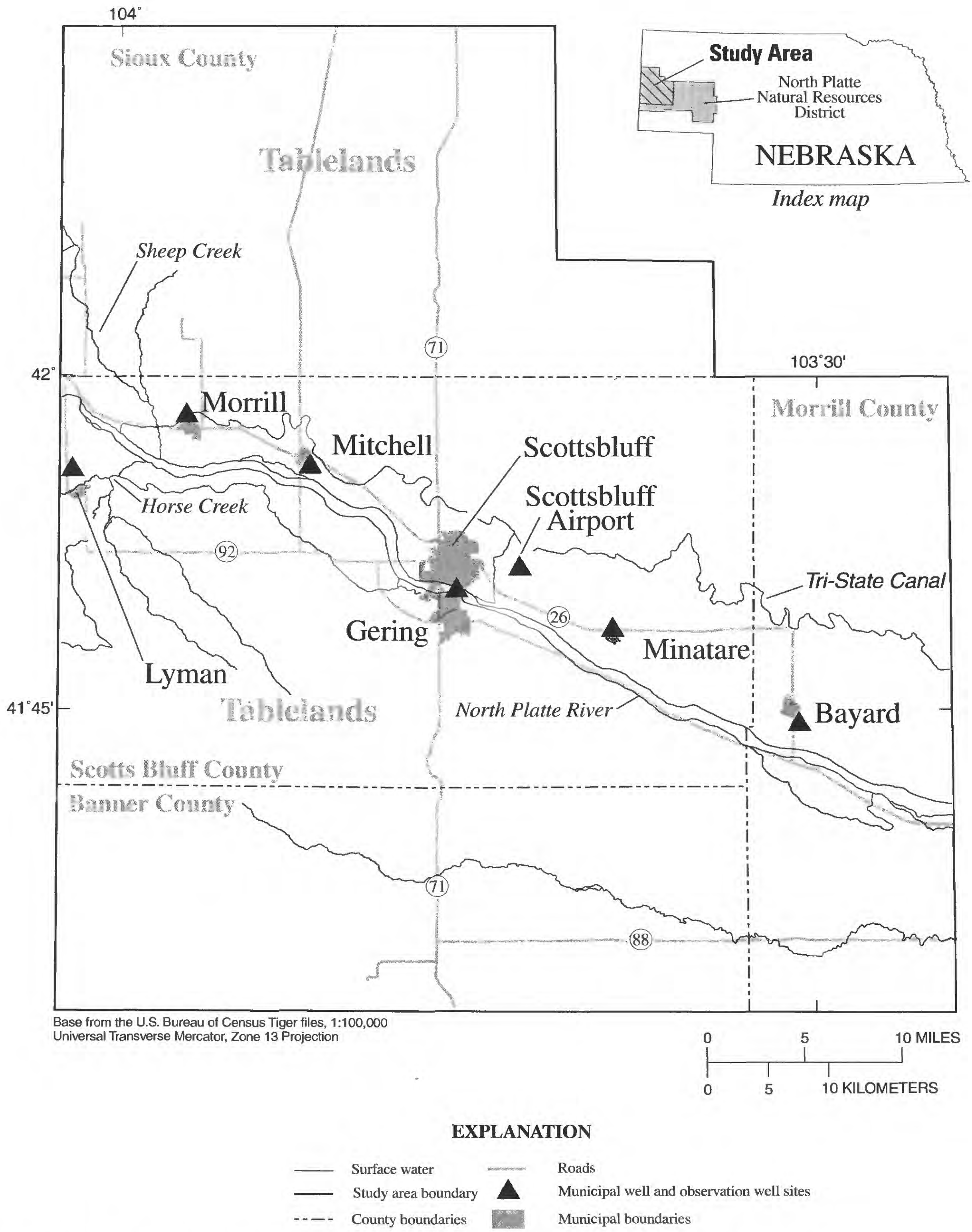

Figure 1. Aquifer-test locations in the North Platte Natural Resources District, western Nebraska.

and Scotts Bluff that provided the land for well installation and the resources for the aquifer characterizations. Special appreciation is extended to the staff of these municipalities who directly or indirectly assisted with this project.

DESCRIPTION OF STUDY AREA

The study area consists of seven sites in the North Platte River and Horse Creek Valleys in the western part of the NPNRD (fig. 1). The NPNRD lies in the panhandle of western Nebraska and is in the High Plains section of the Great Plains Province (Fenneman, 1946). The NPNRD is diverse in landforms including ridges, escarpments, bluffs, river valleys, tablelands, and sand hills (Steele and Cannia, 1997). These diverse landforms relate to the geologic units from which they are formed. The regional slope of the study area is predominantly northwest to southeast, which also characterizes the predominant direction of ground- and surface-water flow in this part of the NPNRD.

Climate and Land Use

The climate of the NPNRD is semiarid with relatively wide temperature ranges and low annual precipitation (National Oceanic and Atmospheric Administration, 1999). Most of this precipitation occurs as rainfall from thunderstorms during the months of May and June. Average monthly temperatures for 1998 at the Scottsbluff Airport ranged from 28.8°F in January, typically the coldest month, to 74.9°F in July, typically the hottest month. Temperature extremes for 1998 at the Scottsbluff Airport ranged from –22°F (December 12, 1998) to 104°F (July 18, 1998) (National Oceanic and Atmospheric Administration, 1999). The annual precipitation for 1998 at the Scottsbluff Airport was 17.25 in. (National Oceanic and Atmospheric Administration, 1999).

The NPNRD covers 3.2 million acres (Nebraska Department of Natural Resources, 1999) that is primarily irrigated and nonirrigated cropland, and rangeland. Land use around the aquifer-test sites is predominantly residential/small community, rural, and agricultural. In the agricultural areas, corn, hay, dry edible beans, and sugar beets are the predominant irrigated crops.

Hydrogeologic Settings

The hydrogeology of the NPNRD is diverse and varies widely with location. Bedrock formations, which serve as the base of the principal aquifer, are massive, terrestrial, volcaniclastic to marine deposits. The Gering, Brule, and Chadron Formations are Tertiary in age and rest unconformably on the undifferentiated marine deposits of Cretaceous age. The Brule, as well as the Arikaree, and Ogallala Formations which also are Tertiary in age, typically make up a majority of the upland areas flanking the river valleys and can be significant sources of nonmunicipal water supply.

The principal source of ground-water supply in the NPNRD is the North Platte River alluvial aquifer of Quaternary age. The alluvial aquifer is in valley-fill deposits from rivers that incised the bedrock formations. The depth of the alluvial valley varies locally with maximum thickness of about 210 ft (Verstraeten and others, 1995) and from less than 1 mi to over 5 mi in width. This aquifer is composed of unconsolidated alluvial sands and gravels interlaced with clay lenses. The clay lenses are not extensive enough to be confining layers; thus, the North Platte River alluvial aquifer is an unconfined, water-table aquifer. Aquifers in tributaries of the North Platte River, such as Horse Creek, are of similar composition to the North Platte alluvial aquifer, but are thinner and narrower.

Ground water typically flows from the tablelands to the north and south of the river valleys toward the rivers, where it discharges into the rivers. Sources of recharge to the alluvial aquifers can include localized inflow from surface water, hydraulically connected ground-water systems, and local precipitation. Ground-water levels near the aquifer-test sites typically range from 5 to 30 ft below the land surface.

Water levels in the alluvial aquifers vary greatly with season and proximity to surface-water systems. In areas where seepage from surface-water irrigation systems does not occur, water levels typically are highest in the spring and lowest in mid- to late summer. In areas where seepage from surface-water irrigation systems does occur, water levels are typically highest in July through mid-September.

Streamflow drainage in the NPNRD is predominantly northwest to southeast. The North Platte River and its tributaries (fig. 1) dominate the surface-water system in the NPNRD. Steele and Cannia (1997) reported that part of the North Platte River generally was a gaining stream. The tributaries of the North Platte River in the NPNRD are a mix of ephemeral, intermittent, and perennial streams.

DESIGN OF AQUIFER TESTS AND METHODS OF ANALYSIS

Aquifer tests at seven sites were designed to determine the hydraulic characteristics of the alluvial aquifers in the western part of the NPNRD. The test sites were located in or near the communities of Bayard, Gering, Lyman, Minatare, Mitchell, Morrill, and Scottsbluff (fig. 1). Public water-supply wells were selected as the pumping wells for the aquifer tests because detailed construction data were available for each, and these wells were the only high-capacity wells that were operational during the late fall and early spring, when influences from irrigation activities on the aquifers were minimal. At least two observation wells were installed per site (table 1). These observation wells either were screened at different depths or were fully screened. The observation wells were located at distances of 25 to 131 ft from the pumping well.

The aquifer tests were used to determine the primary aquifer characteristics hydraulic conductivity, transmissivity, and specific yield. Hydraulic conductivity is a measure of the capacity of a porous medium to transmit water per unit time. Dimensions of hydraulic conductivity are unit length per unit time (L/t). Transmissivity is a product of the average hydraulic conductivity and the thickness of the aquifer. Dimensions of transmissivity are unit length squared per unit time (L^2/t). Specific yield is a dimensionless measurement of the volume of water that would drain under gravity alone per unit volume of aquifer. In addition, because confined aquifers are not dewatered, specific yield is measured only in water-table aquifers.

In 1997 and 1998, seven 24- to 30-hour constant-discharge aquifer tests were conducted. Each aquifer test was designed and analyzed using standard methods described by Dawson and Istok (1991), Domenico and Schwartz (1990), Driscoll (1986), Freeze and Cherry (1979), Kruseman and de Ridder (1990), Lohman (1972), Moench (1993, 1994), Neuman (1975), and Stallman (1965). Before each test, typically 1 week to 1 month, electronic water-level monitoring instruments were installed in the observation wells to measure pretest water levels. Prior to the start of each test, data collected by the instruments were downloaded, and the instruments were synchronized, recalibrated, and set to start measuring automatically at intervals of 6 seconds to 1 hour, with the more frequent measurements taken near the beginning of the test when greater changes in drawdown are expected to occur. Manual measurements using electronic measuring tapes also were taken to supplement and verify the data recorded by the electronic water-level instrumentation.

Hydrographs of the data collected prior to the aquifer tests indicate that natural variations in water levels occurred in all monitoring wells. At five sites, the pretest variations in the water levels were within the tolerances set in the standard methods, and corrections were not needed to adjust the aquifer-test drawdown curve. At the Bayard site, pretest water-level data were unavailable, so based on data from other sites, it was assumed that pretest water levels did not change enough to affect the test. At the Gering site, pretest water-level data indicated that a ground-water-level decline existed before the test. At this site, corrections were made to the water levels collected during the test to compensate for the effect of the ground-water-level decline.

Water-table (unconfined) aquifers are different from confined aquifers in that the top surface is a free and moving boundary. The storativity of an unconfined aquifer is dominated by the gravity drainage of water from the media (specific yield) rather than the elastic expansion of water and compressibility of the aquifer media (storage coefficient). There also can be additional head loss in an unconfined aquifer due to vertical flow components near the falling water table.

Table 1. Location of and construction information about pumping and observation wells used in the aquifer tests, North Platte Natural Resources District, western Nebraska

[Shaded cells indicate pumping wells; NPR, North Platte River alluvium; HC, Horse Creek alluvium]

Well site	Legal identification	Well diameter, in inches	Screened interval below land surface, in feet	Aquifer
Bayard	21N 52W35BCAB1	18	103–133	NPR
23M–1		2.5	10–133	NPR
23M–2		2.5	128–133	NPR
23M–3		2.5	75–80	NPR
23M–4		2.5	10–30	NPR
Gering	22N 55W26DABD1	18	56–81	NPR
14M–1		2.5	61–81	NPR
14M–2		2.5	15–30	NPR
14M–4		2.5	10–80	NPR
Lyman	23N 58W34BCCB1	16	51–91	HC
6M–1		2.5	35–115	HC
6M–2		2.5	10–30	HC
Minatare	21N 53W 7AAA1	18	66–106	NPR
18M–1		2.5	168–188	NPR
18M–2		2.5	90–100	NPR
18M–3		2.5	10–30	NPR
18M–4		2.5	11–191	NPR
Mitchell	23N 56W27ABDC1	16	55–115	NPR
10M–1		2.5	35–115	NPR
10M–2		2.5	10–30	NPR
Morrill	23N 57W16ADAC1	16	92–136	NPR
1H–1		2.5	190–195	NPR
1H–2		2.5	107–112	NPR
1H–3		2.5	10–30	NPR
Scottsbluff Airport	22N 54W21CAAB1	12	60–80	NPR
15M–1		2.5	69–74	NPR
15M–2		2.5	30–50	NPR
15M–3		2.5	30–80	NPR

Because all aquifer tests were completed in unconfined conditions and subject to delayed responses, the water-level data collected during the aquifer test were analyzed using Neuman's method (1975), which accounts for delayed response with the well function $W(U_A, U_B, \beta)$ in equation 1. Neuman's equation (1975) for water-level drawdown in an unconfined aquifer is based on the equation:

$$s = \frac{Q}{4\pi T} W(U_A, U_B, \beta) \qquad (1)$$

where

s is drawdown in the observation well in units of length, and
$W(U_A, U_B, \beta)$ is the well function for the aquifer:

$$U_A = \frac{r^2 S}{4Tt}, \qquad U_B = \frac{r^2 S_y}{4Tt}, \qquad \beta = \left(\frac{r}{D}\right)^2 \frac{K_v}{K_h}$$

$Q =$ discharge in pumping well (L^3/t);
$T =$ aquifer transmissivity, which equals the product of K_h and D (L^2/t);
$r^2 =$ radial distance of observation well from pumping well, feet squared (L^2);
$S =$ the volume of water instantaneously released from storage per unit surface area per unit decline in head (elastic early-time storativity) (dimensionless);
$t =$ time (t);
$S_y =$ the volume of water released from storage per unit surface area per unit decline of the water table (specific yield) (dimensionless);
$K_v =$ vertical hydraulic conductivity (L/t);
$K_h =$ hydraulic conductivity (L/t); and
$D =$ saturated thickness of the aquifer at the start of the test (L).

It was assumed for the aquifer-test analyses that the aquifers were homogeneous, anisotropic, of infinite areal extent, and that flow was radial to the well screen. It also was assumed that continuous and constant discharge from the pumped wells occurred during the test; ground-water density and viscosity were constant; the aquifer was unconfined and of uniform thickness with a horizontally flat bottom; negligible head losses through the well screen occurred; and that ground-water flow was as described by Darcy's Law (Dawson and Istok, 1991).

Equation 1 assumes that all wells are fully penetrating. However, for this study none of the pumping wells and few of the observation wells were fully penetrating. Kruseman and de Ridder (1990) report that partial penetration causes the velocity of the flow lines in the vicinity of the pumping well to be greater than they otherwise would be. Moreover, this leads to an extra loss of head, and converging flow lines are strongest nearest the screen and decrease with increasing distance. Neuman (1975) altered the well-bore boundary condition to specify the vertical position of the screen of the pumping well. This compensates for the vertically convergent flow lines in the vicinity of a partially penetrating pumping well. Neuman's solution for flow to a partially penetrating well, which is the equation that was used for the analyses in this report, is:

$$s = \frac{Q}{4\pi T}\int_0^{\infty} 4yJ_0(y\beta^{1/2})\left[u_0(y) + \sum_{n=1}^{\infty} u_n(y)\right]dy \qquad (2)$$

where

$$u_0(y) = \frac{\{1-\exp[-t_s\beta(y^2-\gamma_0^2)]\}\cosh(\gamma_0 z_D)}{\{y^2+(1+\sigma)\gamma_0^2-(y^2-\gamma_0^2)^2/\sigma\}\cosh(\gamma_0)} \cdot \frac{\sinh[\gamma_0(1-d_D)]-\sinh[\gamma_0(1-1_D)]}{(1_D-d_D)\sin(\gamma_0)}$$

and

$$u_n(y) = \frac{\{1-\exp[-t_s\beta(y^2-\gamma_n^2)]\}\cos(\gamma_n z_D)}{\{y^2-(1+\sigma)\gamma_n^2-(y^2+\gamma_n^2)^2/\sigma\}\cos(\gamma_n)} \cdot \frac{\sin[\gamma_0(1-d_D)]-\sin[\gamma_n(1-1_D)]}{(1_D-d_D)\sin(\gamma_n)}$$

where J_0 = Bessel function of first kind, zero order,

$$t_s = \frac{Tt}{Sr^2} \text{ (dimensionless)},$$

z_D = quotient of the distance above the bottom of the aquifer and the saturated thickness of the aquifer at the start of the test,

d_D = quotient of the distance between the top of the well screen in the pumping well and the initial position of the water table and the saturated thickness of the aquifer at the start of the test,

l_D = quotient of the distance between the bottom of the well screen in the pumping well and the initial position of the water table and the saturated thickness of the aquifer at the start of the test,

$$\sigma = \frac{S}{S_y}, \text{ and}$$

γ_0 and γ_n = root of the following equations:

$$\sigma\gamma_0 \sinh(\gamma_0) - (y^2-\gamma_o^2)\cosh(\gamma_0) = 0, \ \gamma_o^2 < y^2$$

$$\sigma\gamma_n \sin(\gamma_n) + (y^2-\gamma_n^2)\cos(\gamma_n) = 0, (2n-1)/(\pi/2) < \gamma_n < n\pi, \ n \geq 1$$

AQUIFER-TEST RESULTS

Hydraulic characteristics varied substantially in the alluvial aquifers of the western part of the NPNRD. Hydraulic conductivities determined from analysis of the aquifer tests ranged from 1.10×10^{1} to 8.40×10^{2} ft/d (table 2). Values of specific yield ranged from 1.00×10^{-2} to 3.20×10^{-1}. The response of the aquifer to the pumping stress was almost instantaneous in most observation wells. However, response of some water levels in some observation wells was delayed slightly upon startup of the aquifer test.

Bayard Site

At the Bayard site, all wells used in the aquifer test were developed in the alluvial aquifer of the North Platte River. Depth to water in the pumping well at the start of the aquifer test was 6.20 ft below land surface. The pumping well at the Bayard site is screened through the bottom part of the aquifer (table 2, fig. 2) just above the top of the underlying Brule Formation, 133 ft below land surface. The saturated thickness of the aquifer at this site is about 126 ft.

Analysis of data collected during the aquifer test indicates the hydraulic-conductivity value of the aquifer is fairly consistent with depth. Hydraulic-conductivity values ranged from 1.10×10^{1} to 1.33×10^{2} ft/d (table 2). Values of specific yield ranged from 2.46×10^{-1} to 3.00×10^{-1}. Pretest water-level data were not available for this site. Water-level changes at all sites (except Gering) were minimal. Therefore, the pretest water-level change at this site was assumed to be negligible. The composite analysis indicates a hydraulic conductivity value of 6.70×10^{1} ft/d and a specific yield of 3.00×10^{-1} (table 2, fig. 3).

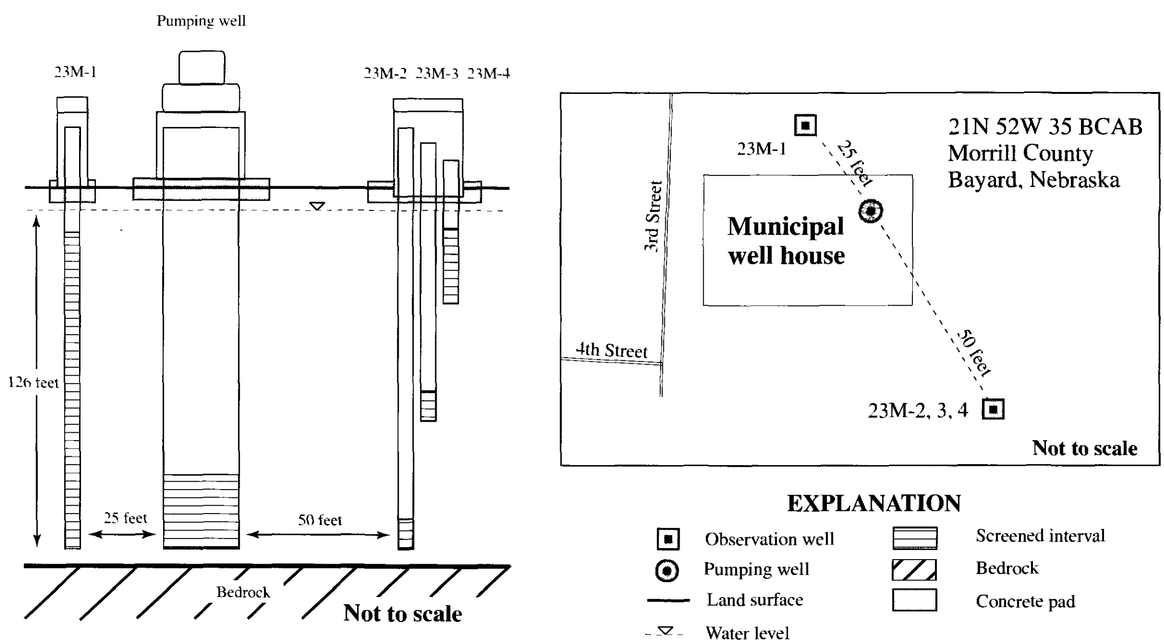

Figure 2. Diagrammatic cross section and plan view map showing the Bayard site.

Table 2. Results of aquifer tests in the North Platte Natural Resources District, western Nebraska, 1997–98

[All measurements in feet unless otherwise noted; ft^2/d, feet squared per day; ft/d, feet per day]

Well site	Aquifer thickness	Well depth	Distance from pumping well	Screened interval below water table	Trans-missivity (ft^2/d)	Hydraulic conductivity (ft/d)	Storativity (dimension-less)	Specific yield (dimension-less)
Bayard	126	133		96–126				
23M–1		133	25	3–126	7.37×10^{3}	5.80×10^{1}	5.22×10^{-3}	2.46×10^{-1}
23M–2		133	50	121–126	1.68×10^{4}	1.33×10^{2}	3.55×10^{-3}	2.46×10^{-1}
23M–3		80	50	68–73	1.07×10^{4}	8.50×10^{1}	1.93×10^{-3}	2.54×10^{-1}
23M–4		30	50	3–23	1.43×10^{3}	1.10×10^{1}	1.13×10^{-3}	3.00×10^{-1}
Composite					8.39×10^{3}	6.70×10^{1}	2.56×10^{-3}	3.00×10^{-1}
Gering	72	81		47–72				
14M–1		81	40	52–72	5.19×10^{4}	7.21×10^{2}	5.30×10^{-3}	2.33×10^{-1}
14M–2		30	39	6–21	4.01×10^{4}	5.57×10^{2}	2.40×10^{-4}	2.55×10^{-1}
14M–4		80	131	1–71	5.11×10^{4}	7.10×10^{1}	2.13×10^{-3}	5.00×10^{-2}
Composite					6.05×10^{4}	8.40×10^{2}	6.66×10^{-3}	8.40×10^{-2}
Lyman	99	91		35–75				
6M–1		115	25	19–99	3.21×10^{4}	3.24×10^{2}	9.31×10^{-3}	1.00×10^{-2}
6M–2		30	25	0–14	3.78×10^{3}	3.82×10^{1}	3.86×10^{-3}	1.14×10^{-1}
Composite					2.21×10^{4}	2.23×1[illegible] 2	[illegible].27×10^{-3}	5.00×10^{-2}
Minatare	180	105		58–98				
18M–1		81	28	160–180	1.14×10^{5}	6.33×10^{2}	1.22×10^{-1}	2.50×10^{-1}
18M–2		100	19	82–92	3.26×10^{4}	1.81×10^{2}	2.27×10^{-2}	8.67×10^{-2}
18M–3		30	23	2–28	1.06×10^{4}	5.89×10^{1}	5.10×10^{-3}	1.84×10^{-1}
18M–4		191	50	8–188	4.09×10^{4}	2.27×10^{2}	6.31×10^{-3}	1.47×10^{-2}
Composite					3.56×10^{4}	1.98×10^{2}	1.65×10^{-2}	5.00×10^{-2}
Mitchell	108	115		48–108				
10M–1		115	25	28–108	5.43×10^{4}	5.03×10^{2}	4.48×10^{-3}	3.20×10^{-1}
10M–2		30	25	3–23	2.00×10^{4}	1.85×10^{1}	1.78×10^{-3}	1.70×10^{-1}
Composite					5.00×10^{4}	4.63×10^{2}	7.67×10^{-3}	3.20×10^{-1}
Morrill	181	136		72–121				
1H–1		195	25	176–181	1.38×10^{4}	7.70×10^{1}	1.01×10^{-3}	2.62×10^{-1}
1H–2		112	25	93–98	2.62×10^{3}	1.50×10^{1}	4.23×10^{-3}	3.00×10^{-1}
1H–3		30	25	0–16	1.06×10^{5}	5.89×10^{2}	3.61×10^{-1}	2.50×10^{-1}
Composite					1.78×10^{4}	9.90×10^{1}	8.00×10^{-3}	3.00×10^{-1}
Scottsbluff Airport	52	80		32–52				
15M–1		80	36	41–46	1.02×10^{4}	1.96×10^{2}	1.40×10^{-3}	2.73×10^{-1}
15M–2		50	36	2–22	1.39×10^{4}	2.62×10^{2}	1.46×10^{-4}	1.41×10^{-2}
15M–3		74	50	2–52	2.28×10^{4}	4.38×10^{2}	8.17×10^{-3}	1.60×10^{-1}
Composite					1.32×10^{4}	2.54×10^{2}	3.71×10^{-3}	2.64×10^{-1}

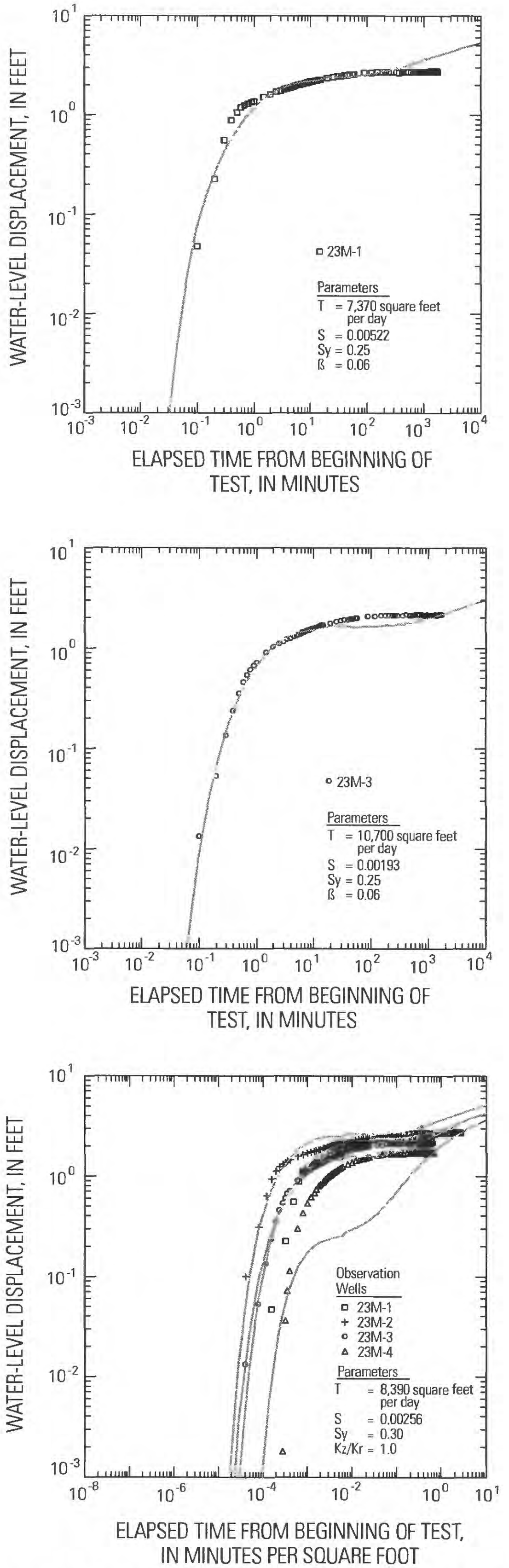

Figure 3. Log-log plot of drawdown versus time for the Bayard site.

Gering Site

At the Gering site, all wells used in the aquifer test were developed in the North Platte River alluvial aquifer. Depth to water in the pumping well at the start of the aquifer test was 9.18 ft below land surface. The pumping well at the Gering site is screened in the bottom part of the aquifer (table 2, fig. 4) near the top of the Brule Formation, 81 ft below land surface. The saturated thickness for this site is about 72 ft.

The North Platte River lies about 160 ft north of the pumping well. Data collected during the test (fig. 5) did not show an appreciable deviation from the predicted drawdown curve; therefore, it was assumed that the North Platte River did not have an effect on the test. Wells 14M–1 and 14M–2 are about 160 ft south of the North Platte River. Well 14M–4 is about 285 ft south of the North Platte River and about 131 ft south of the pumping well.

The hydraulic-conductivity value for observation well 14M–4 (table 2), which lies farthest from the North Platte River, was smaller than the other two observation wells (71 ft/d; table 2). Values of hydraulic conductivity at this site ranged from 7.10×10^{1} to 8.40×10^{2} ft/d (table 2). Specific-yield values ranged from 5.00×10^{-2} to 2.55×10^{-1}. The composite analysis indicates a hydraulic-conductivity value of 8.40×10^{2} ft/d and a specific-yield value of 8.40×10^{-2} (table 2, fig. 5).

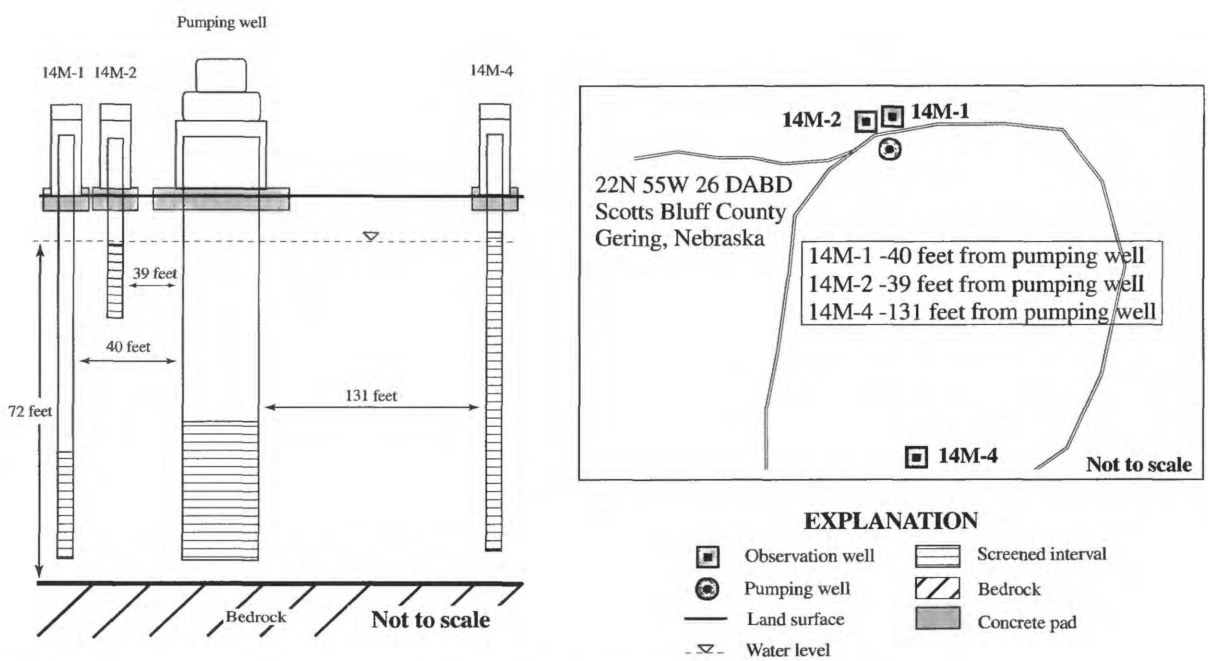

Figure 4. Diagrammatic cross section and plan view map showing the Gering site.

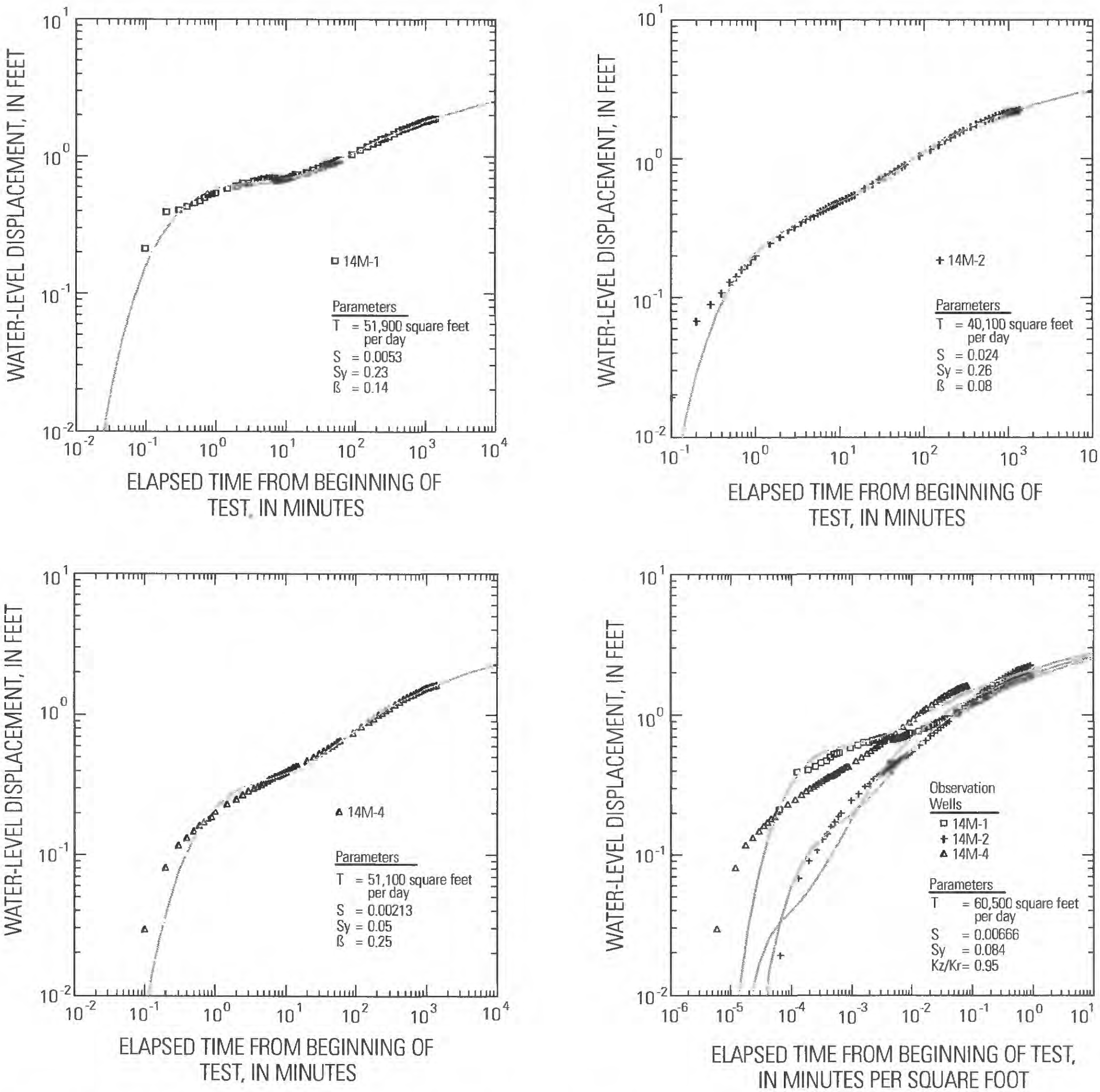

Figure 5. Log-log plot of drawdown versus time for the Gering site.

Lyman Site

At the Lyman site, all wells used in the aquifer test were developed in the alluvial aquifer of Horse Creek. Depth to water in the pumping well at the start of the aquifer test was 15.93 ft. The pumping well at the Lyman site is screened in the bottom part of the aquifer (table 2, fig. 6) near the top of the Brule Formation, 115 ft below land surface. The saturated thickness at this site is about 99 ft.

Horse Creek, the predominant surface-water feature in the area, is perennial and lies about 0.25 mi south of the test site. Analysis of the aquifer-test data (fig. 7) did not show an appreciable deviation from the predicted drawdown curve; therefore, it was assumed that influence from Horse Creek was negligible.

Values of hydraulic conductivity of the aquifer at this site ranged from 3.82×10^{1} to 3.24×10^{2} ft/d (table 2). Values of specific yield ranged from 1.00×10^{-2} to 1.14×10^{-1}. The composite analysis indicates a hydraulic-conductivity value of 2.23×10^{2} ft/d and a specific-yield value of 5.00×10^{-2} (table 2, fig. 7).

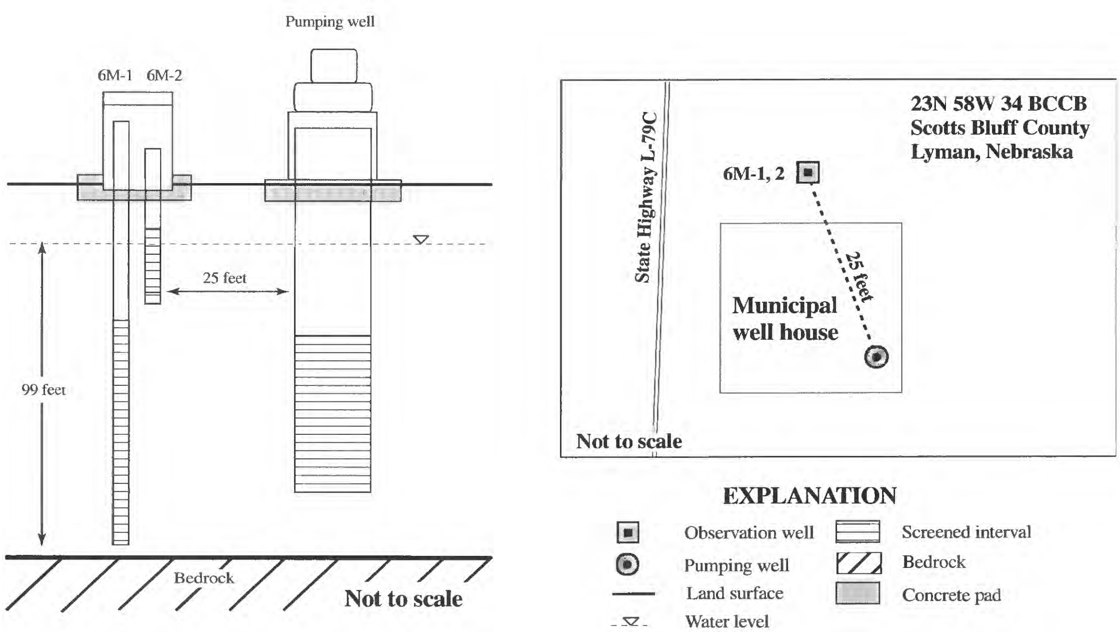

Figure 6. Diagrammatic cross section and plan view map showing the Lyman site.

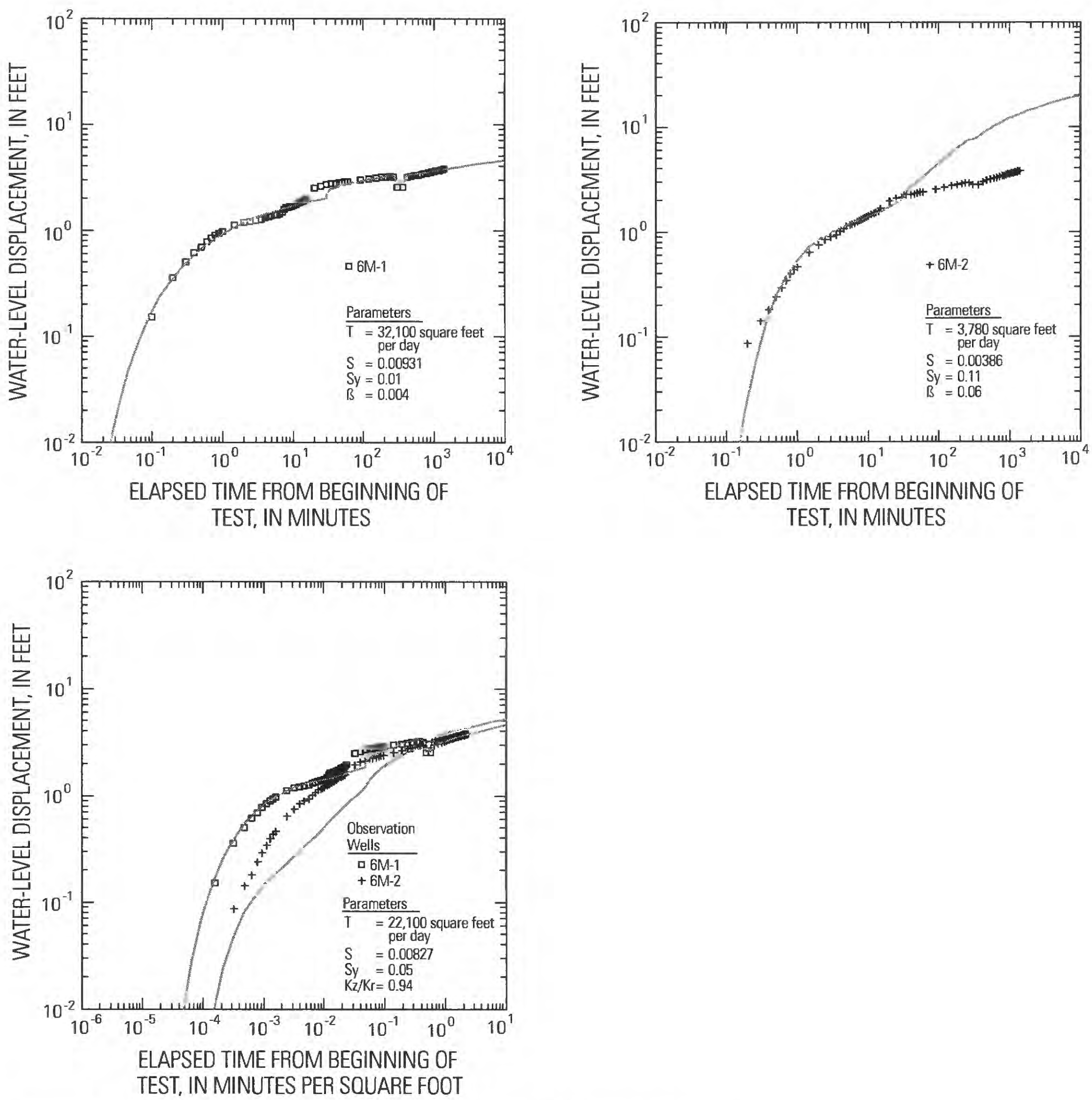

Figure 7. Log-log plot of drawdown versus time for the Lyman site.

Minatare Site

At the Minatare site, all wells used in the aquifer test were developed in the alluvial aquifer of the North Platte River. Depth to water in the pumping well at the start of the aquifer test was 6.90 ft. Depth to bedrock (Brule and Chadron Formations) near the Minatare site is about 187 ft. The saturated thickness at this site is about 180 ft. The pumping well at the Minatare site is screened in the middle part of the aquifer (table 2, fig. 8). The North Platte River, which is about 2 mi south of the site, is the only substantial surface-water feature in the area and is too far from the site to affect the test results. Values of hydraulic conductivity ranged from 5.89×10^{1} to 6.33×10^{2} ft/d (table 2). Values of specific yield ranged from 1.47×10^{-2} to 2.50×10^{-1}. Results of the aquifer test indicate that the hydraulic-conductivity values of the shallowest part of the aquifer (indicated by well 18M–3, table 2) were smaller than those of the deeper parts of the aquifer by a factor of two. The composite analysis indicates a hydraulic-conductivity value of 1.98×10^{2} ft/d and a specific-yield value of 5.00×10^{-2} (table 2, fig. 9).

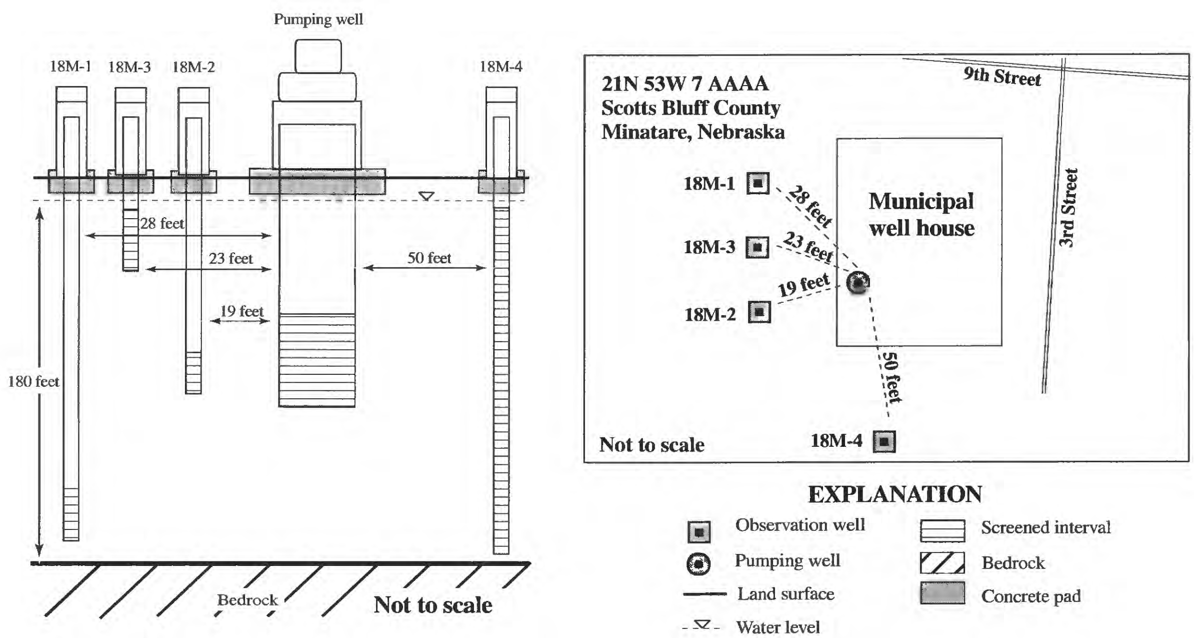

Figure 8. Diagrammatic cross section and plan view map showing the Minatare site.

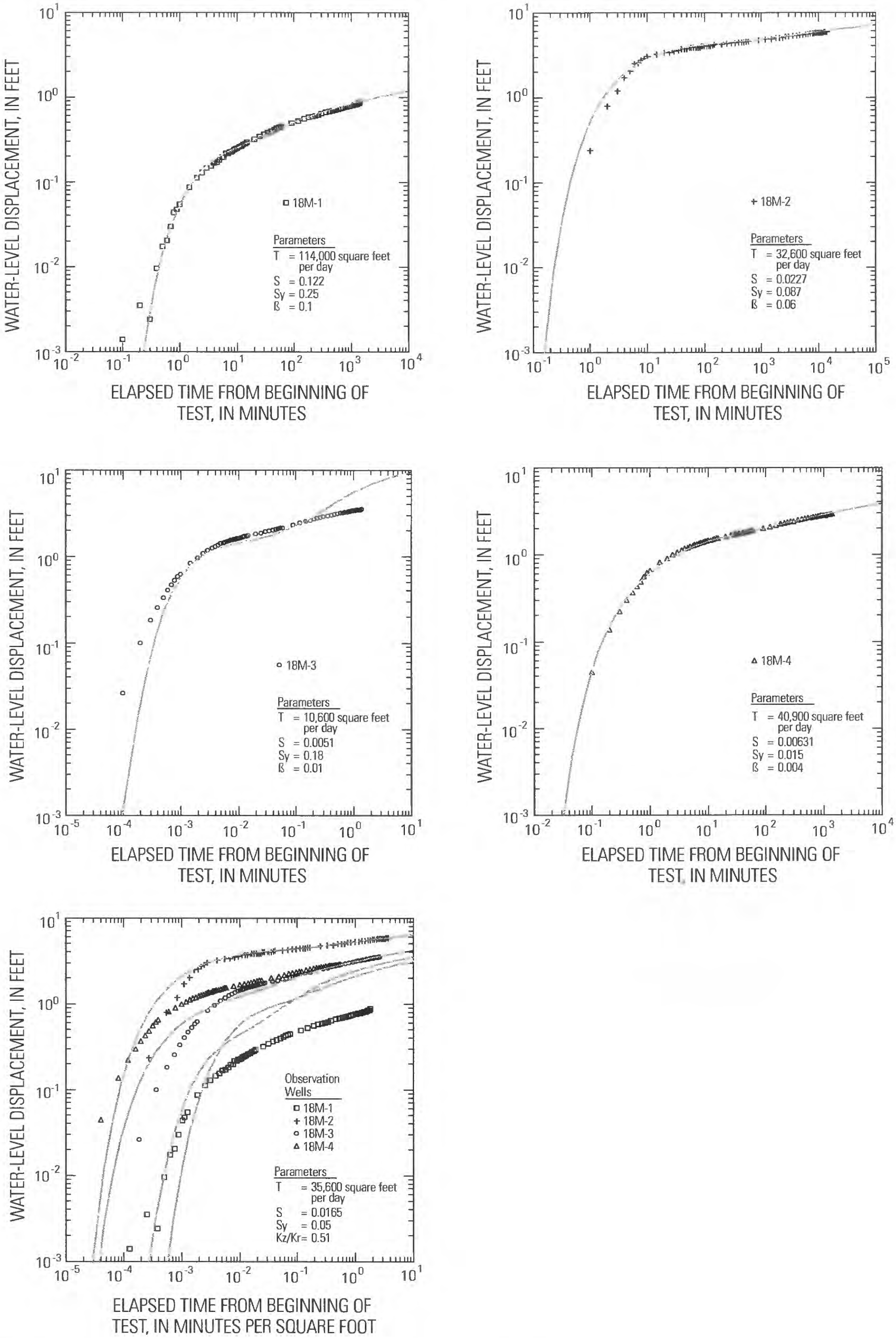

Figure 9. Log-log plot of drawdown versus time for the Minatare site.

Mitchell Site

At the Mitchell site, all wells used in the aquifer test were developed in the alluvial aquifer of the North Platte River. Depth to water in the pumping well at the start of the aquifer test was 6.96 ft. The pumping well at the Mitchell site is screened in the bottom part of the aquifer (table 2, fig. 10) near the top of the Brule Formation, 115 ft below land surface. The saturated thickness for this site is about 108 ft.

The predominant surface-water features in this area are the Tri-State Canal and the North Platte River. Water from the North Platte River is diverted into the Tri-State Canal during irrigation season. When the aquifer test (table 2, fig. 11) was conducted in late October 1997, the canal had not been operational for about 6 weeks. The North Platte River lies about 0.75 mi south of the site. However, data collected during the aquifer test (fig. 11) did not show an appreciable deviation from the predicted drawdown curve.

Values of hydraulic conductivity for this site ranged from 1.85×10^{1} to 5.03×10^{2} ft/d (table 2). Values of specific yield at this site ranged from 1.70×10^{-1} to 3.20×10^{-1}. Results of the aquifer test indicate that the hydraulic conductivity and the storativity of the shallower part of the aquifer (indicated by well 10M–2, table 2) were smaller than those of the deeper parts of the aquifer. The composite analysis indicates a hydraulic-conductivity value of 4.63×10^{2} ft/d and a specific-yield value of 3.20×10^{-1} (table 2, fig. 11).

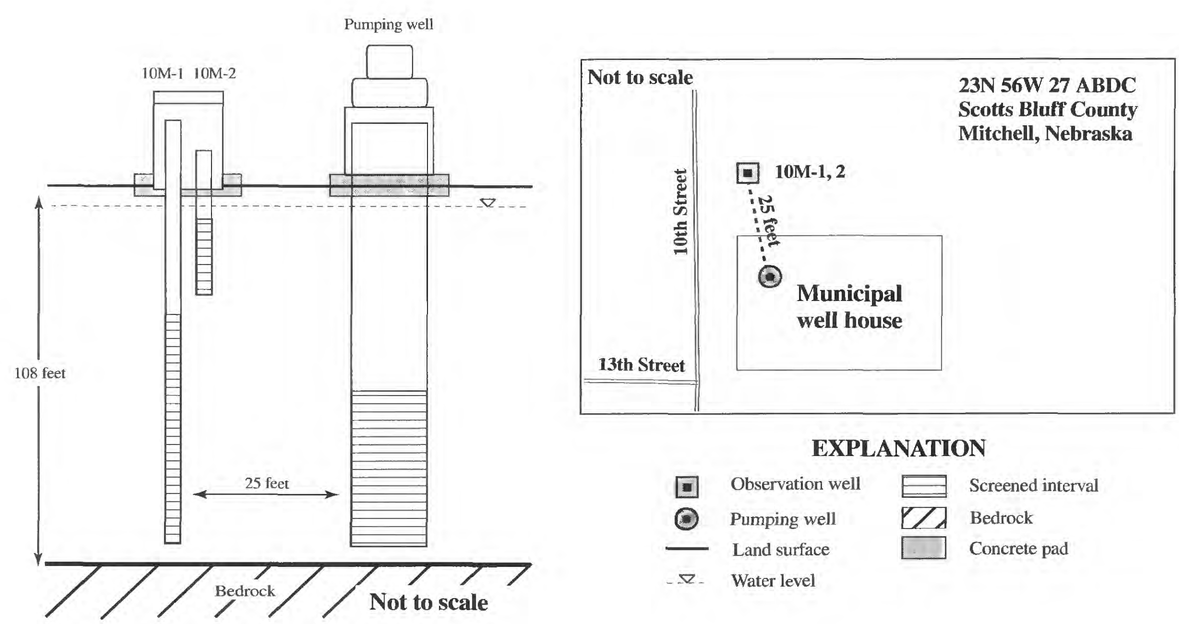

Figure 10. Diagrammatic cross section and plan view map showing the Mitchell site.

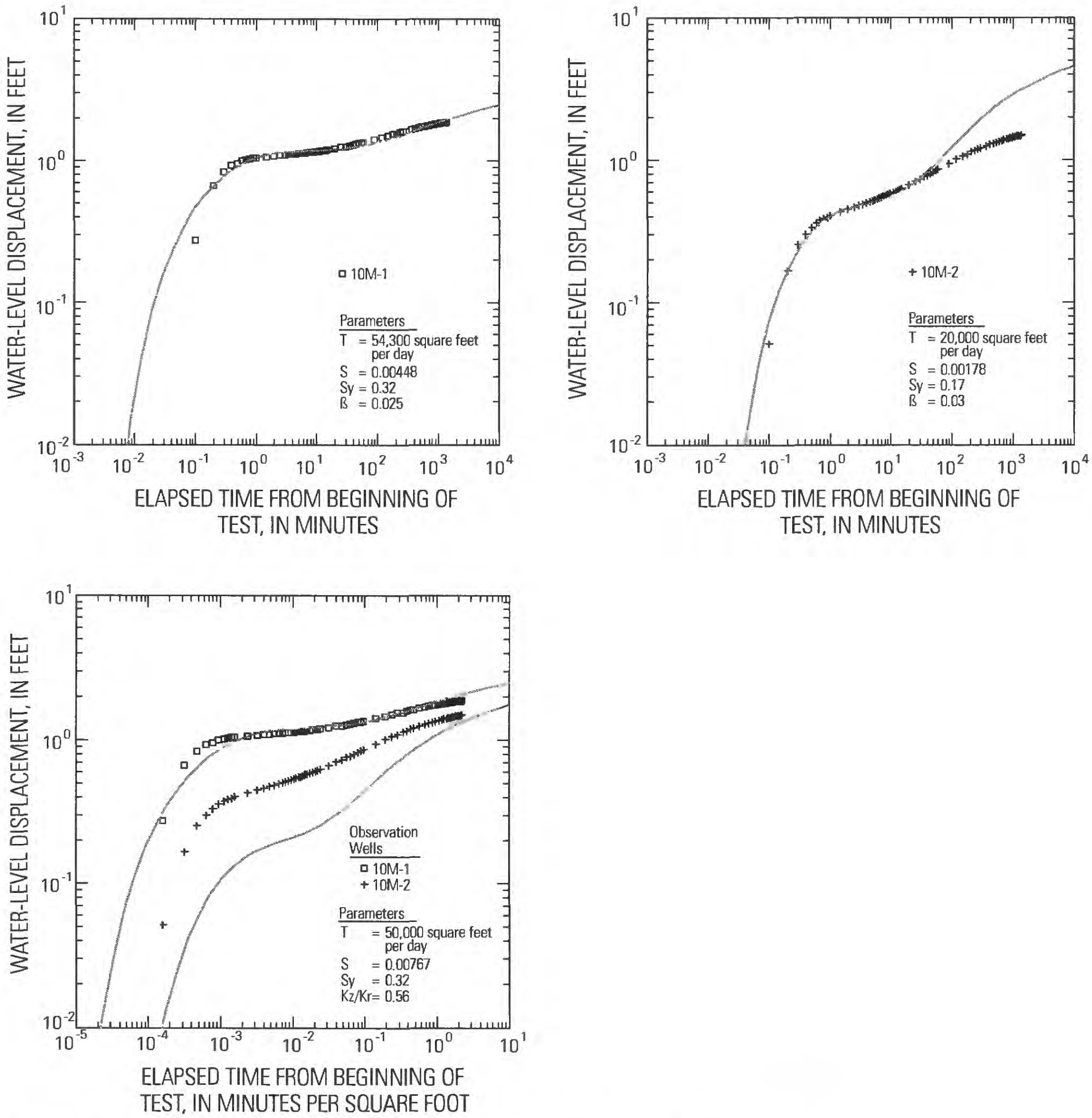

Figure 11. Log-log plot of drawdown versus time for the Mitchell site.

Morrill Site

At the Morrill site, all wells used in the aquifer test were developed in the alluvial aquifer of the North Platte River. Depth to water in the observation wells at the start of the aquifer test was 14 ft. The pumping well at the Morrill site is screened in the middle part of the aquifer (table 2, fig. 12). The top of the Brule Formation is about 195 ft below land surface. The saturated thickness at this site is about 181 ft.

The predominant surface-water feature in the area is Sheep Creek (fig. 1), which lies about 0.75 mi west of the site. Sheep Creek is a perennial stream in the reach that flows nearest Morrill and has an annual mean daily discharge of about 80 ft^3/s and had a discharge of 92 ft^3/s during the test (Nebraska Department of Water Resources, 1998). Data collected during the test (fig. 13) did not show an appreciable deviation from the predicted drawdown curve. Therefore, it was assumed that Sheep Creek did not have an effect on the test.

Results from this aquifer test indicate that the hydraulic properties of this aquifer are variable with respect to depth (table 2, fig. 13). The values of hydraulic conductivity ranged from 1.50×10^1 to 5.89×10^2 ft/d (table 2). Values of specific yield for this site ranged from 2.50×10^{-1} to 3.00×10^{-1}. The composite analysis indicates a hydraulic-conductivity value of 9.90×10^1 ft/d and a specific-yield value of 3.00×10^{-1} (table 2, fig. 13).

The hydraulic-conductivity value determined for the shallow well (1H–3) was an order of magnitude greater than the value of the deeper well (1H–1). However, the vertical distances between the screen of the pumping well and the screens of the deeper well (1H–1) and the shallow well (1H–3) are each about 60 ft. Therefore, the values of hydraulic conductivity (table 2) for wells 1H–1 and 1H–3 may be more representative of vertical hydraulic-conductivity values than horizontal hydraulic-conductivity values. In the shallow well (1H–3), water levels did not respond immediately when the pumping well began pumping. A delay of about 1 minute occurred, and total drawdown in the shallow well (1H–3) during the discharge part of the aquifer test was about 1 ft compared to about 2.9 ft in the deep well (1H–1) and 5.7 ft in the medium well (1H–2). The reason for the delayed response has not been determined. Lithologic logs collected during the installation of these wells do not indicate the presence of confining units. In the analysis of the shallow well (1H–3), only early time data were used to match the type curve.

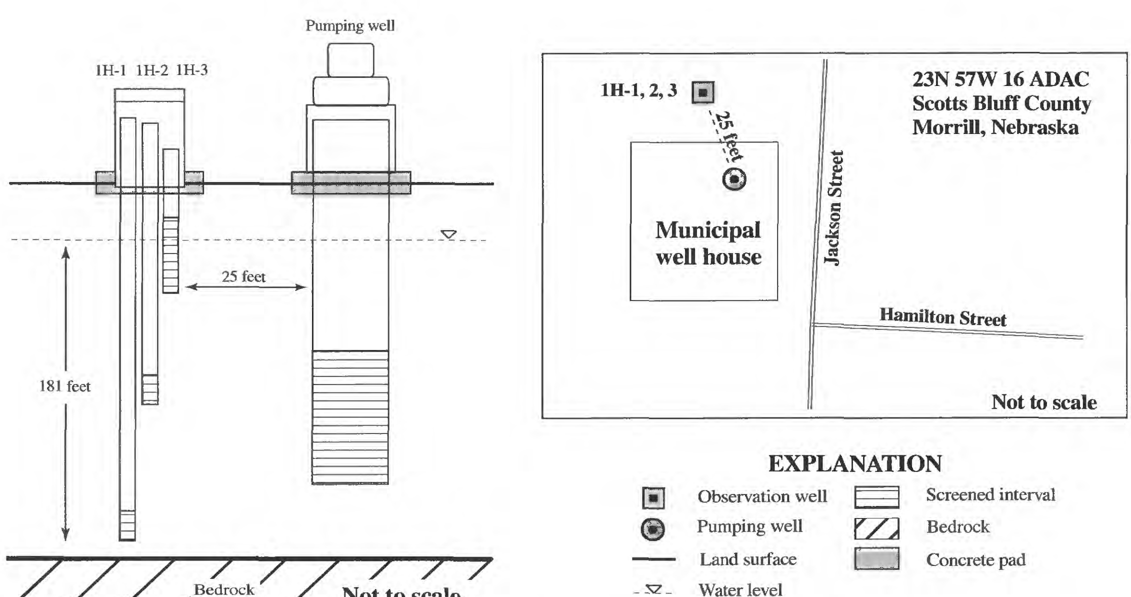

Figure 12. Diagrammatic cross secton and plan view map showing the Morrill site.

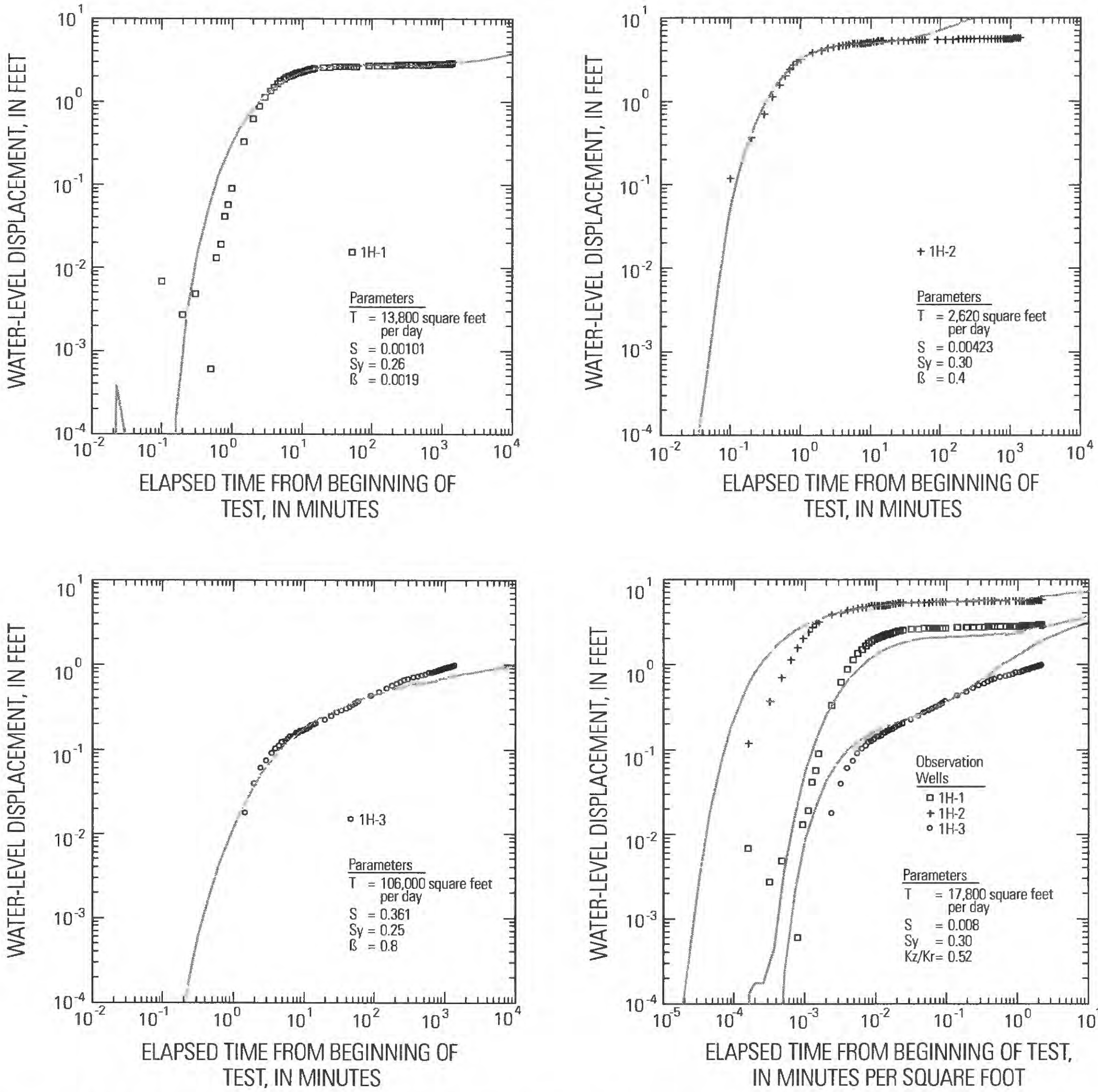

Figure 13. Log-log plot of drawdown versus time for the Morrill site.

Scottsbluff Airport Site

At the Scottsbluff Airport site, all wells used in the aquifer test were developed in the alluvial aquifer of the North Platte River. Depth to water in the pumping well at the start of the aquifer test was 27 ft. The pumping well at the Scottsbluff Airport site is screened in the bottom part of the aquifer (table 2, fig. 14) near the top of the Brule Formation, 80 ft below land surface. The saturated thickness of the aquifer at this site is about 52 ft. The North Platte River, which is about 4 mi south of the site, is the only substantial surface-water feature in the area and is too far from the site to affect the test results.

Aquifer-test results indicate that the hydraulic-conductivity values of the aquifer are fairly consistent with respect to depth (table 2). Values of hydraulic conductivity ranged from 1.96×10^2 to 4.38×10^2 ft/d. Values of specific yield ranged from 1.41×10^{-2} to 2.73×10^{-1}. The composite analysis indicates a hydraulic conductivity value of 2.54×10^2 ft/d and a specific-yield value of 2.64×10^{-1} (table 2, fig. 15).

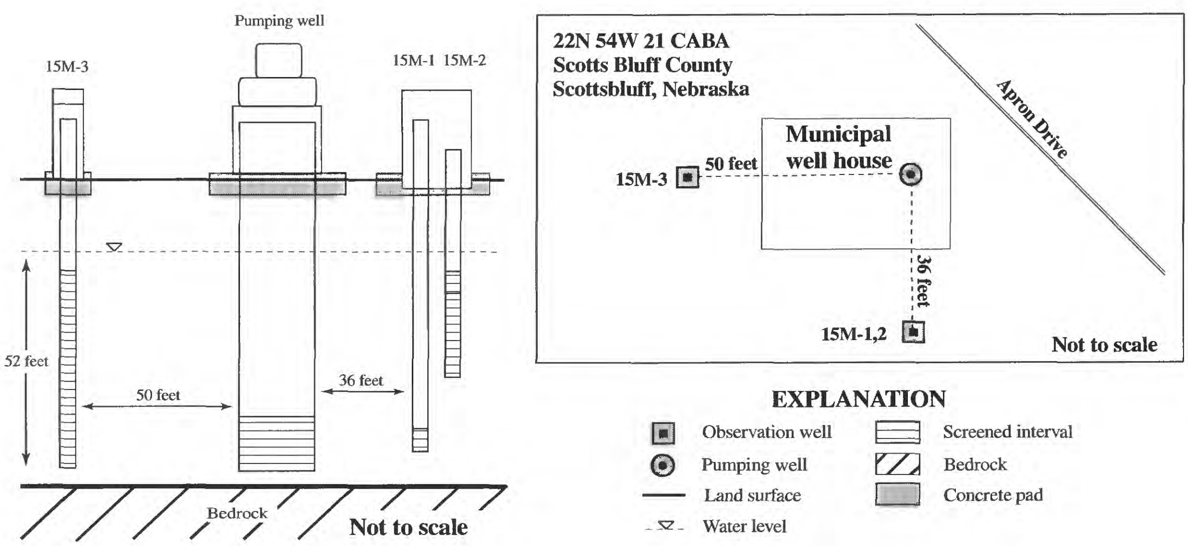

Figure 14. Diagrammatic cross section and plan view map showing the Scottsbluff Airport site.

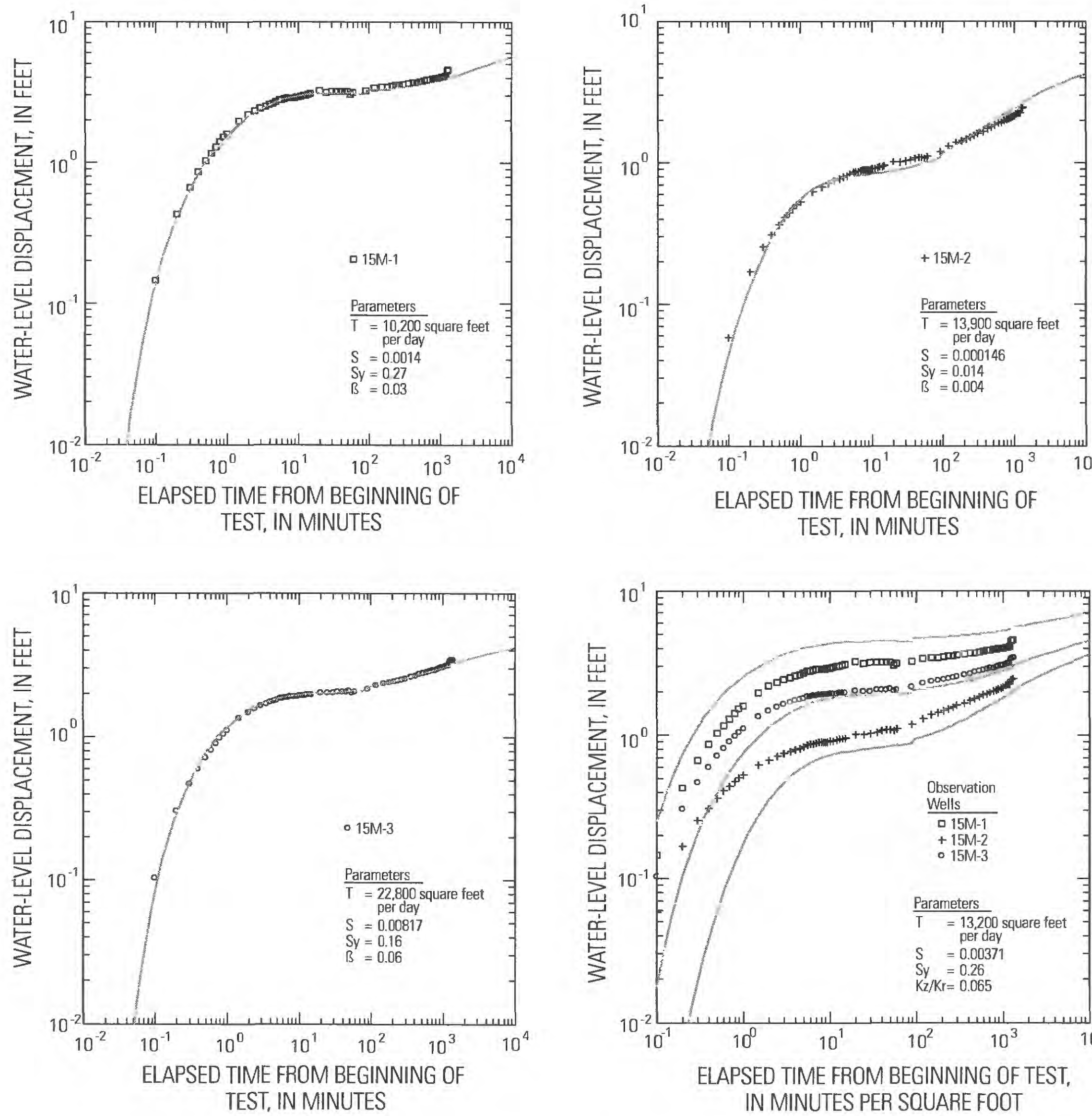

Figure 15. Log-log plot of drawdown versus time for the Scottsbluff Airport site.

SUMMARY AND CONCLUSIONS

Communities in the NPNRD use shallow ground water in alluvial aquifers as a source of drinking water. Between 1997 and 1998, the USGS, in cooperation with the NPNRD, conducted constant-discharge aquifer tests at seven sites to determine hydraulic properties of alluvial aquifers in the western part of the NPNRD. All aquifer tests were conducted for a minimum of 24 hours, and data were analyzed using Neuman's (1975) solution for water-table aquifers.

The hydraulic conductivity values ranged from 1.10×10^{1} to 8.40×10^{2} ft/d. Values of specific yield ranged from 1.00×10^{-2} to 3.20×10^{-1}. In some areas, responses to stresses on the system were instantaneous. In other areas, responses were delayed slightly.

At the Bayard site, the saturated thickness of the aquifer was about 126 ft and the hydraulic conductivity of the aquifer was fairly consistent with depth. The values of hydraulic conductivity ranged from 1.10×10^{1} to 1.33×10^{2} ft/d. Values of specific yield ranged from 2.46×10^{-1} to 3.00×10^{-1}.

At the Gering site, the saturated thickness was about 72 ft. The North Platte River lies about 160 ft north of the pumping well. Evaluation of drawdown data collected during the test indicated that the proximity of the North Platte River did not affect the test. The hydraulic conductivity was smallest at the observation well (14M–4) farthest from the North Platte River. Values of hydraulic conductivity ranged from 7.10×10^{1} to 8.40×10^{2} ft/d. Values of specific yield ranged from 5.00×10^{-2} to 2.55×10^{-1}.

At the Lyman site, the saturated thickness was about 99 ft. Analysis of the aquifer-test data suggests that induced recharge to the aquifer system from Horse Creek was negligible during the test and the hydraulic-conductivity value was larger in the shallow part of the aquifer than in the deeper part of the aquifer. Values of hydraulic conductivity ranged from 3.82×10^{1} to 3.24×10^{2} ft/d. Values for specific yield ranged from 1.00×10^{-2} to 1.14×10^{-1}.

At the Minatare site, the saturated thickness was about 180 ft. The hydraulic-conductivity values ranged from 5.89×10^{1} to 6.33×10^{2} ft/d and the specific-yield values ranged from 1.47×10^{-2} to 2.50×10^{-1}. Also, the hydraulic-conductivity values of the shallower part of the aquifer were smaller than those of the deeper parts.

At the Mitchell site, the saturated thickness was about 108 ft. Values of hydraulic conductivity ranged from 1.85×10^{1} to 5.03×10^{2} ft/d. The values of specific yield at this site ranged from 1.70×10^{-1} to 3.20×10^{-1}. The hydraulic conductivity and the storativity values of the shallower part of the aquifer were smaller than those of the deeper parts of the aquifer.

At the Morrill site, the saturated thickness was about 181 ft. Sheep Creek lies about 0.75 mi west of the site, but analysis of the aquifer-test data indicated that recharge to the aquifer from Sheep Creek was negligible during the test. The hydraulic conductivity ranged from 1.50×10^{1} to 5.89×10^{2} ft/d. Values of specific yield ranged from 2.50×10^{-1} to 3.00×10^{-1}.

At the Scottsbluff Airport site, the saturated thickness was about 52 ft. Aquifer-test results indicate that the hydraulic-conductivity values were fairly consistent with respect to depth. Here, values of hydraulic conductivity ranged from 1.96×10^{2} to 4.38×10^{2} ft/d. Values of specific yield ranged from 1.41×10^{-2} to 2.73×10^{-1}.

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