HYDROLOGIC AND GEOLOGIC ANALYSIS OF

TWO WELLS IN MARION COUNTY, SOUTH CAROLINA

By M. S. Reid, R. A. Renken, R. L. Wait, W. R. Aucott, and R. W. Lee

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ABSTRACT

Two test wells were drilled in Marion County, South Carolina in 1982. Well MRN 77 (Marion 77) was drilled to a depth of 365 feet and was used as an observation well in the Black Creek aquifer and to supply water during drilling of the deeper well. MRN 78 (Marion 78) was drilled and cored through the entire thickness of Coastal Plain sediments into the underlying basement rock to a depth of 1,225 feet.

INTRODUCTION

Deeply buried aquifers in the Coastal Plain of South Carolina range in depth below land surface from about 1,000 feet near Myrtle Beach to about 2,500 feet near Parris Island and Hilton Head Island. The potentiometric surface of these aquifers ranges from about 115 feet above sea level near the North Carolina-South Carolina State line to as much as 175 feet above sea level at Hilton Head Island. Water in these aquifers is confined by overlying slightly permeable clay beds. Limited hydrologic and geologic data is available to determine the characteristics of the aquifers and confining beds. Accordingly, test wells were drilled to establish the geologic and hydraulic character of the Coastal Plain rocks in places where no deep well data existed. The test drilling was performed as part of the Southeastern Coastal Plain Regional Aquifer System Analysis (RASA) investigation.

Purpose and Scope

The purpose of this report is to present geologic and hydrologic data determined by drilling test wells MRN 77 and MRN 78. Data collected include the depth, thickness, lithology, and water chemistry of the Coastal Plain aquifers at the sites. These data will assist in regional correlations of stratigraphy and flow system characteristics, and are presented by graphs, tables, and diagrams.

The scope of the test-drilling project included: (1) a drilling and coring program to obtain cuttings and wireline core samples for geologic and hydrologic testing and paleontological examination, (2) obtaining geophysical logs to aid in the description and definition of the lithology and physical characteristics of the sediments penetrated, (3) collection of water samples from discrete sand beds for water quality analyses, (4) water-level measurements to determine the pressure head in those zones, and (5) the construction of permanent observation wells to obtain long-term water-level data. The two observation wells are available for future water sampling programs to determine possible movement of high chloride water into the area, as well as to record water-level fluctuations. The water levels will be monitored to detect possible declines caused by nearby production wells.

Location of Area

The Britton Neck area is located in southern Marion County, S.C., (fig. 1). The test well sites are located about 3 miles south of Britton Neck and approximately 30 miles northwest of Myrtle Beach, near the Britton Neck fire tower on property owned by the South Carolina State Department of Forestry. The altitude at the sites is 30 feet above sea level (from topographic map).

Acknowledgments

The courtesies and cooperation extended by the South Carolina Department of Forestry, Mr. John M. Shirer, Assistant State Forester, are gratefully acknowledged. The cooperative efforts of Mr. Robert Massey, District Manager, and Mr. Phillip Miller, Chief Driller, both of Layne-Atlantic Drilling Company, resulted in excellent core recovery. The work was done under a cooperative agreement between the Water Resources Division, RASA program, and the Geologic Division of the U.S. Geological Survey.

WELL CONSTRUCTION

Drilling and Casing Procedure

Well MRN 77 (Marion 77) is a water-supply well which was drilled to a depth of 365 feet below land surface and 6-inch casing was installed to 322 feet. Four-inch casing was installed from 315 to 325, 335 to 345, and 355 to 363 feet. The well was screened in the intervals 325 to 335 feet and 345 to 355 feet, with 4-inch, 12-slot (0.012-inch), number 304 stainless steel bar-weld screens. An 8-foot section of 4-inch blank pipe was placed below the lower screen as a sand trap. A lead seal was swedged between the 6-inch and 4-inch casings. Cement grout was placed in the annulus from land surface to a depth of 321 feet.

Well MRN 78 (Marion 78) was drilled to a depth of 1,225 feet and later reamed to accommodate casing and cement after drilling, coring, geophysical logging and water sampling were completed. A 16-inch surface casing was installed to a depth of 64 feet and a 6-inch casing was installed from land surface to 997 feet. The well was finished with a 4-inch casing from 967 to 1,008 feet. A lead seal was swedged between the 6-inch and 4-inch casings. The well was backfilled with sand from a depth of 1,058 to 1,225 feet and a cement plug was placed from 1,038 to 1,058 feet. Above the cement plug, a sump created by a blank piece of 4-inch casing was left from 1,028 to 1,038 feet. Twenty feet of 4-inch, 10-slot opening (0.010 inch), number 304 stainless steel wire-wrapped screen was installed above the sump from a depth of 1,008 to 1,028 feet. Cement grout was placed in the annulus from land surface to a depth of 997 feet.

After completion of well MRN 78, a break in the 6-inch casing was discovered between 260 and 300 feet. Accordingly, a 4-inch liner with a rubber seal at the bottom was installed to a depth of 403 feet and the space between the liner and the 6-inch casing was filled with cement.

Construction diagrams for wells MRN 77 and MRN 78 are shown on plate 1.

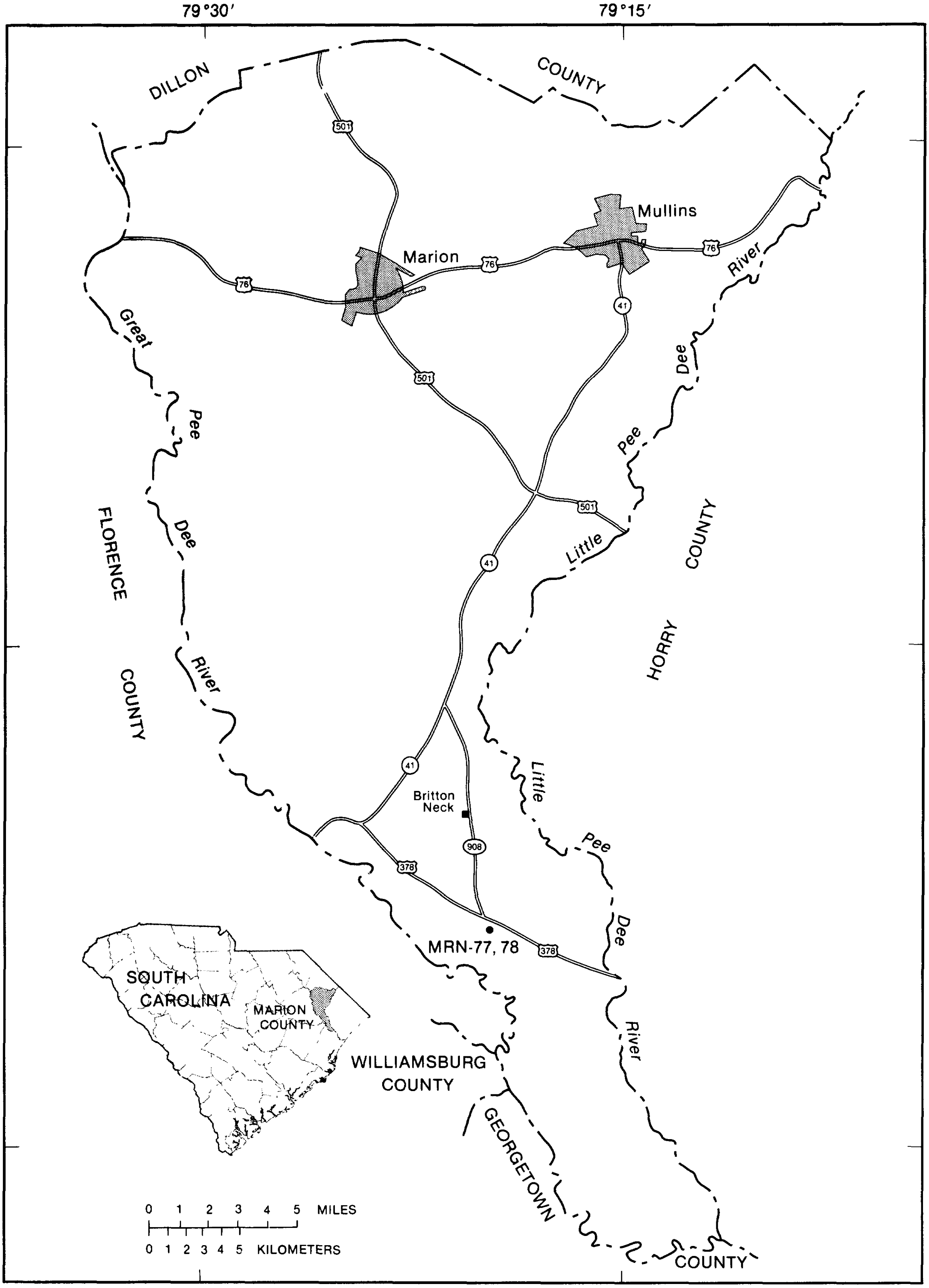


Figure 1.--Location of the test wells.

Coring

Well MRN 78 was cored by the wire-line coring method from land surface to the top of pre-Cretaceous basement rock. Core was retrieved at 5-foot intervals and each length of core was measured, described and placed in plastic tubing for preservation.

Once the basement rock had been reached, the wire-line core barrel was replaced with a standard 8-inch diamond core bit and a Christensen core barrel to core and retrieve samples of the hard basement rock. Although coring this rock was extremely slow, recovery was excellent.

Well Development

Temporary screens were installed opposite the zones selected for recovery testing and water-quality sampling (discussed in later sections of this report). Two zones in well MRN 77 and one zone in well MRN 78 were permanently screened. All screens were gravel packed, and the gravel was placed by washing it down in tremie. The screened intervals were developed by a combination of jetting and air surging. Some intervals required backwashing in addition to surging. Development in all zones continued until the water pumped appeared to be free of drilling mud and sand, and until the specific conductance of the water stabilized. Five zones were selected for testing. The time spent developing the zones varied from 29 to 240 hours depending upon the characteristics of the zone.

HYDROGEOLOGIC DATA

Geology

Marion County is located in the South Carolina Coastal Plain. Coastal Plain rocks in the State consist primarily of unconsolidated to poorly consolidated sand and clay, with minor amounts of limestone. These rocks are all of Late Cretaceous age or younger, and form a generally wedge-shaped prism of sediments that thickens seaward. The Coastal Plain sediments lie on a pre-Cretaceous surface consisting of metamorphic, igneous, and consolidated sedimentary rocks.

Well MRN-77 penetrated surficical deposits of post-Miocene age, the Peedee Formation of Late Cretaceous age, and was completed in sand that is part of the Black Creek Formation of Late Cretaceous age. Well MRN 78 penetrated the entire sequence of Coastal Plain rocks and 53 feet of metamorphic crystalline rock that underlies the Coastal Plain. Geologic units present in well MRN-78 are: post-Miocene surficial deposits; deposits of Late Cretaceous age, including the Peedee, Black Creek, Middendorf (?), and Cape Fear Formations; and quartz biotite schist of unknown age (table 1).

Summary of Lithology in Well Mrn 78

The post-Miocene surficial deposits (land surface to 35 feet below land surface) consist of orange to tan clay and light-brown to tan medium-grained sand.

Table 1.--Description of core samples from well MRN 78

Britton Neck Test Hole - Marion (MRN) - 78
Owner: U.S. Geological Survey
Driller: Layne-Atlantic, Savannah, Ga.
Latitude/Longitude: 335143/0791950
Altitude: 30 feet N.G.V.D. of 1929
Total depth: 1225 feet
Description of core samples
Lithologic description and stratigraphic determinations by Robert A. Renken
Paleontologic identification by James A. Miller

	Depth in feet below land surface
Post Miocene Series	
Surficial deposits	
Clay, orange to tan, sand, light brown to tan, medium-grained (description based on cuttings).	0-35
Upper Cretaceous System	
Gulfian Series	
Peedee Formation	
Contact identified from cuttings and electric log	
Clay, sandy, dark yellowish brown (10YR6/6) to gray (N6)	35-45
Clay, light olive gray (5Y6/1) to greenish gray (5GY6/1), calcareous; some sand, very fine. Microscopic examination at 46.2 feet shows clay, dark gray (5Y8/1), calcareous, almost subfissile when dry; with some sandy limestone or calcareous sandstone, medium to fine clear quartz sand; gypsum crystals; trace lignite in float. At 50 feet, clay is micaceous; numerous foraminifera in float.	45-50
Clay light olive gray (5Y6/1) to greenish gray (5GY6/1); with coarse to fine quartz sand; some gravel size quartz.	50-60
Clay, medium gray (N6), highly calcareous, micaceous, with very fine quartz sand; some sandy limestone in washed sample; numerous foraminifera and ostracoda in float. *Brachycythere rhomboidalis* (Berry), Navarro age.	60-63.5
Clay, medium gray (N6) to greenish gray (5GY6/1); with very fine calcareous quartz sand; mica flakes; numerous microfossils (ostracoda and foraminifera) including *Robulus* sp.	63.5-74.5
Clay, medium gray (N6 to N5); massive, calcareous; shell fragments common, with very fine quartz sand; mica common; gypsum crystals, foraminifera rare (*Robulus* sp.); *Veenia arachanoides* (Berry) Navarro age (83 feet); sand absent from 110-120.	74.5-127
Black Creek Formation	
Top of formation based on occurrence of lignite, absence of sandy limestone or marl and occurrence of fine sand as thin laminae or partings.	
Clay, medium gray (N5), calcareous, micaceous; with clear, fine- to medium-grained, angular quartz sand increasing with depth; trace of phosphate, lignite abundant in several sandy seams or sandy laminae.	127-156
Clay, medium gray (N5 to N6) to medium dark gray (N4), calcareous, micaceous; some very fine clear, angular quartz sand occurs as occasional thin laminations; shell fragments common; some lignite.	156-167
Clay, dark greenish gray (5GY4/1) to greenish gray (5GY6/1), calcareous, micaceous.	167-169

Clay, sandy, olive gray (5Y4/1) to light olive gray (5Y6/1) to medium gray (N5) to medium dark gray (N5), calcareous, in part micaceous, massive; with fine quartz sand; massive clays alternate with more thinly laminated clays with fine sand partings; some phosphate, glauconite; Robulus sp. rare, Vaginulina multicostata Cushman (170 feet), Navarro and Taylor age.	169-215
Sand, clayey, medium gray (N5); laminae not present.	215-229
Clay, medium light gray (N6), calcareous, micaceous; sand, light gray (N7) to yellowish gray (5Y8/1), quartz, fine; sand occurs as thin laminations or partings, becoming more numerous and prevalent with depth; trace of glauconite; gypsum crystals occur as a "bloom" when sample is dried; some sandy limestone fragments in washed sample at 239 feet.	229-249
Clay, sandy, dark greenish gray (5GY4/1), with trace of glauconite.	249-251
Sand, dusty yellow green (5GY5/2) to dark greenish gray (5GY4/1) to greenish gray (5GY6/1), medium grained, quartz, clear, subrounded to subangular; glauconitic; with clay, sandy, slightly calcareous (calcareous nature is notably less below 265 feet), micaceous; phosphate common to rare; trace of lignite; while alternating sand and clay beds are present, sand predominates.	251-274
Clay, with alternating paper thin sand partings or laminae, medium dark gray (N4), greenish gray (5GY6/1) and light greenish gray (5GY6/1), micaceous; with very fine quartz sand; clay layers average .5 cm or thicker; lignite.	274-288
Sand, clayey, fine to medium, quartz; trace of mica, lignite.	288-332
Clay, medium gray (N5), micaceous, waxy, subfissile, some fine quartz sand occurring as laminae, shell fragments abundant; some lignite, trace phosphate.	332-355
Clay, sandy, silty, medium dark gray (N4); micaceous, waxy; highly lignitic.	355-362
Clay, alternating with paper thin sand laminae; clay layers average .5 cm, medium dark gray (N4); with very fine quartz sand; clay, micaceous, waxy; lignite, shell fragments common.	362-389
Sand, medium grained, quartz, subangular to subrounded; some clay, greenish gray (5Y6/1), micaceous; phosphate, lignite, and glauconite rare.	389-398
Sand, quartz, light olive gray (5Y5/2), fine to very fine, numerous shell fragments, some clay interbeds.	398-416
Sand, quartz, light olive gray (5Y5/2), fine to very fine, clear, some silt; scattered interbeds of clay occurring as thin laminae become more common with depth; trace of glauconite, mica; lignitic in places.	416-451
Sand, quartz, very fine to medium, with interbedded silty greenish gray (5GY6/1) clay; micaceous; trace of glauconite.	451-477
Sand, quartz, fine, with interbedded clay, light olive gray (5Y5/2) to olive gray (5Y3/2) to black; clay interbeds range from thin to massive; shell fragments common to abundant; trace of glauconite; Cythereis gapensis (Alexander), Taylor age (477 feet).	477-489
Sand, quartz, light olive gray (5Y6/1), fine to very fine; trace of mica, shell fragments.	489-491
Sand, quartz, greenish gray (5GY6/1) to medium gray, fine to very fine, subangular; with interbeds of clay laminae becoming thicker in places; trace of mica, glauconite.	491-528

Clay, dark greenish gray (5GY4/1) with interbedded fine to very fine quartz sand; trace of glauconite, lignite.	528-539
Sand, light olive gray (5Y6/1), fine to very fine, quartz, subangular; some silt; scattered clay laminae; trace of mica, lignite, glauconite.	539-560
Sand, quartz, greenish gray (5GY6/1) to yellowish gray (5Y8/1) with more clay than above; trace of mica, lignite.	560-566
Clay, alternating with sand lenses, medium gray (N5) to medium dark gray (N4); lignite particularly abundant at 569 feet.	566-574
Sand, alternating with dark gray (N3) clay lenses; sand predominates, quartz, fine to very fine; lignite abundant.	574-578
Clay, grayish black (N2), medium gray (N5) to medium dark gray (N4); waxy, some lignite.	578-594
Sand, quartz, silty, light yellowish gray (5Y8/1) to light greenish gray (5GY8/1) to medium gray (N5); trace of mica, lignite.	594-601
Clay, grayish black (N2) to dark gray (N3), massive, waxy, micaceous, some lignite; washed sample has yellowish gray cast (5Y8/1), slightly calcareous.	601-619
Middendorf (?) Formation	
Top of formation based on overall lithology, occurrence of feldspar, and rip-up clasts.	
Sand, quartz, light olive gray (5Y6/1) to olive gray (5Y4/1), fine; with some silt; carbonaceous material present.	619-625
Silt, clayey, and clay, silty, interlaminated, light olive gray (5Y6/1), mottled to yellowish brown (10YR5/4); rip-up clasts of clayey silt incorporated in core.	625-635
Silt, sandy, and clay, sandy, interlaminated, light olive gray (5Y6/1); with sand, quartz, fine to coarse, angular to subangular, some feldspar, pink.	635-638
Sand, clayey, and clay, sandy, interbedded, light olive gray (5Y6/1), hard, compact; sandier near base; trace of mica and shell fragments.	638-648
Clay, silty, light olive gray (5Y6/1), some iron staining to light brown (5Y5/6); trace of sand, quartz, clear, coarse, angular.	648-654
Clay, sandy, silty, and sand, clayey, interbedded, light olive gray (5Y6/1), iron staining to moderate yellowish brown (10YR5/4).	654-664
Clay, light olive gray (5Y6/1), and silt, yellowish gray (5Y8/1) alternating as thin bands .5 centimeters thick.	664-674
Sand, quartz, clayey, white brownish gray (5YR6/1), coarse to medium, angular to subangular.	674-713
Sand, yellowish gray (5Y7/2), quartz, coarse to medium, some very coarse, angular to subangular.	713-734
Clay, silty, alternating with sandy silt and fine quartz sand, yellowish gray (5Y8/1) to pale red purple (5RP6/2); trace of mica, lignite.	734-750
Sand, quartz, silty, yellowish gray (5Y7/2) to black (N1).	750-765
Sand, medium grained, quartz, unconsolidated.	765-772
Clay, silty, grayish yellow (5Y8/4) to light olive gray (5Y5/2), faintly laminated and mottled.	772-780
Cape Fear Formation	
Top of formation based on cyclic nature of stratification, coarse-grained sand grading upward to medium- and fine-grained sand, then grading upward to silt and clay. Cycles are repetitive, though not necessarily complete, and are similar to the sand-mud couplets described by Heron, Swift and Dill (1968).	

Clay, alternating light olive gray (5Y6/1) to grayish red (5R4/2) to medium light gray (N6) to medium gray (N5), sandy to slightly sandy; with sand, quartz, clear to iron-stained, poorly sorted, fine to coarse, subangular.	780-826
Sand, quartz, medium to coarse, some very coarse, unconsolidated to loosely consolidated; some feldspar, gravel size.	826-830
Clay, greenish gray (5GY6/1) to light brownish gray (5YR6/1), color banding; with some sand, quartz, feldspathic.	830-838
Sand, quartz, clayey to slightly clayey, yellowish gray (5Y7/2), highly oxidized with limonite stains in places, moderate reddish brown (10R4/6); some silt, clayey; micaceous.	838-850
Clay, colors alternate from medium gray (N5) to moderate red (5R4/6), mica common.	850-860
Sand, quartz, yellowish gray (5Y7/2), fine to very coarse, coarser with depth, some pebble size feldspar grains, subangular to angular; some of the feldspar grains are highly friable; some silt and clay, mica.	860-870
Clay, yellowish gray (5Y7/2), silty.	870-872
Sand, clayey, silty, mottled, light olive brown (5Y5/6) to dusky yellow (5Y6/4) to dark yellowish orange (10YR6/6) and moderate brown (5YR4/4), quartz, poorly sorted, fine to coarse; some very coarse feldspar grains, highly oxidized with limonite.	872-873
Clay, yellowish gray (5Y7/2), silty.	873-875
Sand, moderate brown (5YR4/4) to yellowish gray (5Y7/2), quartz, feldspathic, fine to coarse, poorly sorted, angular to subangular, fines upward, some fine gravel size grains present.	875-885
Sand, fining upward to clay, yellowish gray (5Y8/1) to reddish brown where highly oxidized, quartz; trace of feldspar, mica.	885-890
Sand fining upward to silty clay, yellowish gray (5Y8/1) to light olive gray, moderate reddish brown (10R4/6) where oxidized, very coarse sand to small pebble size grains at base, quartz, feldspathic, poorly sorted; trace of phosphate and mica; fining upward sequence does not make complete cycle, grades from coarse sand to fine, then coarse, grading upward to clay; colors of clay alternate to form .5 centimeter bands, dark reddish brown (10R3/4) to light brownish gray (5YR6/1).	890-900
Sand, quartz, fining upward to clay; grades from very coarse sand at base, making several incomplete cycles until grading to clay at 905 feet; light brownish gray (5YR61) to light olive gray (5Y5/2) to moderate brown (5YR4/4) to yellowish gray (5Y7/2).	900-916
Sand, quartz, fining upward to clay, silty, yellowish gray (5Y8/1), grades from very coarse sand upward to clay, three cycles noted, poorly sorted, fine to very coarse, feldspathic.	916-921
Sand, quartz, yellowish gray to very pale orange (10YR8/2) to pale reddish brown (10R5/4), fine to very coarse, some fine gravel size, some silt, highly oxidized in places.	921-933
Clay, light brown (5YR6/4) to very pale orange (10YR8/2) to moderate reddish brown (10R4/6), slightly sandy and silty in places, highly oxidized.	933-940
Sand, very fine to very coarse, quartz, feldspathic; trace of mica.	940-948
Sand, moderate reddish brown (10R4/6) to gray, very coarse at base fining upward to medium- and fine-grained, quartz, feldspathic, highly oxidized.	948-955

Sand, moderate reddish brown (10R4/6) to olive gray (5Y4/1), very coarse in places, clayey and silty in places, poorly sorted, quartz, feldspathic.	955-1,043
Sand, coarse-grained fining upward to medium- and fine-grained; part of fining upward sequence to clay, as above, very light gray (N8) to moderate brown (5YR4/4) to grayish orange (10YR7/4), quartz, iron-stained, subangular to subrounded; highly micaceous.	1,043-1,061
Clay, silty, light gray (N8) to light greenish gray (5GY6/1) to grayish orange (10YR7/4) to moderate reddish brown (10R4/6); some quartz sand, fine; micaceous.	1,061-1,077
Sand, quartz, fines upward to clayey sand and sandy clay (upper 2 feet), and clay, silty, as above, light greenish gray (5GY8/1) to moderate reddish brown (10R4/6), highly oxidized in places, poorly sorted, coarser sand at base; micaceous.	1,077-1,091
Clay, silty, moderate reddish brown (10R4/6) to dark yellowish orange (10YR6/6) to very light gray (N8) to light bluish gray (5B7/1), mottled, some colors vary as bands probably due to oxidation; with fine to coarse quartz sand in places; large mica flakes common.	1,091-1,120
Sand, moderate reddish brown (10R4/6) to light bluish gray (5B7/1), fine to coarse, quartz, subangular to subrounded, some feldspar, mica common.	1,120-1,130
Clay, silty, light gray (N7) to light greenish gray (5GY8/1) and silt, clayey, oxidized light brown (5YR5/6) to moderate yellowish brown (10YR5/4), colors alternate as bands, some are inclined rather than being perpendicular to long axis of core (1,140-1,142 feet), possibly due to deformation in core barrel; some quartz sand, medium-grained, near base of core.	1,130-1,159
Silt, sandy, and sand, silty, interbedded very pale orange (10YR8/2) to dark yellowish orange (10YR6/6); with quartz sand, mostly fine, some coarse-grained, highly micaceous.	1,159-1,171
Pre-Cretaceous System	
Saprolite	
Saprolitic clay and silt, moderate reddish brown (10R4/6), light brown (5YR5/6), moderate brown (5YR4/4) to pale blue (5PB7/2); with quartz sand at 1,172 feet; highly micaceous.	1,171-1,177
Saprolite, highly weathered bedrock (quartz-mica schist), weathers to gravelly sand in places; foliations are nearly vertical in places; highly micaceous. Quartzite at 1,190 feet.	1,177-1,197
Bedrock - base of Coastal Plain	
Bedrock, quartz-mica schist.	1,197-1,120
Not described	1,120-1,225
Total depth 1,225 feet.	

Summary (in feet)	From	To	Thickness
Post-Miocene Series			
Surficial deposits	0	35	35
Cretaceous System			
Gulfian Series			
Peedee Formation	35	127	92
Black Creek Formation	127	619	492
Middendorf (?) Formation	619	780	161
Cape Fear Formation	780	1,171	391
Pre-Cretaceous Series			
Saprolite	1,171	1,197	26
Quartz-mica schist	1,197		

The Peedee Formation of Late Cretaceous age (35 to 127 feet) consists generally of calcareous gray clay or marl with traces of lignite, shell fragments, and microfauna. In places, sandy limestone and quartz sand are present; traces of lignite, shell fragments and microfauna that include foraminifera and ostracoda are not uncommon.

The Black Creek Formation of Late Cretaceous age (127 to 761 feet) consists of medium-gray, calcareous, micaceous clay with interbedded sand occurring as laminae in the upper part of the formation (127 to 250 feet). Sand with clay interbeds that range in thickness from thin laminae to medium beds predominate from 250 to 566 feet. Lignite, shell fragments, mica, glauconite, and phosphate generally occur in trace amounts but are more common in places. The basal part of the Black Creek Formation (566 to 619 feet) consists of alternating beds of clay and sand.

The Middendorf (?) Formation of Late Cretaceous age (619 to 780 feet) consists of alternating beds of light olive gray clayey silt, sandy silt and sandy clay from 619 to 674 feet. The basal part of the Middendorf (?) Formation consists largely of yellowish gray coarse- to medium-grained quartz sand (674 to 780 feet).

The Cape Fear Formation of Late Cretaceous age (780 to 1,171 feet) is the oldest formation of Cretaceous age penetrated. It consists largely of a series of fining-upward cycles of coarse sand grading upward to fine sand, then to silt and clay. These sand-clay sequences are similar to those described by Heron, Swift and Dill (1968).

Twenty-six feet of pre-Cretaceous saprolitic clay and silt (1,171 to 1,197 feet) underlie the Cape Fear Formation. This saprolite is in turn underlain by a quartz-biotite shist that has been intruded by granite (fig. 2).

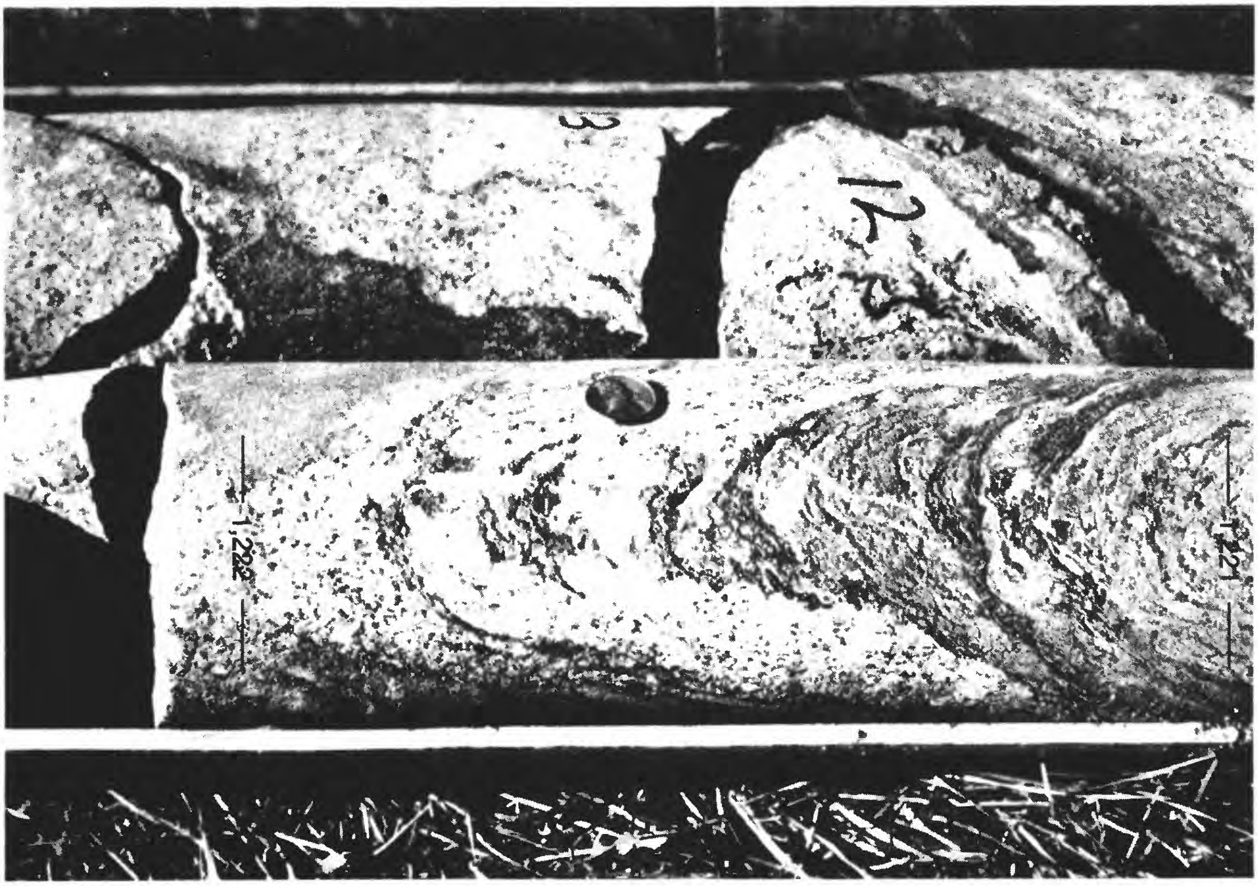
Geophysical Logs

A suite of geophysical logs was made of the uncased well MRN 78 that includes a standard electric log with self-potential and a 16- and 64-inch resistivity curve, guard or focused resistivity log, natural gamma, gamma-gamma density log, neutron log, sonic velocity, temperature and caliper log. The lithologic log and all of the geophysical logs are shown on plate 1.

Temperature, fluid conductivity, and caliper logs were used to locate a leak in the casing. The logs indicated a disruption between about 260 and 300 feet (fig. 3). The caliper log indicated an increase in casing diameter from 172 to 206 feet and from 230 to 272 feet, and the temperature log showed a reversal of temperature from about 250 to 300 feet. The conductivity log showed the greatest difference, increasing from 3,000 micromhos at 262 feet to 6,000 micromhos at 268 feet and increasing further to 9,500 micromhos at about 300 feet. The temperature and conductivity logs indicated that cooler, less mineralized water was entering the casing between 170 and 300 feet.

X-ray Mineralogy

Selected cores from MRN-78 were tested for mineral content. The depth of the nine cores ranges from 340 to 1,012 feet. The results of the x-ray diffrac-



Interval 1,221 to 1,222 feet. Core shows granite (light) injected into quartz biotite schist (dark).

Figure 2.--Core from well MRN 78.

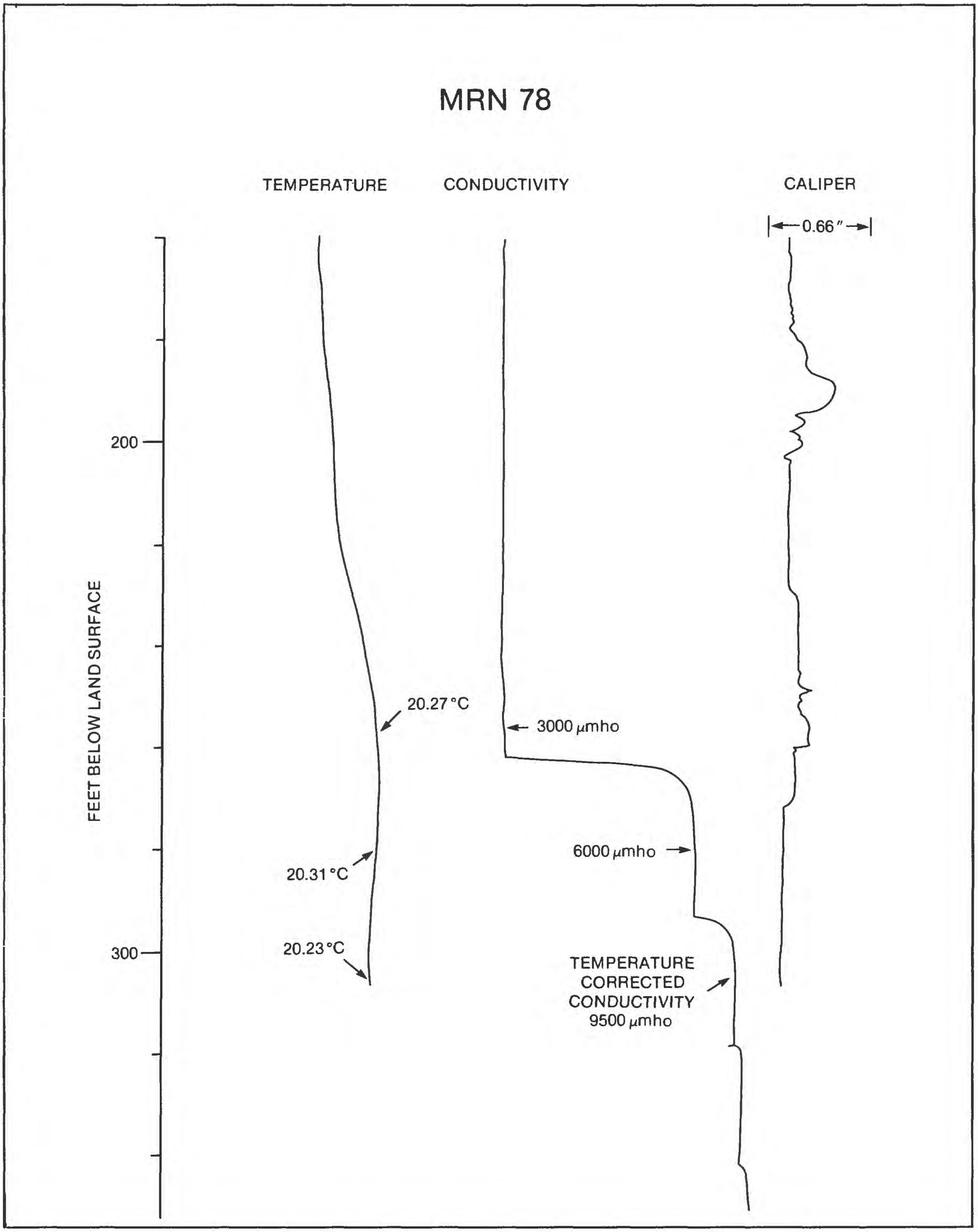


Figure 3.--Temperature, conductivity and caliper logs for the upper part of well MRN 78.

Table 3.--Zone water levels at Britton Neck, South Carolina

Zone	Interval sampled (feet below land surface)	Aquifer	Development time (hours)	Average yield (gpm)	Time (hours)	Water level (feet with reference to land surface) Altitude: 30 feet	Water level date
MRN 78							
5	517-537	Black Creek	49	32	21	-13.4	5/3/82
4	748-768	Middendorf (?)	29	35	17	-20.6	4/24/82
1/3	811-831	Cape Fear (upper)	94	3	30	+17.6	4/21/82
2	1,010-1,030	Cape Fear	63	5	37	+59.6	4/10/82
2/1	1,120-1,140	Saprolite (?)	240	0.5	72	+37.6	4/2/82
MRN 77							
3/	325-335 and 345-355	Black Creek				-11.82	6/15/82

1/ Projected recovery from t/t' plot.

2/ Recovery not complete after 29 hours.

3/ Completed well.

SAMPLING AND CHEMICAL ANALYSES OF WATER

Five zones were selected on the basis of electric and lithologic log characteristics for obtaining water samples, collected to evaluate the water chemistry of various units.

Water samples collected were analyzed by laboratories of the Geological Survey in Doraville, Ga.; Arvada, Colo.; and Reston, Va. Samples were collected and analyzed by established procedures (Skougstad and others, 1979). Temperature, pH, biocarbonate and carbonate were field-determined (Wood, 1976). The pH values were measured to ±0.02 units and are reported to two decimal places accordingly. Ion chromatography was used to determine the major anions (Erdmann and others, 1982), although the reported phosphate (PO_4) value is from the standard nutrient method. Samples for trace metals were field prepared for inductively coupled plasma atomic emission spectroscopy (ICP) analysis (plasma-jet analyzer) by filtration through 0.45 μm pore size filters. Dissolved gas samples were collected in an evacuated glass tube (Hobba and others, 1977) preliminary to gas chromatographic analyses. The stable and radioactive isotope samples, and radiochemical samples were collected according to previously established methods used within the Geological Survey (Busby and others, 1983). The results of the analyses are shown in table 4.

Water chemistry samples collected from MRN 77 represent the combined 325-335 and 345-355 foot intervals which were not differentiated. Five screened zones were samples in MRN 78: zone 1 (1,120-1,140 feet), zone 2 (1,010-1,030 feet), zone 3 (811-831 feet), zone 4 (748-768 feet), and zone 5 (517-537 feet).

Analysis of the water samples from these wells shows that zone 1 had the highest concentrations of calcium, magnesium, sodium, potassium, chloride, sulfate, fluoride, and dissolved solids and the lowest concentration of silica. The highest concentration of silica was in zone 3. The highest concentration of iron was in zone 2. Zone 4 had the lowest concentration of potassium. Zone 5 had the lowest concentration of sulfate. The lowest concentrations of fluoride were in zones 2 and 3. MRN 77 had the lowest concentrations of calcium, sodium, chloride, iron, and dissolved solids. All samples reported a pH above 7.0, indicating an alkaline water, especially from zone 5 and MRN 77.

The water from MRN 77 meets the U.S. Environmental Protection Agency Drinking Water Standards except for pH, whereas the water from MRN 78 does not meet the standards in all constituents in all zones. The water from zones 1, 4, and 5 does not meet the standard for fluoride; the water from zones 1, 2, and 3 does not meet the standards for chloride, iron, nitrate and dissolved solids. The water from zone 1 does not meet the standards for sulfate.

SUMMARY

This report contains the data collected from two test wells drilled in 1982 in Marion County, S.C. The wells were drilled to determine the depth and thickness of sand aquifers in Marion County, S.C., in connection with the Southeastern Coastal Plain Regional Aquifer Systems Analysis investigation.

Well MRN 77, drilled to a depth of 365 feet, was used for observation purposes and to supply water during the drilling of the deeper well. The deeper well, MRN 78, penetrated surficial clay deposits of post-Miocene age, and beds

tograms are shown in table 2. Clastic rocks analyzed consist predominantly of quartz with small amounts of feldspar and mica. Carbonate rocks analyzed are composed primarily of calcite with minor amounts of dolomite.

HYDROLOGIC TESTING

Procedures for Recovery Tests in Well MRN 78

Recovery tests were performed on test well MRN 78 at five water-bearing intervals (1,120-1,140 feet, 1,010-1,030 feet, 811-831 feet, 748-768 feet, and 517-537 feet) as well as the screened horizon of 1,008-1,028 feet. To test a particular water-bearing unit, a temporary screen was set in place, gravel packed, with the test zone sealed above by heavy drilling fluid placed on top of the gravel pack. Water and air jetting and air lift were techniques used to develop the test interval. Subsequently, a submersible pump was installed and development continued until the water pumped was visably clear and its specific conductance and pH remained stable. A water sample was collected for each zone at the end of the development period. The development time varied for each test zone as shown in table 3. The pump was then turned off and the well was allowed to recover. The water level approached land surface in test zones 811-831 feet, 1,010-1,030 feet, and 1,120-1,140 feet, and accordingly, the pump and drop pipe were removed and the well capped with further water-level measurements made using a calibrated pressure gauge. A 1/2-gallon or 5-gallon bucket and a stop watch were used to measure pumping rates. The recovery test was finally terminated when static water level conditions were obtained or when time conditions required the test to be shortened (zones 811-831 feet and 1,120-1,140 feet). The screen line was then raised in preparation for the next shallower zone test.

The recovery test results were plotted for each zone to verify the measured static water levels. In general, however, these tests do not prove to be reliable aquifer tests due to the effect of casing storage resulting from low pumping rates with respect to casing size. This effect is particularly noticeable in low yield aquifers (Schafer, 1978).

Comparison of Predevelopment and Modern Water Levels

Static water levels for the five zones (table 2) provide important data with respect to the regional ground-water flow system. Pre-development water levels were probably about 50 feet above sea level in zones 4 and 5, compared to 90-100 feet above sea level in zone 2, and somewhere between 50-100 feet above sea level for zone 3 (Aucott and Speiran, 1985). A comparison of pre-development conditions and 1982 water levels of these same zones indicate a water level decline of about 40 feet in both zone 4 and 5 and the 325-355 foot zone in MRN 77, probably due to pumpage centers at Johnsonville, Hemingway, Conway, and Myrtle Beach. The effects of pumpage on pre-development conditions in zone 2 is difficult to evaluate. Decline in water levels has occured in zone 3 due to pumpage of overlying aquifers. The vertical hydraulic gradient at the test site is now toward zone 4 from above and below and has increased as a result of pumping.

Table 2.--Mineralogy from selected cores of USGS Test Well at Britton Neck, SC.

DEPTH	QUARTZ	KSPAR	ALBITE	CALCITE	PYRITE	KAOLIN	GMECT	MUSC	OTHER MINERALS	CORE DESCRIPTIONS
340'	S	TR	L	S	TR	-	TR	-	TR DOLOMITE	FINE SANDY LIMESTONE
344'	S	TR	TR	S	TR	TR	TR	-	TR DOLOMITE	FOSSILIFEROUS SANDY LIMESTONE
377'	S	-	-	S	-	-	-	-	-------	SANDY LIMESTONE
444'	S	L	TR	S	M	-	-	-	-------	FOSSILIFEROUS, MEDIUM SAND AND CLAY, CALCITE
520'	S	L	TR	L	M	TR	L	TR	APATITE DRILLING MUD	BIT SAMPLE, COARSE SAND, DRILLING MUD ORGANIC MATERIAL
738'	S	M	S	L	TR	L	TR	L	OLIGOCLASE	FINE SAND AND CLAY, MICA
770'	S	L	TR	TR	M	TR	TR	TR	-------	DARK COARSE SAND WITH DRILLING MUD, PYRITE NUGGET, FELDSPARS
827'	S	L	M	TR	TR	L	TR	TR	ILLITE	COARSE SAND AND CLAY, DRILLING MUD, MICROCLINE AND PLAGIOCLASE
1012'	S	M	-	TR	-	M	L	-	TR MIXED-LAYER CLAY	COARSE SAND AND CLAY, LITTLE OR NO ACCESSORY MINERALS

Legend

S-Strong
M-Medium
L-Low
Tr-Trace

Table. 4--Chemical data from test wells MRN 77 and MRN 78 at Britton Neck, S.C.

Major Water Chemistry

Well	Sampling depth interval (feet)	Temperature (deg C)	Specific conductance (μMHOS)	pH field (units)	Bicarbonate fet-fld (mg/L as HCO_3)	Carbonate fet-fld fet-fld (mg/L as as CO_3)	Calcium dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Chloride, dissolved (mg/L as Cl)	Sulfate dissolved (mg/L as SO_4)	Fluoride dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Solids residue at 180 deg. C dissolved (mg/L)
MRN 77	325-335														
MRN 77	345-355	20.4	550	8.7	290	22	1.4	.24	120	4.1	5.3	6.2	1.2	14	313
78-1	1120-1140	21.6	5800	8.0	430	--	42	12	1230	12	1300	525	6.7	9.5	3470
78-2	1010-1030	23.0	2880	7.5	890	--	9.9	2.6	480	6.6	373	124	0.6	32	1700
78-3	811-831	23.7	2550	7.6	820	--	12	3.4	580	6.1	359	118	0.6	34	1540
78-4	748-768	23.2	765	8.1	380	--	1.7	.36	180	2.2	57	13	2.7	24	450
78-5	517-537	21.4	850	8.6	490	12	2.3	.46	190	3.7	36	<.2	4.7	17	496
E.P.A. Drinking Water Standards				6.5-8.5							250	250	1.6		

Trace Metals

Well	Barium, dissolved (μg/L as Ba)	Beryllium, dissolved (μg/L as Be)	Boron, dissolved (μg/L as B)	Cadmium, dissolved (μg/L as Cd)	Cobalt, dissolved (μg/L as Co)	Cooper dissolved (μg/L as Cu)	Iron, dissolved (μg/L as Fe)	Lead, dissolved (μg/L as Pb)	Manganese, dissolved (μg/L as Mn)	Molybdenum, dissolved (μg/L as Mo)	Strontium, dissolved (μg/L as Sr)	Vanadium, dissolved (μg/L as V)	Zinc, dissolved (μg/L as Zn)	Aluminum, dissolved (μg/L as Al)	Lithium, dissolved (μg/L as Li)	Selenium, dissolved (μg/L as Se)	Mercury, dissolved (μg/L as Hg)
MRN 77	11	<1	510	<1	<3	<10	11	<10	1	<30	39	<6	<3	10	<12	<1	.2
MRN 78-1	170	<1	4700	1	<3	<10	1600	<10	400	10	1500	<6	24	200	80	<1	.1
78-2	60	<1	8000	<1	15	<10	5500	<10	91	40	320	<6	110	10	21	<1	.3
78-3	64	<3	5200	<3	<9	<30	2200	<30	89	<30	440	<10	190	300	28	<1	.3
78-4	18	1	2000	<1	<3	<10	120	<10	10	<30	51	<6	13	20	<12	<1	.1
78-5	31	<1	1900	<1	<3	<10	44	<10	2	<30	71	<6	<3	10	<12	<1	.2
E.P.A. Drinking Water Standards	1,000			10		1,000	300	50					5,000				

Table 4.--Chemical data from test wells MRN 77 and MRN 78 at Britton Neck, S.C.-Continued

Nutrients and Trace Constituents

Well	Nitrogen dissolved (mg/L as N)	Nitrogen, organic dissolved (mg/L as N)	Nitrogen, ammonia dissolved (mg/L as N)	Nitrogen, nitrate dissolved (mg/L as N)	Nitrogen, ammonia + organic dis. (mg/L as N)	Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	Phosphate, ortho, dissolved (mg/L as PO_4)	Phosphorus, dissolved (mg/L as P)	Phosphorus, ortho, dissolved (mg/L as P)	Carbon, organic dissolved (mg/L as C)	Sulfide total (mg/L as S)	Nitrate dissolved (mg/L as NO_3)	Iodide, dissolved (mg/L as I)	Bromide, dissolved (mg/L as Br)
MRN 77	---	.30	.110	<.05	.41	<.10	---	.030	<.060	1.3	<.5	----	.010	<.10
MRN 78-1	---	1.6	.690	4.50	2.3	<.01	---	<.010	<.060	.7	<.5	20	.330	5.6
78-2	.49	.00	.420	5.40	.39	.10	---	.120	<.060	2.7	<.5	24	.040	1.7
78-3	---	.03	.360	2.60	.39	<.10	---	.080	<.060	.5	<.5	12	.040	1.7
78-4	.37	.08	.100	<.05	.18	<.10	---	.260	<.060	1.1	<.5	----	.010	.26
78-5	---	.25	.210	.05	.46	<.10	.18	.140	.060	1.9	<.5	.20	.010	<.10
E.P.A. Drinking Water Standards												10		

Radiochemistry, Isotopes, and Dissolved Gases

Well	Gross alpha, dissolved (μg/L as U-NAT)	Gross beta, dissolved (PCi/L as Sr/Yt-90)	Carbon 14 percent modern	C-13/C-12 stable isotope ratio (per mil)	H-2/H-1 stable isotope ratio (per mil)	O-18/O-16 stable isotope ratio (per mil)	Tritium (total T.U.)	Nitrogen dissolved (mg/L as N_2)	Oxygen dissolved (mg/L)	Argon dissolved (mg/L)	Methane dissolved (mg/L as CH_4)	Carbon dioxide dissolved mg/L as CO_2)	Helium dissolved (mg/L)	Hydrogen dissolved (mg/L as H_2)
MRN 77	<14	<13	<.70	-5.55	-23.0	-4.60	0.5	25	.02	1.0	.02	1.1	.0007	.0019
78-1	<97	<63	4.7	-13.55	-23.0	-3.90	0.6	--	---	---	---	9.8	.038	-----
78-2	<57	<29	6.0	-12.90	-24.5	-4.05	0.7	25	.04	.92	<.02	24.0	.004	tr.
78-3	<51	<23	2.4	-12.20	-25.0	-4.35	0.9	24	.02	.91	<.02	32.0	.003	.0001
78-4	<12	<5.6	2.5	-10.25	-24.0	-4.55	0.7	24	.36	.91	<.02	5.6	tr.	.0006
78-5	<15	<6.7	2.9	-7.25	-24.0	-4.40	0.0	22	<.01	.92	<.02	2.6	.0017	tri.
E.P.A. Drinking Water Standards		15	200											

of sand, clay and silt of the Peedee, Black Creek, Middendorf (?) and Cape Fear Formations of Late Cretaceous age before reaching basement at a depth of 1,156 feet. Total depth of the well was 1,225 feet.

Data from the wells include description of the core samples from MRN 78, geophysical logs, zone water levels, chemical analysis of the water sampled and results of tests for mineral content. Head in MRN 78 increases with depth. The waters sampled were all sodium bicarbonate type except for the deepest zone (1,120-1,140 feet) sampled in MRN 78, which yielded a sodium chloride type water.

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