GROUND-WATER RESOURCES
OF KERSHAW COUNTY, SOUTH CAROLINA

STATE OF SOUTH CAROLINA
DEPARTMENT OF NATURAL RESOURCES

WATER RESOURCES REPORT 24

2002

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by

Roy Newcome, Jr.

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LAND, WATER AND CONSERVATION DIVISION
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GROUND-WATER RESOURCES OF KERSHAW COUNTY, SOUTH CAROLINA

by
Roy Newcome, Jr.

ABSTRACT

Kershaw County, S.C., has adequate ground water for considerable growth in the public, industrial, and irrigation supplies that rely on that resource. The county has a surface-water source in Lake Wateree, which supplies the towns of Camden, Lugoff, and Elgin. The ground water is thus mostly left for development by industries, farm irrigators, and the normal rural domestic users.

Aquifers in the county are of two basic types: 1) Paleozoic bedrock in the northwestern quarter of the county where the water occurs in fissures and generally supports only low-yielding wells; and 2) Cretaceous sand beds in the Coastal Plain formation (Middendorf) that thickens from 0 at the Fall Line to 350 feet at the southeast border. Wells in the latter can produce several hundred gallons per minute where the sand beds are of adequate thickness.

Water quality is usually good, both in the bedrock wells and the sand wells, although it is of different types. Water from rock wells is more mineralized and harder, with a near-neutral pH. The sand-aquifer water is remarkable in its similarity to rainwater–very soft and low in mineralization and with low pH.

INTRODUCTION

Kershaw County, S.C., lies just to the northeast of Richland County, in which residential communities and commercial developments are growing explosively in a northeastward direction. It is likely that presently existing public water supplies will be able to satisfy expanding demands of this growth, but small-industry, rural-domestic, and lawn-irrigation needs probably will be sought increasingly from more economical sources, such as private wells. Most of Kershaw County possesses an adequate source of ground water for these supplies, and in parts of the county considerably larger supplies are available for public-supply and industrial use and for farm irrigation.

The purpose of this report is to describe the ground-water resources and evaluate their availability, magnitude, and quality throughout the county. The files of the Department of Natural Resources (DNR) contain much information in the form of well drillers' records, geophysical logs of wells, chemical-quality analyses, and pumping tests that reveal aquifer properties. These have not previously been considered together to provide a comprehensive description of the county's ground water.

Location and Description of County

Kershaw County is just northeast of the geographic center of South Carolina. It comprises an irregular area of 722 square miles, most of which is in the Coastal Plain physiographic province. The Fall Line trends through the northwestern part of the county, leaving one-fourth of the county in the Piedmont physiographic province (Fig. 1). Latitude and longitude limits for the county are 34°04' to 34°37'N and 80°17' to 80°53'W. Adjacent counties are Lancaster on the north, Chesterfield and Lee on the east, Richland and Sumter on the south, and Fairfield and Richland on the west.

The principal drainage for Kershaw County is by means of the Wateree, Lynches, and Little Lynches Rivers, all of which are fed by a dense network of tributaries. Significant areas of swampland are adjacent to the major streams, especially the Wateree below Camden. Wateree Lake, formed behind the Wateree Dam 5 miles above Camden, occupies nearly 14,000 acres in Kershaw and Fairfield Counties.

Numerous U.S. Geological Survey topographic quadrangles provide complete coverage of Kershaw County (Fig. 2). The land surface ranges from flat to moderately rugged; most of the county could be categorized as rolling. The highest elevation is 620 ft (feet) above sea level, in the northwest near Stoneboro; the lowest is 125 ft on the southern boundary near the Wateree River.

Climate

The climate of Kershaw County is one of hot summers and mild winters, with long and pleasant springs and autums. Average temperatures are 78° F for summer and 44° F for winter. Extremes range, generally, between +100° F and +20° F. Prevailing winds are westerly or southwesterly. The growing season is about seven months long.

Rainfall averages 46 inches per year and is well distributed temporally. The wettest month is likely to be July, with about 5 inches; the driest October, with about 3 inches. Snow is rare.

Summer thunderstorms are common in the region. Atlantic hurricane effects are sometimes felt, but usually to a lesser degree than in the counties just to the south and east.

Population and Economic Development

The population of Kershaw County was 52,647 in 2000 (U.S. Census), a 21-percent increase since 1990. A formerly

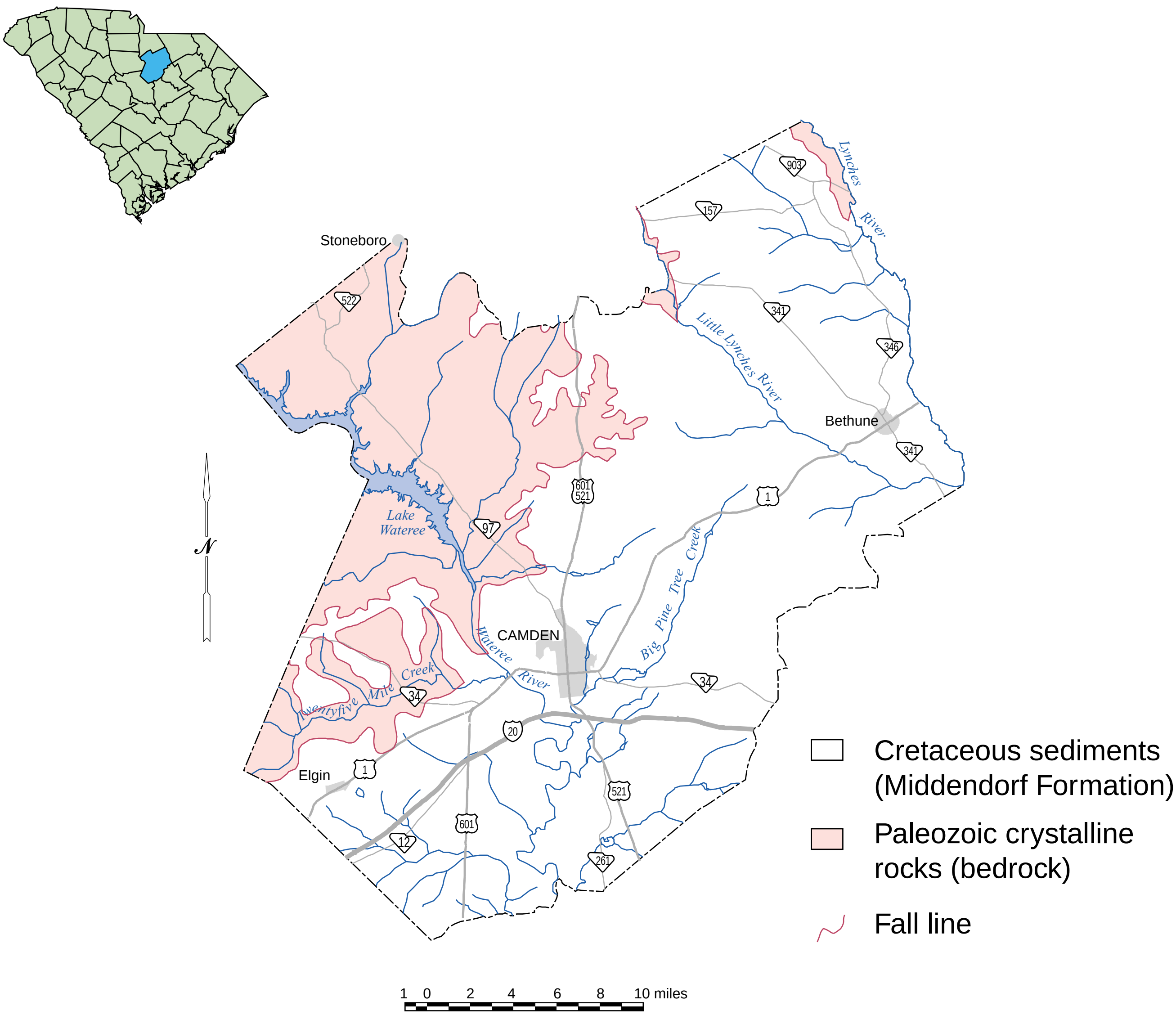

Figure 1. Areas of bedrock exposure and Middendorf Formation in Kershaw County.

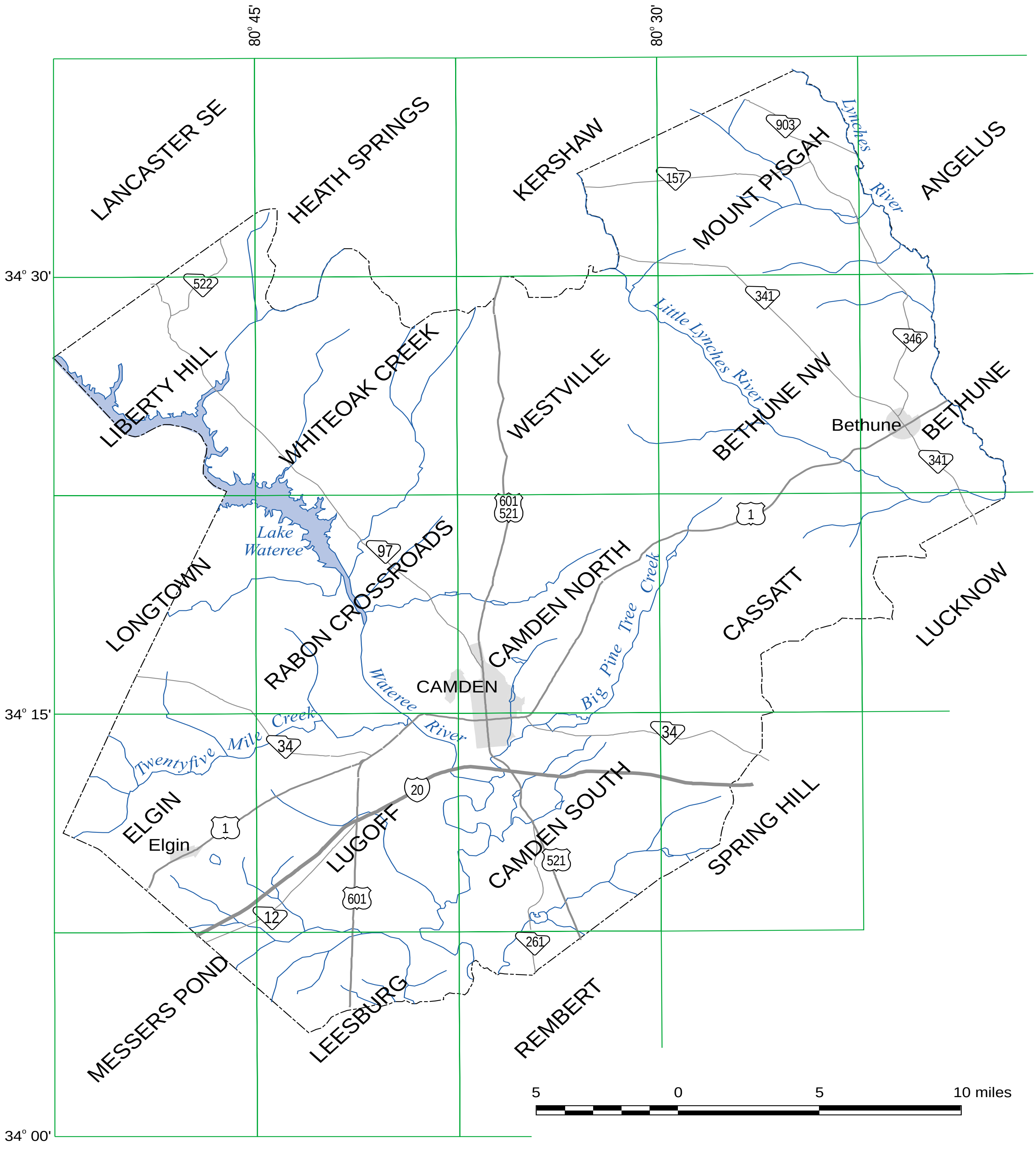

Figure 2. Topographic-map coverage of Kershaw County (U.S. Geological Survey 7 1/2-minute quadrangles).

agricultural county, it has become industrialized over the past several decades, with DuPont's May plant near Camden in the vanguard of development. Many of the county's citizens, as well as a generous supply from neighboring counties, travel to work each day at DuPont and smaller industries. At least 52 industries, employing 4,728 people, are listed on the Internet (www.TEAMSC.com, December 2001).

The largest towns are Camden, the county seat, (with 6,700 people), Lugoff (6,300), Elgin (800), and Bethune (350), according to the 2000 U.S. Census. These numbers could be misleading, because much of the population is outside the town limits. Population served by the public water systems is more revealing. The Camden water system serves nearly 15,000 people, the Lugoff-Elgin system more than 11,000, and the Bethune system about 700. Two other large public water systems, Bethune Rural Water and Cassatt Water Co., serve 2,100 and 22,000 people, respectively, although part of the latter system's customers live in Lee County, and several of their supply wells are in that county.

Besides the larger employers–the chemical and textile plants–poultry and animal-feed producers are important to the economy of Kershaw County. Many acres are devoted to tree farming, and there remains the traditional corn and soybean crop production. Cotton has not been a major crop since the 1940's.

Water Supply

Water use in Kershaw County averages about 22 mgd (million gallons per day). In 2000 the estimated use of water was, by type, industrial 13.3 mgd, public supply 7.3 mgd, crop irrigation 0.5 mgd, golf-course irrigation 0.5 mgd; and rural domestic supply 0.4 mgd.

Camden, Lugoff, and Elgin obtain their supplies from Lake Wateree. Bethune uses wells. In addition, Bethune Rural Water and the Cassatt Water Co. have far-flung rural systems supplied by wells. Camden, pumping an average of 3.0 mgd, ranks 40th in public water system size in the State. The Lugoff-Elgin Water Authority's average pumpage of 2.0 mgd ranks 60th, and the Cassatt Water Co., at 1.9 mgd, ranks 62nd (Newcome, 2000a). Many of the rural residents of Kershaw County have access to the public water supplies mentioned earlier. Nevertheless, many wells are drilled annually (nearly 300 in 2000) for domestic supplies and lawn irrigation.

Crop irrigation is not a major activity in the county. Less than 5,000 acres of crop land is irrigated.

Table 1 contains information on the wells currently in use or in standby status by the major public-supply systems of the county. Note that all of the Lugoff-Elgin system wells are in the standby (STB) category inasmuch as that system now employs Lake Wateree as a source.

HYDROLOGIC SETTING

Kershaw County contains two kinds of aquifers, crystalline rocks of Paleozoic age (500 million years old) and sand of late Cretaceous age (100 million years old). The first underlie the entire county, but exposures are restricted mainly to the northwestern part, above the Fall Line (Fig. 1). Fractures in the hard rocks transmit the ground water, usually in limited quantities. The surface of the crystalline rocks slopes toward the coast (southeastward) and is covered below the Fall Line by sandy, clayey, and limy formations.

In Kershaw County, alternating beds of sand and clay of Upper Cretaceous age overlie the bedrock. These beds have been correlated with the Tuscaloosa Formation, a well-established unit in the stratigraphy of the Gulf Coast. More recently, the formation in South Carolina has been called Middendorf, after its type locality in Chesterfield County, just northeast of Kershaw County. The stratigraphy of these sediments is currently being restudied, with the likelihood that the names Cape Fear and Cane Acre will be applied to them (pers. com. J.A. Gellici, DNR). For this report, the Upper Cretaceous part of the Coastal Plain section in Kershaw County is referred to as Middendorf Formation. The sand beds vary greatly in thickness and continuity but usually are capable of transmitting many times the quantities of water available from the underlying crystalline rocks. The thickness of the entire formation ranges from 0 to 350 ft in Kershaw County. As it dips coastward, the next overlying formation, commonly known as the Black Creek, covers the Middendorf southeast of Kershaw County. Their differentiation is usually on the basis of fossil evidence because these two formations are similar in lithology and in the quantity and chemical quality of the water that can be obtained from their sand aquifers.

Piedmont Rocks

Wells in the Piedmont section of Kershaw County are drilled in the hard crystalline rocks of igneous origin, usually referred to as "granite," whether they truly are granite or some other crystalline rock. In such rocks the location of water supplies is largely unpredictable and the yields low. Occasionally, however, a surprisingly large supply is achieved. Success depends on the drill hole intersecting a fracture zone that is sufficiently extensive or connected with other zones to provide a reliable supply of water.

The Piedmont rocks are the "bedrock" on drillers' logs of wells that start in the sand and clay of the Middendorf Formation. The structure-contour map (Fig. 3) is based on drilling logs and geophysical logs for Kershaw County. Used in conjunction with the topographic elevation of a specific site, this map will permit an estimate of the depth of drilling required to reach the bedrock.

Coastal Plain Sediments

The Coastal Plain sediments, mostly of Cretaceous, Paleocene, and Eocene ages, form a seaward-thickening wedge lying upon the crystalline bedrock. This wedge reaches a thickness of 4,000 ft at the southern tip of South

Table 1. Wells used in the major public water supplies serving Kershaw County, 2001 (from Newcome, 2001)

System	Well name	Owner no.	Depth (feet)	Yield (gpm)	Electric log	Chemical analysis	Pumping test	County number	SC grid number	Date drilled
Bethune	Blackmon St. (STB)	1	125					KER-145	23K-a1	10/1975
	Inside Treat. Plant	2	185	160				KER-88	23J-v1	6/1972
	Behind Treat. Plant	3	150	175			X	KER-270	23J-v4	9/1987
Bethune Rural Water	Road 111	1	180	190				KER-146	23J-s1	
	Best Rd	2	157	244		X	X	KER-148	23K-i1	2/1977
	Hwy 341	3	500	180		X	X	KER-149	24I-x2	11/1979
	Hwy 903	4	550	170		X	X	KER-150	24H-v1	11/1979
Cassatt Water Co.	Midway Well	1	95	200	X			KER-98	24K-q1	10/1975
	Elliot Lot	2	182	240	X	X	X	KER-262	24K-q3	12/1986
	Highway 1	3	92	165	X			KER-87	24K-p1	11/1970
	Shepard Tank	4	165	250	X		X	KER-258	25L-h2	2/1986
	Sycamore Rd. (STB)	5	400	60		X	X	KER-259	26L-i1	1985
	Friendship Rd. (STB)	6	260	110		X		KER-164	26L-n1	7/1978
	Joyner Lot	7	127	140				LEE-56	24M-k3	10/1980
	Cedar Creek	8	336	320		X	X	LEE-69	23M-j1	9/1985
	Baker Lot	9	127	210		X	X	LEE-55	23N-b3	11/1980
	Lucknow	10	263	210	X	X	X	LEE-36	23L-k1	5/1978
	Threatt Well	13	137	250	X		X	KER-275	25K-k1	10/1992
	Elliot Well	14	438	225	X	X		LEE-72	20N-p1	12/1991
	St. Charles Comm	15	458	270	X	X	X	LEE-73	21O-d1	1/1992
	Black River Rd.	18	160	300				KER-272	25M-m1	1980
	Singleton Cr. Rd.		280	120		X	X	KER-278	28J-q1	8/1996
	Arrowhead Rd.		300	110		X	X	KER-279	28J-w1	9/1996
Lugoff-Elgin WA	Blaney Hills Iva Rd. (STB)	1	224	200				KER-268	28M-v4	12/1989
	Bowen St. (STB)	2	205	100		X		KER-101	28M-w2	12/1970
	Hwy Church Rd. (STB)	3	145	100	X	X	X	KER-140	28N-il	12/1976
	White Pond Rd. (STB)	4	150	100	X	X	X	KER-141	28N-j1	4/1977
	Watson St. (STB)	6	178	240				KER-142	28M-v3	5/1988
	Green Hill Rd. (STB)	8	212	350	X			KER-252	28M-v2	7/1985

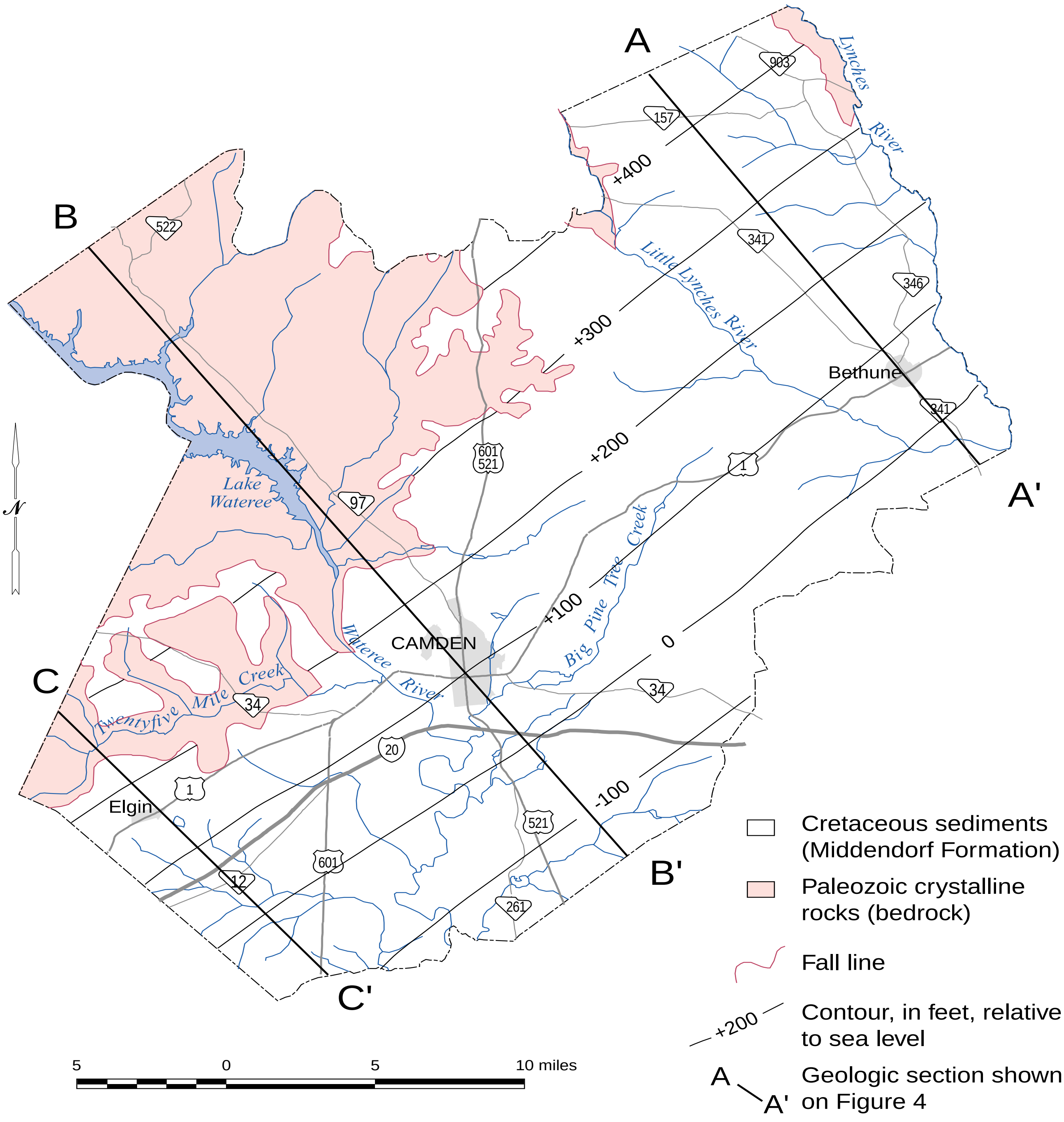

Figure 3. Contours on the top of bedrock where it is covered by the Middendorf Formation in Kershaw County.

Carolina, but the part of it in this county is no more than the 350 ft that represents the Middendorf Formation.

For a short distance below the Fall Line, the sand-and-clay sediments are too thin to be relied on for water supplies, and drilling usually continues into the bedrock. Reliable wells in sand aquifers must have not only a screenable thickness of aquifer but also sufficient available drawdown to provide the required supply. Available drawdown is the distance between the static (nonpumping) water level in the well and the top of the screen. Well depth is also a consideration in sanitary protection of the well, to facilitate sealing off possible paths for contaminants from the land surface or shallow-buried pollutants.

The geologic sections through Bethune (A-A'), Camden (B-B'), and Elgin (C-C') illustrate the southeastward thickening of the Coastal Plain beds (Middendorf Fm). See Figure 4.

Drainage

The northeastern quarter of Kershaw County is drained by the Lynches River, which forms the boundary with Chesterfield County. Its principal tributary is the Little Lynches River. The rest of the county is drained by the Wateree River and its tributaries Twentyfive Mile Creek and Big Pinetree Creek (Fig. 1). Wateree Lake receives all drainage from the bedrock streams of the county.

The Wateree River at Camden has a drainage area of about 5,100 square miles, not all of it in Kershaw County, of course. Annual mean flow of the Wateree at Camden, since 1930, has been 6,176 cfs (cubic feet per second) or 3,970 million gallons per day. The lowest annual mean flow occurred in the year 2000 and was 3,177 cfs. The lowest daily mean flow was 143 cfs on September 28, 1980. At the other end of the flow scale, the greatest instantaneous peak flow of record was 366,000 cfs on August 26, 1908. More detailed information on the Wateree at Camden can be found in Water Resources Data, South Carolina–Water Year 2000 (Cooney and others, 2000).

Recharge to Aquifers

The 46 inches of annual precipitation in the Kershaw county area is distributed as evapotranspiration (30 inches), runoff (14-15 inches), and ground-water recharge (1 inch or less). Runoff, as used here, includes direct runoff over the land following rainfall plus the later seepage from the soil and rocks into the streams. The part of this that infiltrates to maintain the water table is the ground-water recharge.

The water table generally mimics the topography and slopes toward the streams draining the aquifer outcrops. It is not under pressure, and water does not rise in wells that tap the aquifer. Where the aquifer is saturated and is covered by impermeable material, such as clay, its water is confined and is thus under pressure. The water table has then become a potentiometric surface, and water in wells rises to a level above the top of the aquifer.

Depending upon the effectiveness of a confining bed between two aquifers, there will be movement of water between the aquifers if their hydrostatic pressures are different, and the more difference there is in pressure, or head, the more water will be transferred. It is important to consider this in places where one aquifer may have inferior water quality or contaminants. The primary rule to remember is that water will always have a tendency to flow in the direction of lower head.

The bedrock aquifers of Kershaw County, which underlie the entire county, are recharged wherever water can seep directly from the surface into weathered zones and fractures or, more commonly, can seep through the overlying soil blanket and into the fracture zones. Once in the hard rock, the water is confined in the irregular fracture zones, many of which have been sealed, enlarged, or extended by weathering and geochemical processes.

The sand aquifers are more predictable, continuous, and productive. As mentioned earlier, they cover three-quarters of the county. Their thickness varies greatly, but they make up a substantial portion of the Middendorf Formation, which is 0 to 350 ft thick, depending on location. Recharge to these aquifers takes place by rain that falls directly on their outcrops or seeps through the soil and the thin deposit of Quaternary terrace material that caps some of the interstream areas.

Scattered arcuate bodies of eolian-deposited (windblown) sand older than the Quaternary terrace deposits and younger than the Cretaceous-age Middendorf Fm have commercial importance in the county. Known as "dune sand," this material exceeds 100 ft in thickness in some deposits and composes the well-known "Sand Hills" of the upper Coastal Plain in the Carolinas. Its origin is believed by some to be reworked sand of the Middendorf Fm.

The hydrologic significance of the Sand Hills probably is not great. Although they serve as a catchment for rainfall, the water drains through them and into the underlying Middendorf sand beds or outward into adjacent swamplands, ending its travel much as it would if the sand hills were not there.

WELLS

Open-Hole (Rock) Wells

In the bedrock area, of Kershaw County, "open-hole" wells are the rule. In these wells, casing (usually 6-inch, but larger for public-supply and industrial wells) is set into the rock and grouted with cement so as to provide a water-tight seal in conformance with regulations and standards promulgated by the South Carolina Department of Health and Environmental Control. For Kershaw County, records in DNR files indicate a range of 30 to 240 ft for casing depth, with a median depth of about 100 ft. Open-hole wells are not confined to the bedrock area. Some wells penetrate a substantial thickness of unconsolidated sand and clay of the Middendorf Formation and are completed in the underlying

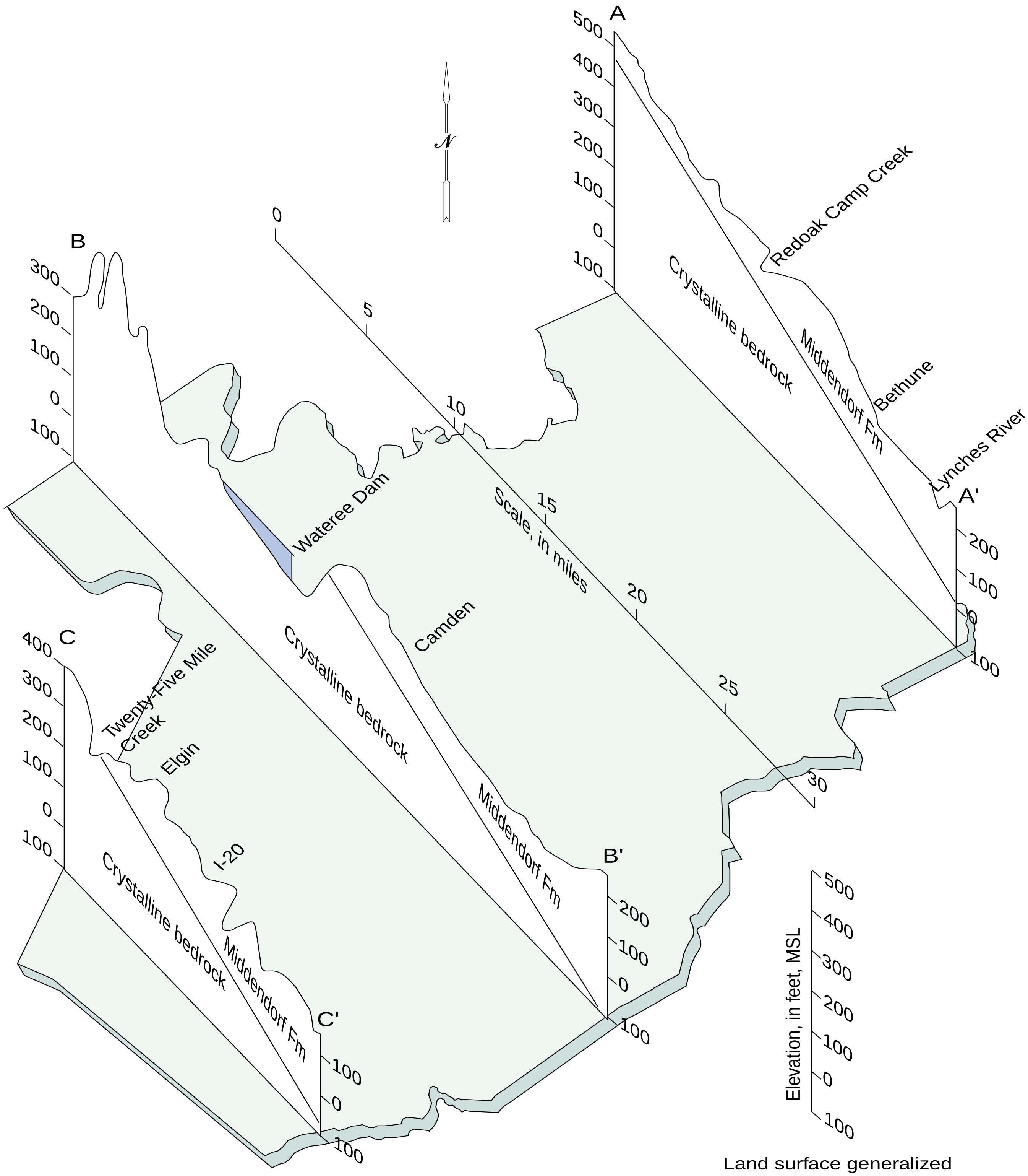

Figure 4. Geologic sections along the dip through Bethune, Camden, and Elgin.

bedrock. Casing would be installed to seal off the upper material.

Wells producing from bedrock aquifers range, generally, in depth between 115 and 625 ft, with a median depth just under 300 ft. Water levels in the wells typically stand within 50 ft of the land surface, but flowing wells are rare. The wells, almost invariably, are of low yield, generally less than 10 gpm (gallons per minute), although rare yields of 50 to 180 gpm are recorded.

Low-yield wells are nonetheless useful for many purposes, including domestic supply, if the water system is built with adequate tank storage or casing diameter. Inasmuch as 6-inch well casing holds 1½ gallons per foot of pipe, the water between the static level and the pump setting represents a reservoir that enhances the pumping yield. For example, if a well's static water level is 30 ft below land surface and the pump intake is at 60 ft, there are 45 gallons (30 x 1½) available before the pump has to rely only on inflow from the aquifer.

Screened (Sand) Wells

The greater proportion of wells in Kershaw County are "sand wells." Most are constructed with 4-inch casing and 20-30 ft of screen; they range, generally, between 40 and 250 ft in depth and are most commonly between 50 and 150 ft. Wells constructed for public-supply or industrial use nearly all have 6- or 8-inch casing and screen; a few are 10 or 12 inches in diameter. It is the practice to gravel-pack the sand wells to enhance the flow of sand-free water through the screen.

Static (nonpumping) water levels in the sand wells are less than 40 ft below land surface in half of the wells and between 40 and 80 ft in another third. There are very few flowing wells.

Because the overwhelming majority of wells in Kershaw County are used for rural domestic supply or lawn irrigation, they are not constructed or equipped to furnish large quantities of water. They are fitted with pumps that produce 10 to 30 gpm as a rule, even though many of the wells could provide much more.

More than 40 wells in Kershaw County have current or past yields of 200 to nearly 600 gpm. These wells supply industrial plants, public water systems, and farm irrigation systems. The largest producing wells, nearly 600 gpm, are used for irrigation at the Redbank Farm south of Camden. Groups of large wells are at Bethune and Elgin. The Cassatt Water Co. and Bethune Rural Water have several large wells along their rural water lines. Just outside of Kershaw County, in Chesterfield, Lee, and Sumter Counties, there are wells producing 900 to 2,000 gpm.

One of the heaviest concentrations of large-yield wells (300 gpm) is at the DuPont Plant just west of Camden. These wells are different from the others in that they are shallow (less than 45 ft deep) and on the bank of the Wateree River. They produce 300 gpm each from valley alluvium. Pumping-test results suggest that the proximity of the wells to the river permits a hydraulic connection that allows them to induce flow from the river.

Well Numbering

Wells in DNR files have county numbers assigned sequentially as their records are obtained, as KER-263. They also are given a number in the South Carolina Well Grid System that locates the wells to the nearest minute of latitude and longitude and assigns a sequential number within that minute. Thus, KER-263 has the grid number 24I-il, which would place it near the northeast corner of the county, as may be seen on Figure 5.

AQUIFER AND WELL HYDRAULICS

Bedrock Aquifers

Pumping tests of wells in the bedrock of Kershaw County have produced aquifer transmissivity values of 180 to 2,800 gpd/ft (gallons per day per foot of aquifer width). A median value of 700 is indicated, which is of use primarily for comparison with the much higher transmissivity demonstrated by tests of the sand aquifers. Aquifer hydraulic characteristics in the bedrock probably are of little use in predicting well performance or pumping effects, inasmuch as permeable zones are untraceable over even short distances. Water, more likely, is "where you find it."

Specific capacities of bedrock wells tested are very low, usually less than 1 gpm per foot of drawdown (based on a 1-day pumping period).

Sand Aquifers

Twenty-three pumping tests of wells screened in confined aquifers in and near Kershaw County (Table 2) gave transmissivity values ranging from 1,200 to 100,000 gpd/ft, with a median of 21,000. Where the aquifer has this median transmissivity, a properly constructed well could have a specific capacity as great as 10 gpm per foot of drawdown. For a hypothetical well in which the static water level is at 30 ft and the top of the well screen is at 80 ft, a 50-ft drawdown is available. Such a well could produce 500 gpm.

Aquifer transmissivity (T) is the product of aquifer thickness times hydraulic conductivity (K); therefore the values given above incorporate variable thicknesses and variable K's. Most wells screen less than the full thickness of available aquifers, and calculated K values for the Middendorf Formation in this area range from 50 to 700 gpd/ft^2 (gallons per day per square foot of aquifer). A median value of 420 is indicated. To put this K value in perspective, a figure of 300 gpd/ft^2 would be indicative of an average satisfactory aquifer, 100 would be low but usable, and 700 would be excellent. The following example will illustrate the significance of the mean K of 420 gpd/ft^2**:**

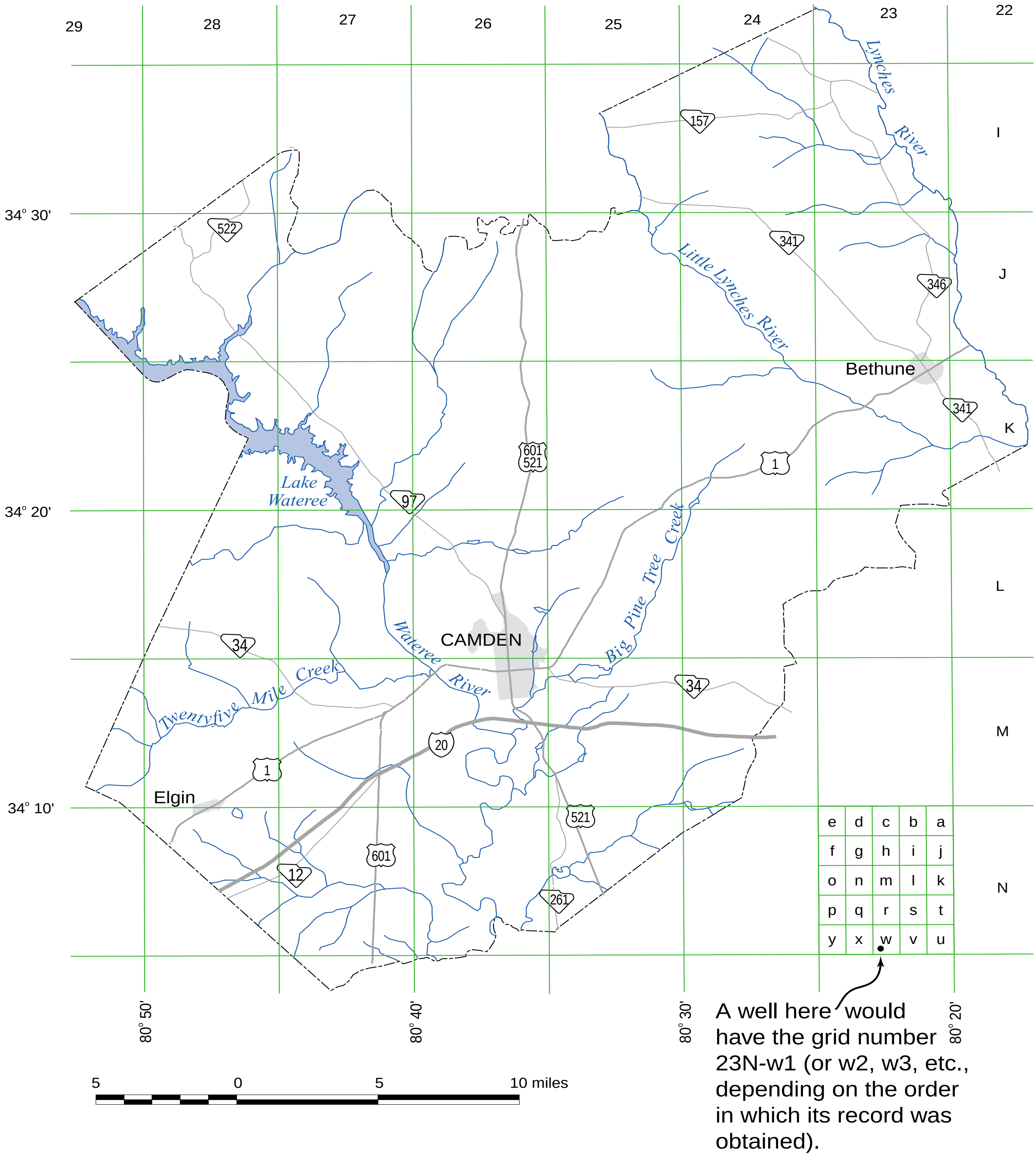

Figure 5. South Carolina grid system as it applies to Kershaw County.

Table 2. Results of pumping tests of wells producing from the Middendorf Formation in and near Kershaw County (from Newcome, 2000b)

County well number	S.C. grid number	Location	Electric log	Depth (ft)	Aquifer thickness (ft)	Date of test	Duration (hr) (dd/recov)	Static water level (ft)	Pumping rate (gpm)	Transmissivity (gpd/ft)	Storage coefficient	Specific capacity (gpm/ft)	Well efficiency (percent)	Hydrologic boundary
						KERSHAW COUNTY								
KER-19	23J-u2	Bethune, 3/4 mi NE		194	60	9/2/53	46/20	20	300	3,000	0.0002	2.6	100	Recharge
KER-139	25M-n1	Camden, 3 1/2 mi SE		139	55	6/5/78	24/1	15	102	6,400		3.0	95	
KER-140	28N-i1	Elgin, 2 1/2 mi S	X	145	90	12/15/76	24/1.5	51	150	8,600		2.4	55	Recharge
KER-141	28N-j1	Elgin, 3 mi SE	X	150	40	4/20/77	24/1	53	150	3,400		2.2	100	
KER-148	23K-i1	Bethune, 1 mi SSW		157	80	2/3/77	24/2	42	300	36,000		7.5	40	
KER-159	25L-c1	Camden, 6 1/2 mi NE (Shepard)	X	175	30	1/18/83	24/0.5	102	250	16,000		9.3	100	
KER-258	25L-h2	Camden, 5 mi NE	X	165	55	2/1986	24/	78	410	30,000		15	100	Recharge
KER-262	24K-q3	Cassatt, 2 1/2 mi WSW	X	182	40	12/1986	24/3	97	375	24,000		10	80	Recharge
KER-270	23J-v4	Bethune, NW edge		150	—	9/14/87	24/1	20	178	17,000		4.1	45	Recharge
KER-275	25K-k1	Cassatt, 4 mi W	X	137	65	10/12/92	24/5	33	305	22,000		12	100	
						CHESTERFIELD COUNTY								
CTF-79	20J-g1	McBee, 6 1/2 mi E	X	260	85	10/1/91	24/	111	250	47,000		6.2	25	
CTF-80	20I-v1	Patrick, 5 mi SW	X	335	115	9/23/91	24/	116	250	66,000		8.5	25	
CTF-83	22J-t1	McBee, 1 1/2 mi S	X	358	125	6/9/95	24/12	135	400	81,000		6.1	15	
						LEE COUNTY								
LEE-36	23L-k1	Lucknow (water tank)	X	263	100	5/18/78	21/	42	268	21,000		2.4	25	
LEE-55	23N-b3	Mannville, 3 mi W		130	—	1/1981	24/1	35	454	36,000		17	100	
LEE-69	23M-j1	Bishopville, 5 mi W		336	—	9/1985	24/3.5	49	500	78,000		22	65	Discharge
LEE-74	21K-v1	Bishopville, 9 1/2 mi NNE		445	100	4/1/93	25/.5	122	900	70,000		35	100	
LEE-79	22M-l1	Bishopville (Piedmont Road)		347	—	2/13/95	24/1.8	36	806	100,000		42	95	
						RICHLAND COUNTY								
RIC-502	29N-h2	Pontiac, 1 1/2 mi NW		135	19	8/21/85	2.5/2	70	14	4,800		1.9	85	
RIC-506	29N-p1	Pontiac, 3 1/2 mi SW	X	130	50	7/2/86	4/2.5	65	150	21,000		5.7	55	
RIC-508	29N-p3	Pontiac, 3 mi WSW		222	—	3/19/86	4/4	125	25	1,200		0.6	100	
RIC-511	30N-t3	Pontiac, 3 3/4 mi WSW		180	—	3/7/86	4/4	109	22	11,000		1.6	30	
RIC-525	30N-k1	Pontiac, 3 1/2 mi WSW	X	100	30	8/7/88	2/9	71	26	14,000		4.1	60	

Note: Although transmissivity is given here in gallons per day per foot of aquifer width, it is frequently reported in feet squared per day; the latter can be obtained by dividing the former by 7.48, the number of gallons in a cubic foot.

> Assume 50 ft of aquifer thickness and a static water level 20 ft below ground level. If the top of the screened interval is at 75 ft, there would be available drawdown in the amount of 55 ft A fully efficient well in this situation could produce 575 gpm; a well only 75-percent efficient could produce 430 gpm.

The foregoing example argues for the reasonableness of expecting well yields of 500 gpm or more from the Middendorf Formation, especially in the southeastern part of the county where the formation is at its thickest. To realize this kind of well yield, it is encumbent on the engineer or driller to use care and good judgment in designing a well that takes advantage of the natural situation. This means (1) careful analysis of the materials penetrated in drilling; (2) obtaining and correctly interpreting an electric log of the hole; (3) selecting the optimum screen length and opening size; (4) sizing the gravel-pack material to the aquifer; and (5) developing the well over sufficient time to enhance the hydraulic conductivity of the aquifer in the vicinity of the well.

It is worth noting that sources of recharge were indicated by five of the pumping tests listed in Table 2 (see last column). The occurrence of recharge means that the rate of drawdown will be reduced after the recharging effect occurs. Such an effect could be caused by abrupt thickening of the aquifer or interception of a surface-water body by the spreading cone of depression caused by pumping. One test showed a discharging boundary (barrier to flow). This could have been caused by abrupt thinning or pinching out of the aquifer or interference by other pumping in the area.

Unconfined, or water-table, aquifers generally are not sources for large-yield wells. They are shallow in depth, and therefore the wells lack the available drawdown necessary for large production.

Well Interference

In choosing sites for new wells, the effects of pumping should be considered. If multiple large wells are not adequately spaced, their pumping effects on one another (increased depth to water) will reduce the amount of water available and increase the cost of pumping. The pumping-interference graphs of Figure 6 (a, b) are presented as a suggested guide for spacing wells in the sand aquifers of Kershaw County. The well-field planner will need to consider, for each well, the water-level drawdown caused by pumping that well plus the drawdown caused by other wells. To do this, a knowledge of the aquifer transmissivity in the locality is required. This can be obtained by means of a pumping test or by computation, using an estimated hydraulic conductivity and known aquifer thickness. The latter means should be resorted to only if it is not feasible to obtain pumping-test data.

The graphs of Figure 6 presuppose that no extraneous sources of recharge nor barriers to flow are encountered. The former would result in less drawdown and the latter in more.

POTENTIAL WELL YIELDS

It is not possible, at present, to predict potential well yields in the bedrock aquifers. As stated earlier, water in the rocks is "where you find it." It is safe to say, however, that yields seldom exceed 20 gpm, and it is rare indeed to obtain more than 100 gpm. A few noteworthy wells yield substantially more than 100 gpm (see Table 1).

The sand aquifers present an altogether different picture. In the southeastern half of Kershaw County, 50 to 200 ft of sand that can be expected to provide moderate to large supplies is generally available. Thickness increases in the direction of formation dip – that is, toward the southeast (Fig. 7). Of course, the thicker the aquifer the more water it usually can supply. A thin aquifer composed of coarse sand might supply more than a thick one of fine sand, but the thicker aquifers typically are also coarser.

Two features of a well determine how much water it can produce. They are (1) specific capacity and (2) available drawdown. *Specific capacity*, mentioned briefly under "Aquifer and Well Hydraulics," is dependent on aquifer transmissivity and well efficiency and is the number of gallons per minute the well will produce for each foot of water-level drawdown. *Available drawdown* is the interval between the static (nonpumping) water level and the top of the well screen. It is undesirable to lower the water level below the top of the well screen, because aeration of the screen can promote screen corrosion and encrustation and can cause both chemical and bacteriological degradation of the water and aquifer. The graphs of Figure 8 show the well yields that can be expected from various combinations of specific capacity and available drawdown.

WATER QUALITY

Bedrock Wells

The water from bedrock wells in Kershaw County is generally potable, with dissolved-solids concentrations usually less than 200 mg/L (milligrams per liter) and pH between 7 and 8. Hardness is variable, ranging from very soft to hard. There seems to be no relation between depth and mineralization, depth and hardness, nor depth and pH, at least in the available chemical analyses (see Table 3). Locations of the wells for which analyses appear in Table 3 may be seen on the map of Figure 9.

Bedrock water is palatable unless it is affected by excessive concentrations of certain minerals or by pollutants. Because it flows through cracks and crevices in the rocks, there is little or no filtration, so it is subject to contamination from local or distant sources. Such contamination has not been a common problem in Kershaw County.

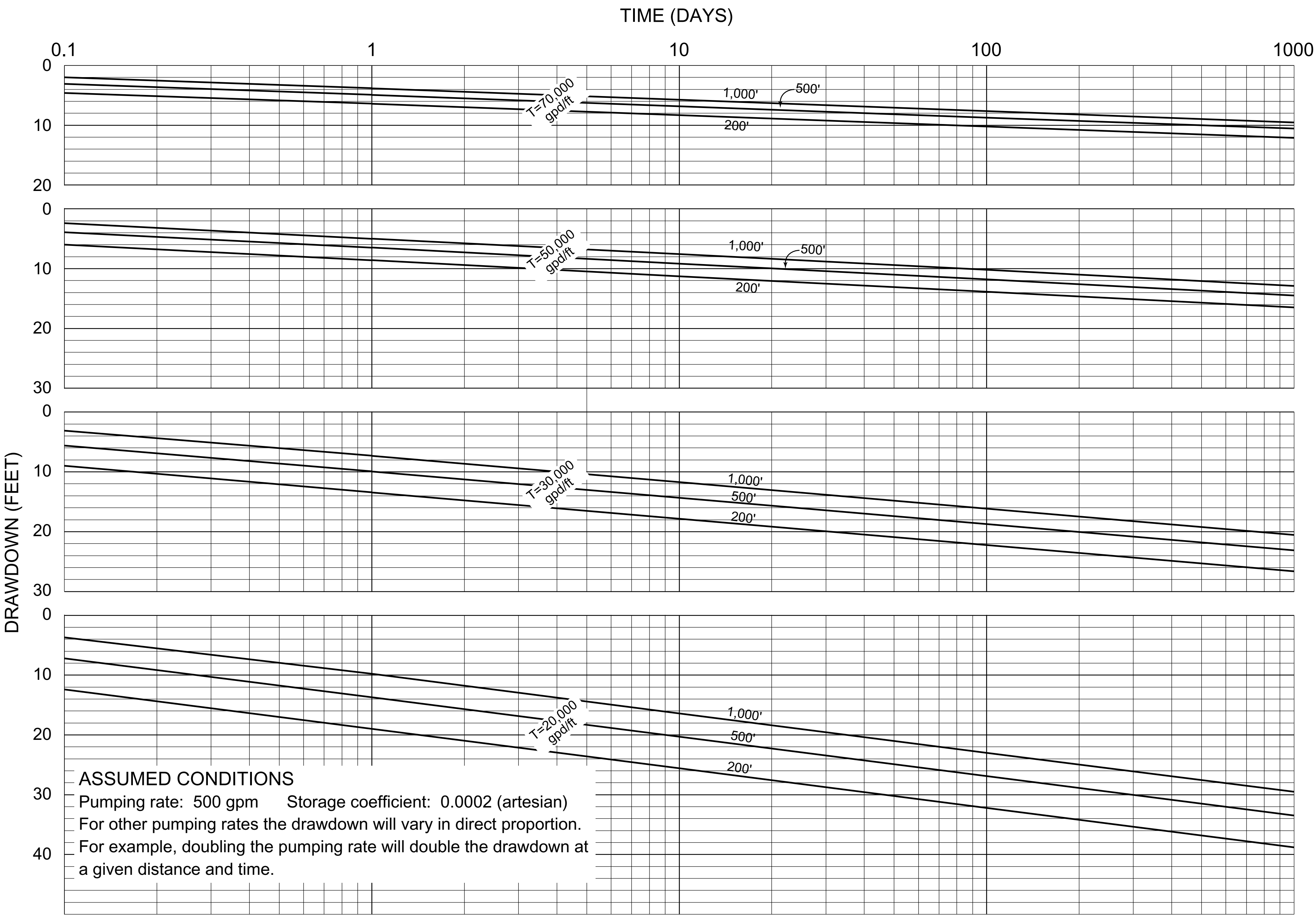

Figure 6a. Predicted pumping effects at various distances and times for the Middendorf Formation in Kershaw County. Transmissivities of 20,000 to 70,000 gpd/ft and a pumping rate of 500 gpm.

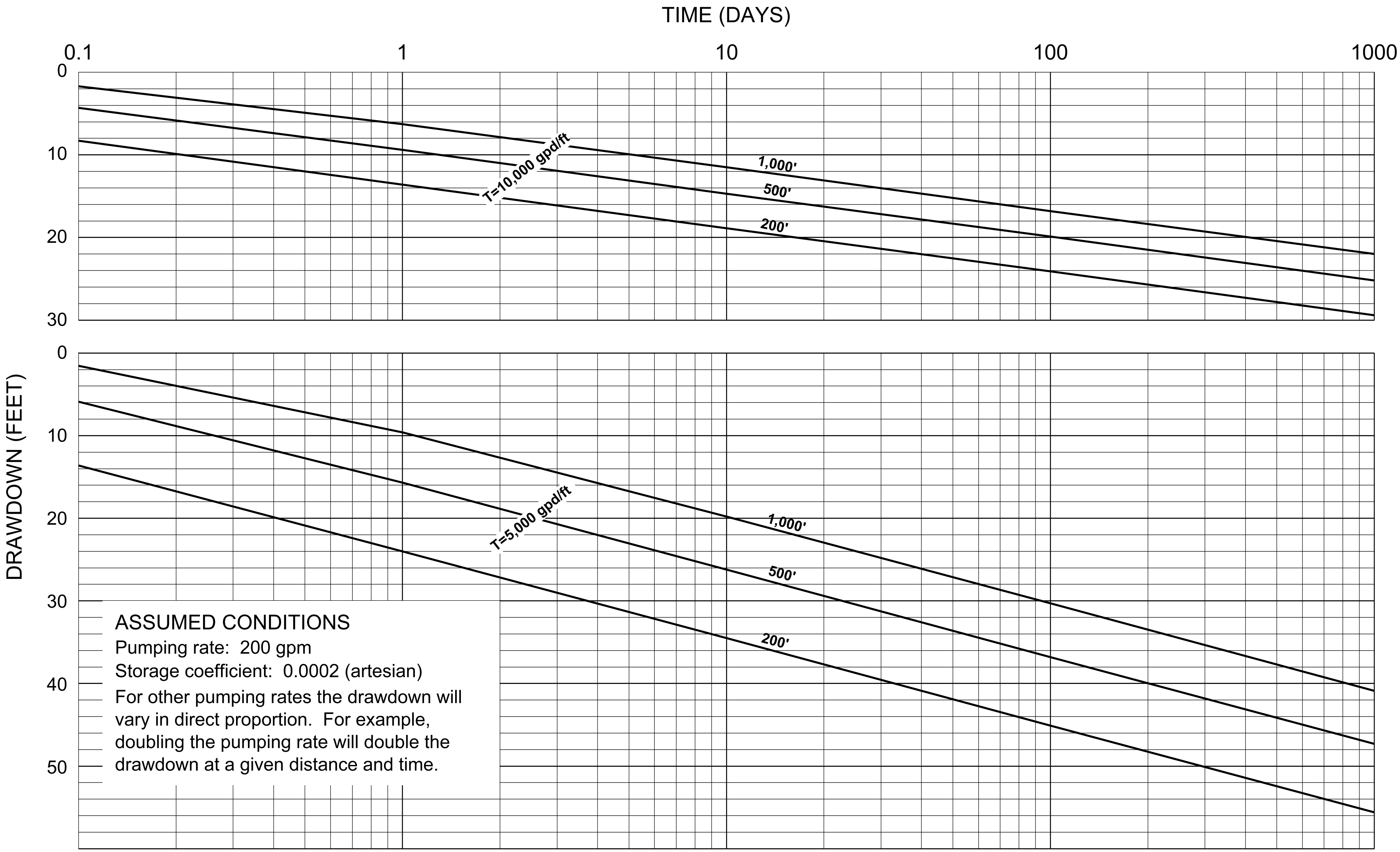

Figure 6b. Predicted pumping effects at various distances and times for the Middendorf Formation in Kershaw County. Transmissivities of 5,000 and 10,000 gpd/ft and a pumping rate of 200 gpm.

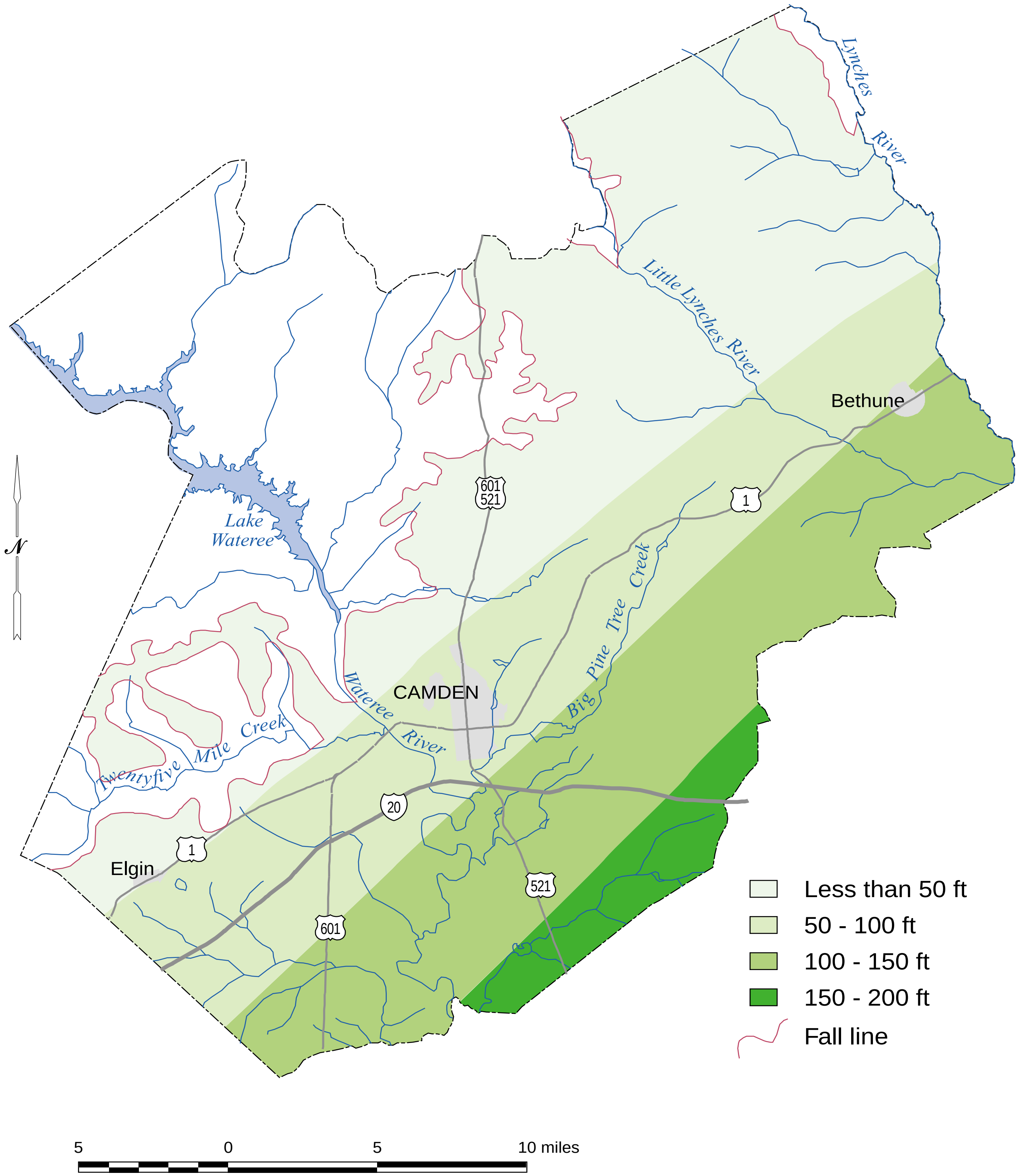

Figure 7. Aggregate thickness of sand aquifers in the Middendorf Formation in Kershaw County.

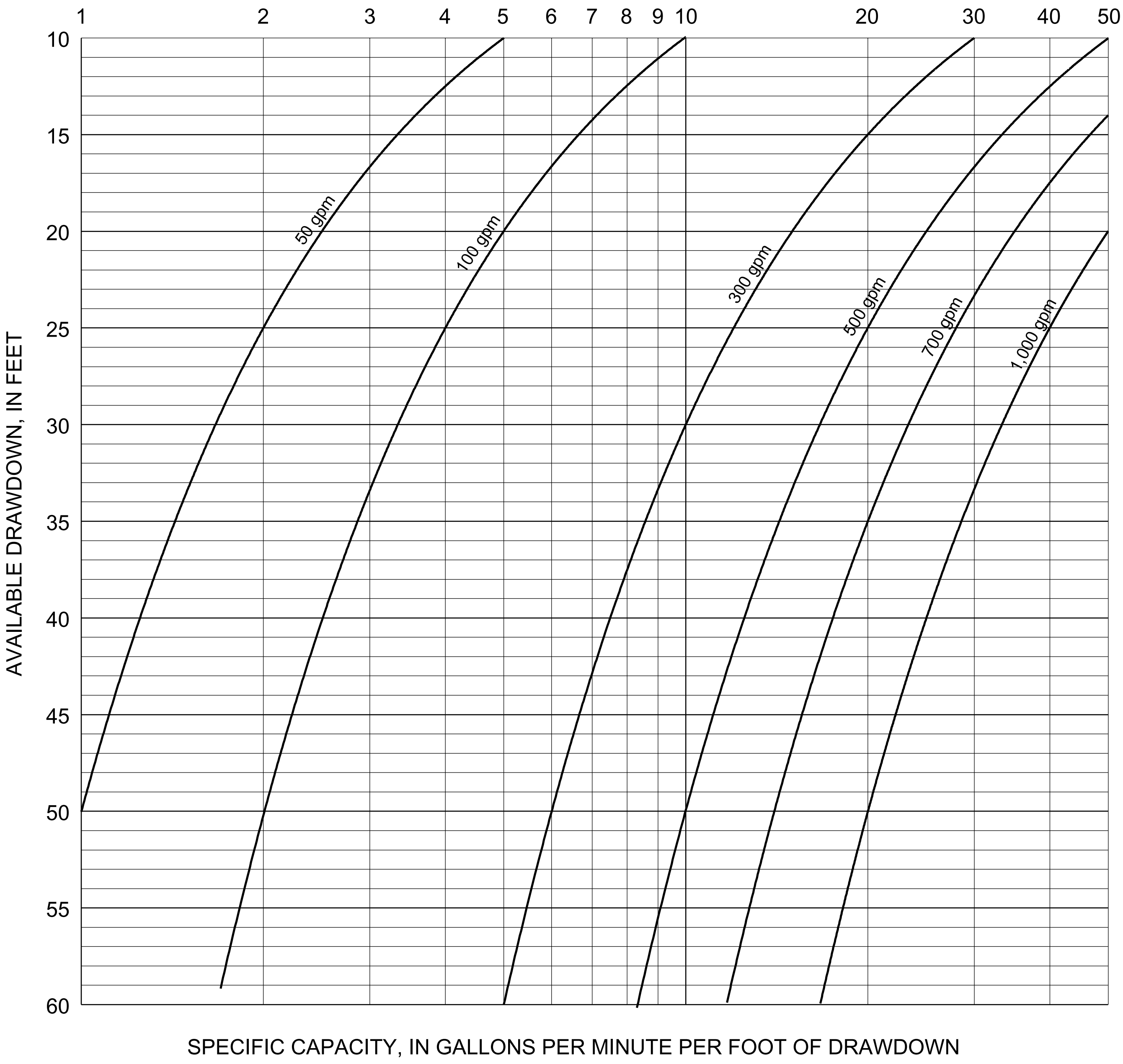

Figure 8. Well yields for various specific capacities and available drawdowns.

Table 3. Chemical analyses of water from wells in Kershaw County
(constituents are in milligrams per liter, essentially the same as parts per million)

County well no.	S.C. grid no.	Location	Date	Depth (ft)	Silica	Iron	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Sulfate	Chloride	Fluoride	Nitrate	Dissolved solids	Hardness	pH	Analyst**
ROCK WELLS																			
107	27M-t4	Lugoff, 2 mi S	9/78	305		0.13	3.4	5.5			74*		12	0.6			32*	7.9	Com
109	27M-t7	Lugoff, 2 mi S	2/80	484		0.06	37.0	8.3	21.0	2.8			1.4			262	120		SCWRC
149	24I-x2	Kershaw, 6 1/2 mi ESE	12/70	500		0.05	<1.0			3.0	60*	1.0	2.0	0.2	<.02	62	<5*	7.4	Com
150	24H-v1	NE corner of county	12/79	556		<.20	<1.0			3.6	72*	1.0	2.0	<.5	<.07	70	<5*	7.3	Com
152	24I-y2	Kershaw, 6 mi ESE	11/79	500		<.10	1.4			0.2	91*	0.6	2.0	0.1	0.06	34		8.0	Com
155	27M-j1	Lugoff, 1/2 mi NE	10/80	425		1.80	15.0	7.3	13.0	2.5	134*	3.4	2.0	0.2	<.10	150	69	8.0	Com
156	27M-j2	Lugoff, 1/2 mi NE	5/81	625		0.02	11.0	5.5	39.0	2.6	145*	1.5	1.8	0.5	<.10	156	52*	7.8	Com
158	28J-g2	Liberty Hill, 3/4 mi SW	4/74	420		<.05	21.0	4.6	16.0	1.4	109*		13	1.0			72		Com
163	26K-b1	Westville, 2 1/2 mi S	7/81	140		0.80	13.0				130*		4.5		0.36	120	77	7.6	DHEC
164	26L-g1	Camden, 4 mi NNW	9/81	260		0.10	12.0				77*		3.0			120	46	7.8	DHEC
165	27K-e1	Liberty Hill, 5 1/2 mi SE	9/81	600		0.10	12.0				76*		2.5			130	51	7.7	DHEC
259	26L-i1	Camden, 2 1/2 mi N	9/85	400		0.19	1.7			2.9	72*	2.0	1.0	0.3	0.02	63*		7.4	Com
278	28J-q1	Liberty Hill, 2 1/4 mi S	9/96	280		<.05	46.0	5.5	17.0	1.2	156*	4.3	16	1.2	0.02	180	137	7.3	Com
279	28J-w1	Liberty Hill, 3 1/2 mi SSE	9/96	300		0.01	9.2	2.1		1.1	43*	0.6	1.9	0.3	<.01	150	31*	7.7	Com
SAND WELLS																			
11	23K-a2	Bethune	3/46	165		0.23					3	1.0	4.0	0.1	9.20		24		USGS
19	23J-u2	Bethune, 1 mi NE	9/53	194	7.9	0.07	1.5	0.8	(1.8)		6	2.6	2.0	0.1	0.30	20	7	5.6	USGS
101	28M-w2	Elgin, 1/2 mi W	6/97	205	5.4	0.21	1.4		2.6	0.45	4.3	2.2	3.3	0.1	0.76	19	5.4	5.2	USGS
139	25M-n1	Camden, 3 1/2 mi SE	1/79	139	3.0	0.00	4.0	1.0	(3.6)		13	0.0	8.0	0.1		26	14	5.7	Com
140	28N-i1	Elgin, 2 1/2 mi SSE	12/76	145	8.0	0.01	1.6	0.1	(2.6)		8.6	0.0	3.0	0.1		17	6	6.2	Com
141	28N-j1	Elgin, 2 3/4 mi SE	4/97	150	5.3	0.25	0.43			0.32	2.3		1.6	0.1	0.84	12	2.5*	4.8	USGS
143	28M-x1	Elgin, 1 mi WSW	6/97	210	5.6	0.05	0.51		3.0	0.22	2.5		1.9	0.1	0.94	15	3.6*	5.0	USGS
148	23K-i1	Bethune, 1 1/4 mi SW	2/77	157	6.4	0.01	1.2		(5.7)		9.8	0.8	2.0	0.1	7.30	26	5.3	4.6	Com
159	25L-c1	Camden, 6 1/2 mi NE	2/83	175		<.01	0.14		2.5	0.36	0	<1.1>	2.0	<.1	0.94	8	1.4	4.3	Com
262	24K-q3	Cassatt, 2 3/4 mi WSW	1/87	182		<.01	0.18		1.4	0.16	0	<1.1>	2.0	<.1	0.80	10*	1.0	4.2	Com

* Calculated by the author.
** Analyst: Com (Commercial); SCWRC (S.C. Water Resources Commission); DHEC (S.C. Dept. of Health and Environmental Control); USGS (U.S. Geological Survey)

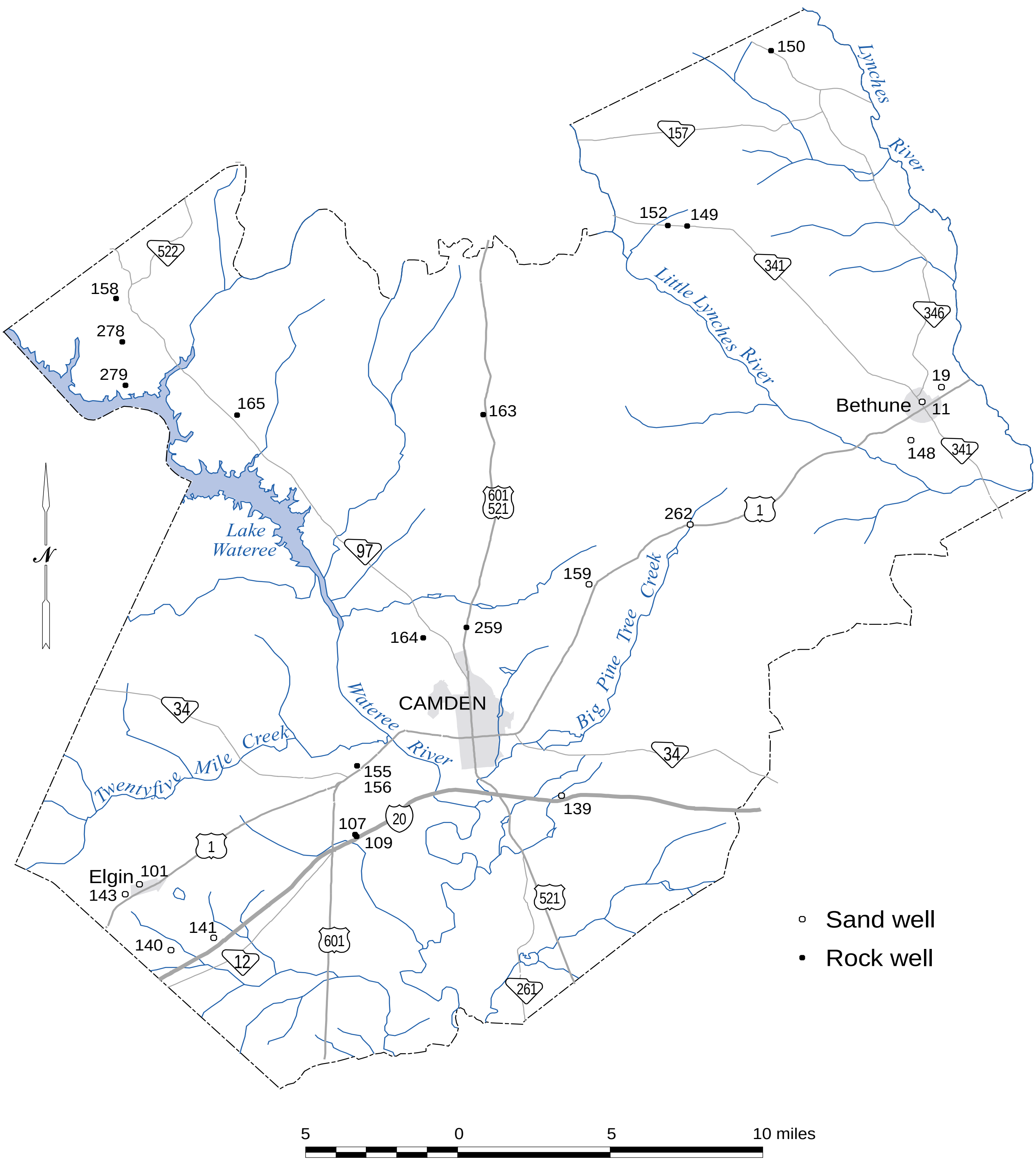

Figure 9. Locations of ground-water chemical analyses listed in Table 3.

Sand Wells

Water quality in the sand wells is remarkable for its similarity to that of rainwater. A dissolved-solids concentration as high as 30 mg/L would be unusual, and the pH is nearly always well under 6, 4 to 5 being the common range. Hardness also is extremely low, usually less than 10 mg/L.

The acidity of the water can cause corrosion of metal well and plumbing parts, and this may produce a rusty color and taste of iron in the water supply. The growth of iron-producing bacteria (Crenothrix) is sometimes a problem in the sand wells. It often is difficult to ascertain the cause of this, whether it is in the aquifer, is introduced in the drilling process, or is fostered by lowering the water level below the top of the well screen. The use of plastic (PVC) casing, well screen, and plumbing pipes reduces the corrosion potential, and careful sterilization of the well during development is important in controlling bacteriological problems.

The sand aquifers of the Middendorf Formation generally have the capacity to support crop-irrigation wells, and the water, being so similar to rainwater, is eminently suitable for this purpose.

SUMMARY

Wells in Kershaw County obtain their water from Paleozoic crystalline rocks or from sand aquifers in the Cretaceous-age Middendorf Formation. Rock wells usually are of low yield, but the water is of good chemical quality. All water supplies in the northwestern quarter of the county are obtained from these wells. Ground-water supplies in the rest of the county come from wells in the sand aquifers. Well yields of several hundred gallons per minute are obtained in places where adequate sand thickness is available. This water is practically indistinguishable from rainwater.

The ground-water resources of Kershaw County are capable of supporting considerable additional development for public, small-industry, and farm-irrigation supplies. Because of the variability of aquifer thickness, efforts to obtain moderate to large well yields should be guided by careful drilling and testing programs.

SELECTED REFERENCES

Aucott, W.R., Davis, M.E., and Speiran, G.K., 1987, Geohydrologic framework of the Coastal Plain aquifers of South Carolina: U.S. Geological Survey Water-Resources Investigations Report 85-4271.

Colquhoun, D.J., and others, 1983, Surface and subsurface stratigraphy, structure and aquifers of the South Carolina Coastal Plain: University of South Carolina, Department of Geology.

Cooney, T.W., Drewes, P.A., Ellisor, S.W., and Melendez, Frank, 2000, Water resources data, South Carolina–Water year 2000: U.S. Geological Survey Water Data Report SC-00-1.

Newcome, Roy, Jr., 2000a, The 100 largest public water supplies in South Carolina–2000: South Carolina Department of Natural Resources Water Resources Report 21.

_____2000b, Results of pumping tests in the Coastal Plain of South Carolina (Supplement to Water Resources Commission Report 174): South Carolina Department of Natural Resources Open-File Report 5.

_____2001, Wells used by the major public water supplies of South Carolina's Coastal Plain: South Carolina Department of Natural Resources Open-File Report 8.

Park, A.D., 1980, The ground-water resources of Sumter and Florence Counties, South Carolina:South Carolina Water Resources Commission Report No. 133.

Soller, D.R., and Mills, H.H., 1991, Surficial geology and geomorphology; Chapter 17 *in* Horton, J.W., Jr., and Zullo, V.A., Geology of the Carolinas: Carolina Geological Society, Fiftieth Anniversary Volume, ed. by J.W. Horton, Jr., and V.A., Zullo, p. 290-308.

U.S. Department of Agriculture, 1977, Geologic map of South Carolina: Soil Conservation Service.