POTENTIOMETRIC SURFACE OF THE MIDDENDORF AQUIFER IN SOUTH CAROLINA

NOVEMBER 2009

STATE OF SOUTH CAROLINA
DEPARTMENT OF NATURAL RESOURCES

LAND, WATER AND
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Brenda L. Hockensmith

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STATE OF SOUTH CAROLINA
The Honorable Nikki R. Haley, Governor

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ABSTRACT

The potentiometric surface of the Middendorf aquifer for November and December 2009 shows that the generally southeastward ground-water flow is affected by several potentiometric lows. These cones of depression have developed because of ground-water pumping around Florence, Hemingway, Kingstree, Mount Pleasant, and Kiawah Island.

Comparing the 2009 data with historical data shows that water levels near the outcrop areas of this aquifer have not changed significantly. In areas influenced by pumping, water levels have declined as much as 278 feet during various periods of record. The cone of depression at Mount Pleasant has recovered as much as 99 feet since 2004 because of surface-water augmentation of public supplies.

INTRODUCTION

The Middendorf aquifer is the source of water for many public, industrial, and agricultural supplies in the Coastal Plain of South Carolina. This important water resource is monitored by regularly measuring the nonpumping water levels in wells. The potentiometric surface of an aquifer is defined by the elevations at which water stands in tightly cased wells completed in the aquifer. This potentiometric-surface map was prepared by the Land, Water and Conservation Division of the South Carolina Department of Natural Resources (DNR), using data collected during late 2009. Trends in ground-water levels for selected wells are shown by hydrographs.

METHOD OF INVESTIGATION

The boundaries of the Middendorf aquifer used in this investigation are those defined by Aucott, Davis, and Speiran (1987), who delineated the aquifer on the basis of geologic data (primarily geophysical well logs), water-level data, water-chemistry data, and previous investigations. They acknowledged that the complex deposition of sediments in the Coastal Plain makes aquifer delineation problematic. This aquifer has been studied extensively by Cooke (1936), Siple (1957), Colquhoun and others (1983), Renken (1984), Aucott and Speiran (1985a and 1985b), Stringfield and Campbell (1993), Aucott (1988 and 1996), Aadland and others (1995), Hockensmith and Waters (1998), and Hockensmith (2003 and 2008).

The potentiometric map presented here was constructed by using water levels measured in 159 wells in November and December 2009 (see table), although some measurements were taken in early 2010. Water-level measurements made during that period are likely to be representative of median aquifer conditions, whereas in other periods, such as late winter or mid-summer, measurements represent maximum and minimum levels, respectively. Data were collected by DNR, U.S. Department of Energy, South Carolina Department of Health and Environmental Control (DHEC), and U.S. Geological Survey, Office of Ground Water, Ground-Water Resources (USGS) personnel. Wells measured by previous investigators were used, where possible, to compare 2009 data with earlier potentiometric maps.

The hydrographs were constructed from measurements by DNR and USGS. Where continuous records were available, daily mean water levels were plotted.

GEOHYDROLOGIC FRAMEWORK

The Coastal Plain formations of South Carolina compose a wedge of sediment that thickens from about 0 ft (feet) at the Fall Line to more than 4,000 ft at Hilton Head Island. The sediment consists of sand, clay, and limestone of Late Cretaceous and younger ages that were deposited on a pre-Cretaceous basement complex of metamorphic, igneous, and consolidated sedimentary rock.

The Middendorf Formation is between the Black Creek Formation and the Cape Fear Formation, the latter being the oldest of the Cretaceous formations in the region. The Middendorf aquifer is composed mostly of permeable sediments of the Middendorf Formation (hence its name), but locally it includes sediment from underlying or overlying formations. In the updip areas, the aquifer is composed of sand interbedded with clay lenses deposited in an upper delta plain environment. Toward the coast, the aquifer is composed of thin- to thick-bedded sand and

Table showing water-level elevations during November 2009 in wells completed in the Middendorf aquifer in South Carolina

Well number	Grid number	Latitude, in degrees, minutes, and seconds	Longitude, in degrees, minutes, and seconds	Water level elevation, in feet above or below (-) mean sea level	Change in water level from 2004 to 2009, rounded to nearest foot
AIK-430	39X-e1	33 19 40	81 44 35	193	-4
AIK-643	38W-n1	33 22 40	81 38 20	214	-2
AIK-817	40V-s2	33 26 15	81 46 12	231	-2
AIK-818	40V-s3	33 26 15	81 46 12	234	-2
AIK-826	36U-o1	33 32 32	81 29 08	269	-2
AIK-831	39U-y2	33 30 36	81 44 21	283	-4
AIK-845	36U-o2	33 32 35	81 29 08	268	-2
AIK-865	39X-n62	33 17 12	81 43 20	170	-1
AIK-866	39N-w2	33 20 16	81 42 31	196	-3
AIK-871	38W-n3	33 22 38	81 38 27	217	-2
AIK-872	40Y-k7	33 12 51	81 45 32	> 154.6	
AIK-873	40Y-k8	33 12 51	81 45 32	160	
AIK-892	39W-w3	33 20 15	81 42 31	190	-5
AIK-902	40W-q1	33 21 10	81 48 35	164	-1
AIK-2380	40W-q4	33 21 12	81 48 33	164	-1
AIK-2450	39U-r6	33 31 29	81 42 32	306	-4
ALL-347	35AA-q2	33 01 29	81 23 04	183	-2
ALL-358	37Z-t3	33 06 47	81 30 23	181	-2
ALL-370	37Z-x11	33 06 48	81 30 20	181	-2
ALL-377	35AA-q10	33 01 29	81 23 04	183	-2
ALL-378	37AA-g2	33 03 41	81 33 50	166	
BAM-77	31X-h1	33 18 22	81 02 08	258	
BFT-10	27JJ-c1	32 19 47	80 42 28	131	-13
BFT-11	27II-s2	32 21 09	80 41 25	117	-12
BRK-46	18W-a1	33 24 20	79 55 34	21	21
BRK-431	19Y-w3	33 10 20	80 02 19	7	-2
BRK-444	18AA-e4	33 04 24	79 59 35	-15	4
BRK-654	17AA-w1	33 00 22	79 52 35	-54	-54
BRN-79	35W-f1	33 23 49	81 24 05	226	
BRN-243	37Y-o1	33 12 09	81 34 41	180	-1
BRN-246	38Y-m1	33 12 46	81 37 27	176	-1
BRN-303	38Y-b1	33 14 45	81 36 57	179	-1
BRN-312	37W-u1	33 20 41	81 30 01	211	-1
BRN-314	37Y-t1	33 11 28	81 30 48	184	-1
BRN-316	39Y-u1	33 10 57	81 40 43	167	-1
BRN-327	37Y-o4	33 12 09	81 34 41	179	-1
BRN-330	33Y-m3	33 12 49	81 37 28	176	-1

Table showing water-level elevations during November 2009 in wells completed in the Middendorf aquifer in South Carolina (continued)

Well number	Grid number	Latitude, in degrees, minutes, and seconds	Longitude, in degrees, minutes, and seconds	Water level elevation, in feet above or below (-) mean sea level	Change in water level from 2004 to 2009, rounded to nearest foot
BRN-335	38Z-i3	33 08 42	81 36 28	177	-2
BRN-349	34Y-x1	33 10 42	81 18 52	188	-1
BRN-356	34Y-x8	33 10 44	81 18 52	187	-3
BRN-358	35X-e2	33 19 16	81 24 24	206	-2
BRN-366	35X-e6	33 19 14	81 24 28	207	-2
BRN-370	38X-n56	33 17 09	81 38 06	180	-1
BRN-379	38Y-o12	33 12 39	81 39 27	172	-1
BRN-382	37W-u3	33 20 41	81 30 01	212	-2
BRN-383	37X-t3	33 1128	81 30 48	184	-2
BRN-384	39Y-u3	33 10 57	81 40 43	166	-1
BRN-385	37Y-f7	33 13 47	81 34 31	181	-1
BRN-391	39X-u10	33 15 11	81 40 21	166	-6
BRN-417	37Y-f8	33 13 47	81 34 31	181	-1
BRN-423	38Y-o10	33 12 39	81 39 27	171	-1
BRN-430	38X-n58	33 17 09	81 38 06	180	0
BRN-438	39X-u9	33 15 10	81 40 21	172	-1
BRW-1865*	2Q-j6	33 53 30	78 35 23	51	-13
CAL-27	30R-j2	33 48 36	80 54 53	113	0
CAL-115	30R-g2	33 48 40	80 58 58	150	
CHN-2	18CC-r1	32 51 21	79 57 41	-34	29
CHN-14	18DD-k3	32 47 30	79 55 53	-39	48
CHN-163	17DD-m5	32 47 17	79 52 18	-100	70
CHN-172	19CC-x1	32 50 48	80 03 53	-8	12
CHN-173	16CC-y1	32 50 43	79 49 37	-30	99
CHN-174	20GG-e1	32 34 51	80 09 37	-1	68
CHN-178	18DD-l3	32 47 03	79 56 35	-22	43
CHN-183	16CC-k1	32 52 05	79 45 56	-32	-32
CHN-185	17DD-a4	32 49 14	79 50 15	-43	-43
CHN-186	20FF-v1	32 36 02	80 06 23	-130	-18
CHN-187	16DD-m2	32 47 13	79 47 18	28	19
CHN-219	15DD-f1	32 48 22	79 44 02	-7	-7
CHN-559	17DD-a6	32 49 30	79 50 53	-44	-44
CHN-601	17DD-u7	32 45 34	79 50 56	-27	51
CHN-603	16DD-q2	32 46 37	79 48 35	15	29
CHN-604	16DD-j1	32 48 12	79 45 17	-14	38
CHN-635	16DD-y3	32 45 53	79 50 00	23	31
CHN-801	19FF-q1	32 365 3	80 03 06	-57	-57

Table showing water-level elevations during November 2009 in wells completed in the Middendorf aquifer in South Carolina (continued)

Well number	Grid number	Latitude, in degrees, minutes, and seconds	Longitude, in degrees, minutes, and seconds	Water level elevation, in feet above or below (-) mean sea level	Change in water level from 2004 to 2009, rounded to nearest foot
CHN-831	19FF-q2	323653	800306	-59	
CHN-849	17DD-n1	324730	795354	-49	
CLA-3	21S-r2	334149	801218	81	-2
CLA-20	21S-m1	334159	801249	88	-2
CLA-25	23T-v1	333542	802116	84	-12
CLA-27	21S-s1	334118	801138	80	
CLA-146	22T-i1	333807	801601	81	
COL-49	26BB-n2	325703	803804	102	
COL-50	26CC-d2	325443	803852	> 90	
CTF-44	19I-i1	343348	800151	167	0
CTF-57	17H-l4	343736	795625	104	
CTF-84	18I-e1	343434	795909	178	
CTF-85	19I-i2	343350	800145	194	
CTF-221	22J-v1	342544	801658	245	
CTF-222	22J-v2	342544	801658	261	
DAR-82	20K-s3	342113	800701	145	-40
DAR-96	17I-v3	343026	795122	71	
DAR-100	20K-e4	342406	800935	220	
DAR-208	17L-i4	341836	795135	73	
DAR-221	15L-o4	341717	794430	28	
DAR-228	17J-m1	342732	795248	133	-1
DAR-231	19K-e1	342455	800455	194	4
DIL-79	9K-u4	342042	791006	62	
DIL-132	10J-g2	342857	791854	88	1
DOR-221	20BB-o4	325737	800948	0	
DOR-228	21BB-d1	325742	801207	6	-7
FLO-95	16M-d3	341413	794847	98	
FLO-128	13M-p3	341144	793450	47	16
FLO-146	16M-w1	341011	794718	-51	-27
FLO-153	18N-i2	340813	795619	57	-29
FLO-274	16Q-s1	335120	794559	5	-5
HOR-973	5S-f1	334317	785410	101	-7
JAS-426	30FF-o2	323705	805944	128	-7
KER-82	22J-y7	342511	801930	210	4
KER-87	24K-p1	342107	802918	224	0
KER-100	28M-w1	341006	804740	264	
KER-146	23J-s1	342622	802118	257	

Table showing water-level elevations during November 2009 in wells completed in the Middendorf aquifer in South Carolina (continued)

Well number	Grid number	Latitude, in degrees, minutes, and seconds	Longitude, in degrees, minutes, and seconds	Water level elevation, in feet above or below (-) mean sea level	Change in water level from 2004 to 2009, rounded to nearest foot
KER-270	23J-v4	34 25 20	80 21 20	249	
LEE-59	21M-r3	34 11 46	80 12 32	183	
LEE-60	21N-q1	34 06 36	80 13 34	169	-2
LEE-74	21K-v1	34 20 45	80 11 36	213	-2
LEE-75	21M-k1	34 14 06	80 11 04	183	-2
LEE-79	22M-l1	34 12 40	80 16 25	186	76
LEX-838	35Q-o3	33 52 05	81 24 26	449	-5
LEX-844	32S-b4	33 44 46	81 06 27	291	-1
LEX-1671	36Q-t1	33 51 28	81 24 59	444	
MLB-180	13H-c2	34 39 29	79 31 53	145	
MLB-27	13I-h1	34 33 48	79 32 07	111	-1
MLB-39	14I-y2	34 30 24	79 39 26	91	1
MLB-110	15J-d2	34 29 35	79 43 10	62	-2
MLB-112	15H-l2	34 37 15	79 41 15	131	1
MLB-131	14G-l1	34 42 12	79 36 26	192	-5
MLB-187	13H-c3	34 39 36	79 32 50	155	
MRN-68	13M-a1	34 14 47	79 30 01	27	5
MRN-69	12L-y1	34 15 06	79 29 50	31	2
ORG-79	29V-v1	33 24 45	80 50 53	156	-4
ORG-383	31W-l5	33 22 05	81 01 52	174	4
ORG-389	31W-s4	33 21 45	81 01 59	172	11
RIC-543	27Q-m1	33 52 30	80 42 09	136	-1
RIC-585	29P-t4	33 56 56	80 50 27	199	1
SUM-69	23P-t1	33 56 11	80 20 47	109	-6
SUM-119	22P-y2	33 55 04	80 19 17	83	-5
SUM-153	23Q-r1	33 51 54	80 22 36	79	6
SUM-161	22Q-e2	33 54 58	80 19 27	78	0
SUM-230	24S-d2	33 44 17	80 28 11	103	-6
SUM-296	25S-l1	33 42 38	80 31 56	81	-1
SUM-488	24Q-l1	33 52 28	80 26 16	117	
SUM-492	19P-q3	33 56 44	79 58 48	64	
WIL-37	12S-c1	33 44 51	79 27 06	-25	
WIL-51	16R-n2	33 47 15	79 48 15	17	
WIL-118	17S-u1	33 40 21	79 50 13	-40	
WIL-176	12S-h1	33 43 53	79 27 44	-27	1
WIL-203	16S-n6	33 42 15	79 48 50	-44	
WIL-207	18U-b1	33 34 36	79 56 12	12	

Table showing water-level elevations during November 2009 in wells completed in the Middendorf aquifer in South Carolina (continued)

Well number	Grid number	Latitude, in degrees, minutes, and seconds	Longitude, in degrees, minutes, and seconds	Water level elevation, in feet above or below (-) mean sea level	Change in water level from 2004 to 2009, rounded to nearest foot
WIL-208	17T-w1	33 35 01	79 52 15	-4	
WIL-211	13S-x1	33 40 54	79 33 26	-18	
WIL-212	13T-a5	33 39 13	79 30 07	-17	
WIL-213	12R-s1	33 46 22	79 26 53	-29	
Other Wells:					
Middendorf/Black Creek aquifers					
MRN-9	11M-p2	34 09 57	79 24 30	0	23
Middendorf/Cape Fear aquifers					
BFT-454	27KK-d1	32 14 55	80 43 53	144	-7
BFT-2055	27KK-r14	32 11 29	80 42 14	140	-9
BFT-2092	24JJ-f1	32 18 49	80 29 20	149	
Cape Fear aquifer					
ALL-348	35AA-q3	33 01 29	81 23 06	199	0
BFT-2380	28LL-j7	32 08 48	80 45 43	76	20
MRN-78	10Q-p2	33 51 43	79 19 50	68	-4

* Well BRW-1865 is located in Brunswick County, North Carolina.

clay that were deposited in marginal marine or lower delta plain environments. In general, the Middendorf aquifer has coarser sand and less clay in the western part of the Coastal Plain than in the eastern part.

The Middendorf crops out along the Fall Line from Chesterfield County to Edgefield County, except for some areas in Aiken County where it is not exposed. Its outcrop is narrowest in southwestern Edgefield County and widest in Chesterfield County. The aquifer dips southeastward near the Fall Line and southward along the coast. The top of the aquifer is at elevation 100, -700, and -1,700 ft msl (feet, referenced to mean sea level) at Aiken, Little River, and Charleston, respectively. Thickness ranges from 0 ft at the Fall Line to more than 300 ft in Dorchester County.

GROUND-WATER FLOW

The potentiometric surface of the Middendorf aquifer generally slopes toward the coast, and the direction of ground-water flow is southeastward. In areas where the aquifer crops out, it is recharged directly by rainfall. In the upper Coastal Plain, stream valleys are incised into the aquifer; where contours are deflected upstream near the Great Pee Dee, Congaree, Wateree, and Savannah Rivers, the aquifer discharges to those rivers. In the lower Coastal Plain the aquifer discharges only into overlying aquifers and through pumping wells.

Dimpling this surface are cones of depression caused by pumping. The potentiometric surface has been most affected by pumping in Berkeley, Charleston, Florence, and Williamsburg Counties. The lowest point on the potentiometric surface, -130 ft msl, is at Kiawah Island.

HISTORICAL TRENDS

The potentiometric levels of the Middendorf aquifer have been recorded since 1917 or earlier (Cooke, 1936). Aucott and Speiran (1985a and 1985b) compared estimates of the predevelopment surface with November 1982 water levels and determined that Middendorf aquifer water levels had declined throughout the northeastern two thirds of the Coastal Plain. Stringfield and Campbell (1993) published November 1989 water levels and observed that levels in Berkeley, Charleston, Dorchester, Kershaw, and Williamsburg Counties had further declined since 1982. Hockensmith and Waters (1998), using November 1996 data, showed additional declines and a generally southeastward ground-water flow influenced by large cones of depression in the Florence-Hemingway area and around Mount Pleasant. Historical water-level trends in five Middendorf aquifer wells are shown on the hydrographs. Hockensmith (2003) noted that by 2001, the cones of depression in Florence and Charleston Counties had expanded and deepened. Hockensmith (2008) noted that the cones of depression about Mount Pleasant and around Kiawah and Seabrook Islands had deepened since 2001. In northern Florence County, however, water levels recovered significantly from 2001 to 2004.

The region most affected by ground-water pumping is Charleston and Berkeley Counties, centered at Kiawah Island and the Huger-Mount Pleasant areas. The deepest point on the potentiometric surface is centered about CHN-186 on Kiawah Island, where the water level was -130 ft msl; a decline of 18 ft from 2004 to 2009. CHN-174, measured in February 2010 at -1 ft msl, showed an apparent recovery of 68 ft from 2004 to 2010; however, the comparison is between a November 2004 measurement, after a period of heavy use, with a February 2010 measurement, after several months of recovery. Seasonal variability is probably significant in this well. Predevelopment water levels for CHN-174 were at least 148 ft msl, thus indicating total declines of 149 and 278 ft, for CHN-174 and CHN-186, respectively. Kiawah and Seabrook Islands are primarily resort communities for which a large portion of the water is used for golf-course and lawn irrigation.

About Charleston, the cone of depression is still present but has recovered since 2004. CHN-163, at the center of the cone of depression noted in Mount Pleasant in 2004 and 2009, recovered 70 ft to -100 ft msl in 2009. Predevelopment levels were estimated near 130 ft msl (Aucott, 1988); therefore, a decline of about 230 ft has occurred in this area. Most Charleston County wells measured within this cone of depression in both 2004 and 2009 showed recoveries ranging from 12 ft (CHN-172) to 99 ft (CHN-173). Water levels in CHN-14 were -39 ft msl in 2009, recovering 48 ft, albeit with seasonal fluctuations, since 2004. The hydrograph for CHN-14 showed a decline of more than 93 ft between June 1991 and August 2004, to a low of -95 ft msl in August 2004, and -87 ft msl in November 2004.

Water-level recoveries are likely due to the decline in ground-water withdrawal in Charleston County from 3,806 million gallons (Mgal) in 2004 to 1,986 Mgal in 2009. Water supply withdrawal in 2009 was 1,443 Mgal (Butler, 2010), less than half of that in 2004 (2,993 Mgal) (Childress and Bristol, 2005). Although the withdrawal is not itemized by specific aquifers, it is likely that a significant portion of the decline in pumpage is from the Middendorf aquifer.

In Berkeley County, a cone of depression exists about BRK-654, whose water level measured -54 ft msl in 2009. BRK-444 showed a recovery of 4 ft since 2004. The hydrograph for BRK-431 shows the effects of pumping from Summerville prior to November 1994, when water levels declined to a minimum of 38 ft msl. From November 1994 through August 1996, water levels recovered to a maximum of 42 ft msl. From August 1996, water levels declined to 2 ft msl in January 2008. Water levels recovered to 7 ft msl in December 2009.

Hydrographs of selected wells.

In Summerville, DOR-221 and DOR-228, with water levels of 0 and 6 ft msl, respectively, place the 0-ft msl potentiometric contour and the western edge of the regional cone of depression just to the east of the city. DOR-228 showed a decline in water level of 7 ft from 2004 to 2009.

Ground-water pumpage decreased slightly in Berkeley County from 1,220 Mgal in 2004 to 1,202 Mgal in 2009; however, the quantity withdrawn from the Middendorf aquifer is not known. The largest withdrawal was for industrial use, which decreased from 1,101 Mgal in 2004 to 1,086 Mgal in 2009. The second largest withdrawal was for water supply, which also decreased from 175 Mgal to 73 Mgal from 2004 to 2009 (Childress and Bristol, 2005; and Butler, 2010).

Water levels in the Middendorf aquifer at Walterboro remained above 90 ft msl in 2009. Two wells were measured in Walterboro in December 2009. Both wells flowed and were measured with pressure gauges. The water level in COL-49, converted from pressure, was 102 ft msl. COL-50, recovering from being pumped earlier in the day, measured at least 90 ft msl. Water levels in this well were 95 ft msl in 2004. Aucott and Speiran (1985a) reported a water level of 150 ft msl in a well north of Walterboro, which suggests a decline of about 48 ft since 1980.

The cone of depression in northern Florence County, first mapped in 1989 (Aucott and Speiran, 1985b), deepened in 2009. Water levels declined 27 ft in FLO-146, from -24 ft msl in 2004 to -51 ft msl in 2009. In western Florence County, water levels declined 29 ft in FLO-153, from 86 ft msl in 2004 to 57 ft msl. Water levels in FLO-128, reported to be 61 ft msl in 1959 (Aucott and Speiran, 1984), recovered 16 ft from 31 ft msl in 2004 to 47 ft msl in 2009. The hydrograph for this well shows a general recovery for the past decade.

Ground-water pumpage in Florence County declined from 4,915 Mgal in 2004 to 4.851 Mgal in 2009. Water-supply pumpage, the greatest use of ground water, increased by 545 Mgal to 4,418 Mgal from 2004 to 2009. This increase is water-supply withdrawals, though not all from the Middendorf aquifer, is likely the cause for the decline near Florence.

Middendorf water levels in northern Marion County declined from predevelopment levels between 50 and 75 ft msl (Aucott and Speiran, 1985a) to 27 ft msl in MRN-68 and to 31 ft msl MRN-69 in 2009. Water level in MRN-9, a well screened in both Black Creek and Middendorf aquifers, was 0 ft msl and had recovered 23 ft from 2004. Water-supply pumpage for the county decreased from 1,357 Mgal in 2004 to 1,171 Mgal in 2009 with withdrawals from both the Black Creek and Middendorf aquifers. Contours of the Middendorf are drawn to reflect the estimated effects of pumping; however, the pumping effects are thought to be greater in the overlying Black Creek aquifer. Pumping in the Middendorf and Black Creek aquifers may be influencing water levels in the underlying Cape Fear aquifer. Water levels in MRN-78 (open to the Cape Fear aquifer) in southern Marion County declined 4 ft since 2004 to 68 ft msl, although no pumping from this aquifer has been noted in the region.

Two cones of depression, centered at Hemingway and Kingstree, are defined by the 0-ft contour in Williamsburg County. The increased detail in the 2009 potentiometric map is due to efforts in recent years to locate additional observation wells in the network. At Hemingway, the water level in WIL-176 was -27 ft msl after only a short pumping recovery period; however, this is 1 ft greater than that measured in November 2004. Water levels were -29 and -25 ft msl for WIL-213 and WIL-37, respectively. Measurements in these three wells, along with WIL-211 and WIL-212, with water levels of -18 and -17 ft msl, respectively, confirm and define the -25-ft contour that was indicated by only one well in previous maps. Water levels were 54 ft msl for WIL-37 in 1970 (Aucott and Speiran, 1984), and total water-level decline in this area was about 79 ft in November 2009. At Kingstree, water levels were -40 and -44 ft msl, for WIL-118 and WIL-203, respectively. Water levels were -4, 12, and 16 ft msl in WIL-208, WIL-207 and WIL-51, respectively. These data define the -25-ft and 0-ft contours about Kingstree.

Annual ground-water pumpage for public supply in Williamsburg County, much of which is from the Middendorf aquifer, increased from 689 to 718 Mgal between 2004 and 2009. Countywide, ground-water pumpage decreased from 1,618 to 1,266 Mgal between 2004 and 2009 (Childress and Bristol, 2005; and Butler, 2010).

Water-level declines in Sumter County are a result of pumping in and around the City of Sumter. Water levels declined 6 ft in SUM-69 to 109 ft msl, and 5 ft in SUM-119 to 83 ft msl from 2004 to 2009. Levels remained the same in SUM-161, at 78 ft msl, whereas, levels recovered 6 ft in SUM-153 to 79 ft msl during the same period. Predevelopment water levels were about 125 ft msl (Aucott and Speiran, 1985a), indicating declines as great as 47 ft have occurred. A recorder was installed in SUM-153 (operated by DHEC) and a new DNR observation, SUM-488, was constructed to aid in the monitoring and evaluation of hydrologic conditions in the future near Sumter. Annual ground-water withdrawal from the Black Creek and Middendorf aquifers in 2009 exceeded 5991 Mgal, a decrease of 879 Mgal from 2004, for Sumter County (Childress and Bristol, 2005; and Butler, 2010). Because the median transmissivity of the Middendorf aquifer in this area is about 45,000 gpd/ft (gallons per day per foot) (Newcome, 1993), a shallow cone of depression exists about the city, although it is not apparent from the data distribution.

The cone of depression defined about Bishopville in November 2004 is not present in November 2009. Water levels in wells in this vicinity were 183 ft msl for LEE-59 and LEE-75, and 186 ft msl for LEE-79. The hydrograph for LEE-75 shows seasonal fluctuations but no significant long-term downward trend.

Near the outcrop area, most wells in Calhoun, Chesterfield, Kershaw, Lee, Lexington, Marlboro, and Richland Counties showed little to no change between November 2004 and November 2009. Pumping-induced potentiometric patterns are not obvious owing to the widely spaced observation points and are superimposed upon the patterns formed by natural discharge.

Water levels in Aiken, Allendale, and Barnwell County declined in all wells between 2004 and 2009. In Barnwell County, BRN-391 showed the maximum decline of -6 ft for the county during this period; however, most wells declined by less than 2 ft. Allendale County wells declined 3 ft or less between 2004 and 2009. In Aiken County, AIK-892 showed the maximum decline of -5 ft during this period; however, most wells declined by less than 2 ft. Water levels in AIK 430 declined 4 ft to 193 ft msl from 2004 to 2009 and the hydrograph shows a general decline for the period of record.

Ground-water users in Aiken, Allendale, and Barnwell Counties pumped 6,692, 3,998, and 1,093 Mgal, respectively (Butler, 2010), from the Middendorf and overlying aquifers in 2009. The extent to which pumping affects water levels is not discernible from the 2009 data, owing to the high transmissivity of the Middendorf aquifer, the distribution of measurements, and the effect of natural discharge to the Savannah River.

Three wells were measured in Orangeburg County. Water levels in ORG-79, located south of Orangeburg, declined 4 ft from 2004 to 2009. Water levels in ORG-383 and ORG-389, recovered 4 and 11 ft, to 174 and 172 ft msl, respectively between 2004 and 2009. Much of the pumpage in this area, a reported 1,440 Mgal in 2009 (Butler, 2010) is for thermoelectric use and is likely to fluctuate seasonally. In light of this pumpage and the water levels measured at Bamberg (BAM-77) of 258 ft msl, there is probably a cone of depression about ORG-383 and ORG-389, though not shown on this map.

Ground-water levels have declined in southern South Carolina. The water level in JAS-426 has declined 7 ft since 2004. Near Beaufort, BFT-10 and BFT-11 declined 13 and 12 ft, respectively, since 2004. Wells BFT-454 and BFT-2055 (open to both the Middendorf and Cape Fear aquifers) on Hilton Head Island had similar water levels, 144 and 140 ft msl, respectively, in 2009 but had declined 7 and 9 ft, respectively since 2004. They are influenced by the pumping from BFT-2155, on southern Hilton Head Island (Kelley Ferda, South Island Public Service District, oral communication, 2007). In view of these data, the 150-ft potentiometric contour, present near Beaufort in 2004, is now absent in Beaufort and Jasper Counties.

There is a need for additional Middendorf aquifer observation wells in several areas of the Coastal Plain. Some counties either had no observation wells (Georgetown and Hampton), only one (Bamberg and Jasper), or the available wells are screened in more than one aquifer (HOR-973). The boundaries of the cones of depression between Mount Pleasant and Hemingway are poorly known because of a paucity of observation wells. Large data gaps exist in Calhoun, eastern Orangeburg, Marion, and central and southern Florence Counties. Lastly, the extent to which North Carolina or Georgia ground-water pumpage influences the aquifer is not known and, in light of pressures to provide sufficient water for all users, obtaining data in these areas should have high priority. Efforts should be intensified among ground-water users and governmental bodies to maintain existing observation wells and seek additional wells.

SUMMARY AND CONCLUSIONS

The potentiometric map for the Middendorf aquifer, constructed by using water-level data from 159 wells measured during late 2009 and early 2010, shows that the generally southeastward ground-water flow is affected by potentiometric lows around Florence, Hemingway, Kingstree, Mount Pleasant, and Kiawah Island.

Historical data show that water levels are stable near the aquifer's outcrop area and that fluctuations have occurred in areas influenced by pumping. Near the outcrop, wells have changed little since 2004. The deepest point on the potentiometric surface was -130 ft msl, located at Kiawah Island. Although the cone of depression about Mount Pleasant recovered as much as 99 ft since 2004, it remains a major feature. Improvements in the data coverage in Williamsburg County have shown cones of depression about Kingstree and Hemingway.

Potentiometric maps are only as good as the data available to construct them. A greater availability of observation wells, timely measurements, and periodic construction of potentiometric maps will provide improved understanding of the aquifer and subsequently allow better management of this resource.

REFERENCES

Aadland, R.K., Gellici, J.A., and Thayer, P.A., 1995, Hydrogeologic framework of west-central South Carolina: South Carolina Department of Natural Resources, Water Resources Report 5, 200 p., 47 plates.

Aucott, W.R., 1988, Predevelopment ground-water flow system and hydrologic characteristics of the Coastal Plain aquifers of South Carolina: U.S. Geological Survey Water-Resources Investigations Report 86-4347, 66 p.

——— 1996, Hydrology of the southeastern Coastal Plain aquifer system in South Carolina and parts of Georgia and North Carolina: U.S. Geological Survey Professional Paper 1410-E, 83 p.

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, 7 sheets.

Aucott, W.R., and Speiran, G.K., 1984, Water-level measurements for the Coastal Plain aquifers of South Carolina prior to development: U.S. Geological Survey Open-File Report 84-803, 36 p.

——— 1985a, Potentiometric surfaces of the Coastal Plain aquifers of South Carolina prior to development: U.S. Geological Survey Water-Resources Investigations Report 84-4208, 5 sheets.

——— 1985b, Potentiometric surfaces of November 1982 and declines in the potentiometric surfaces between the period prior to development and November 1982 for the Coastal Plain aquifers of South Carolina: U.S. Geological Survey Water-Resources Investigations Report 84-4215, 7 sheets.

Butler, Alexander, 2010, South Carolina water use report – 2009 summary: South Carolina Department of Health and Environmental Control, Bureau of Water Technical Document 06J-11, 44 p.

Childress, J.M., and Bristol, P.L., 2005, South Carolina water use report – 2004 summary: South Carolina Department of Health and Environmental Control, Bureau of Water Technical Document 004-05, 39 p.

Colquhoun, D.J., Woollen, I.D.,VanNiewenhuise, D.S., Padgett, G.G., Oldham, R.W., Boylan, D.C., Bishop, J.W. and Howell, P.D., 1983, Surface and subsurface stratigraphy, structure, and aquifers of the South Carolina Coastal Plain: Columbia, South Carolina, University of South Carolina, Department of Geology, 78 p.

Cooke, C.W., 1936, Geology of the Coastal Plain of South Carolina: U.S. Geological Survey Bulletin 867, 196 p.

Hockensmith, B.L., 2003, Potentiometric surface of the Middendorf aquifer in South Carolina, November 2001: South Carolina Department of Natural Resources, Water Resources Report 28, 1 sheet.

——— 2008, Potentiometric surface of the Middendorf aquifer in South Carolina, November 2004: South Carolina Department of Natural Resources, Water Resources Report 46, 11p., 1 plate.

Hockensmith, B.L., and Waters, K.E., 1998, Potentiometric surface of the Middendorf aquifer in South Carolina, November 1996: South Carolina Department of Natural Resources, Water Resources Report 19, 1 sheet.

Newcome, Roy, Jr., 1993, Pumping tests of the Coastal Plain aquifers in South Carolina: South Carolina Water Resources Commission Report 174, 52 p.

Renken, R.A., 1984, The hydrologic framework for the sand aquifer of the Southeastern United States Coastal Plain: U.S. Geological Survey Water-Resources Investigations Report 84-4243, 30 p., 8 sheets.

Siple, G.E., 1957, Ground water in the South Carolina Coastal Plain: Journal of the American Water Works Association Reprint, v. 49, no. 3, p. 283-300.

Stringfield, W.J., and Campbell, B.G., 1993, Potentiometric surfaces of November 1989 and declines in the potentiometric surfaces between November 1982 and November 1989 for the Black Creek and Middendorf aquifers in South Carolina: U.S. Geological Survey Water-Resources Investigations Report 92-4000, 2 sheets.

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