THE OCCURRENCE AND GEOCHEMISTRY OF SALTY GROUND WATER IN THE NORTHERN ATLANTIC COASTAL PLAIN

REGIONAL AQUIFER-SYSTEM ANALYSIS

U.S. GEOLOGICAL SURVEY PROFESSIONAL PAPER 1404–D

The Occurrence and Geochemistry of Salty Ground Water in the Northern Atlantic Coastal Plain

By HAROLD MEISLER

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FOREWORD

THE REGIONAL AQUIFER-SYSTEM ANALYSIS PROGRAM

The Regional Aquifer-System Analysis (RASA) Program was started in 1978 following a congressional mandate to develop quantitative appraisals of the major ground-water systems of the United States. The RASA Program represents a systematic effort to study a number of the Nation's most important aquifer systems, which in aggregate underlie much of the country and which represent an important component of the Nation's total water supply. In general, the boundaries of these studies are identified by the hydrologic extent of each system and accordingly transcend the political subdivisions to which investigations have often arbitrarily been limited in the past. The broad objective for each study is to assemble geologic, hydrologic, and geochemical information, to analyze and develop an understanding of the system, and to develop predictive capabilities that will contribute to the effective management of the system. The use of computer simulation is an important element of the RASA studies, both to develop an understanding of the natural, undisturbed hydrologic system and the changes brought about in it by human activities, and to provide a means of predicting the regional effects of future pumping or other stresses.

The final interpretive results of the RASA Program are presented in a series of U.S. Geological Survey Professional Papers that describe the geology, hydrology, and geochemistry of each regional aquifer system. Each study within the RASA Program is assigned a single Professional Paper number, and where the volume of interpretive material warrants, separate topical chapters that consider the principal elements of the investigation may be published. The series of RASA interpretive reports begins with Professional Paper 1400 and thereafter will continue in numerical sequence as the interpretive products of subsequent studies become available.

Dallas L. Peck

Dallas L. Peck
Director

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ILLUSTRATIONS

[Plates are in pocket at back of report]

TABLE

METRIC CONVERSION FACTORS

For readers who prefer to use metric (International System) units rather than inch-pound units, the conversion factors are listed below.

Multiply inch-pound unit	*By*	*To obtain metric unit*
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)

THE OCCURRENCE AND GEOCHEMISTRY OF SALTY GROUND WATER IN THE NORTHERN ATLANTIC COASTAL PLAIN

By HAROLD MEISLER

ABSTRACT

Salty ground water underlies freshwater in the eastern part of the northern Atlantic Coastal Plain. The transition zone between freshwater and saltwater is represented in this report by a series of maps showing the depths to chloride concentrations of 250, 1,000, 5,000, 10,000, and 18,000 milligrams per liter. The maps are based on chloride data obtained from water-quality analyses supplemented by interpretation of borehole spontaneous-potential and resistivity logs. They indicate that the transition zone between 250 and 18,000 milligrams of chloride per liter ranges in thickness from 400 to 2,200 feet.

The saltwater-freshwater transition zone is shallowest in North Carolina and deepens northward, attaining its greatest depth in Maryland and New Jersey. It deepens inland from the coast except locally in North Carolina and in New Jersey, where it is deepest along the coast. Ground water containing chloride concentrations of less than 5,000 milligrams per liter extends 55 miles eastward from the New Jersey coast and extends progressively shorter distances from the coast farther south.

Depth to the saltwater-freshwater transition zone is partly controlled by the natural flow pattern of fresh ground water; areas where the transition zone is relatively shallow commonly coincide with areas of natural ground-water discharge. On the other hand, the occurrence of the transition zone at great depths in New Jersey and Maryland and the occurrence offshore of water considerably fresher than seawater probably can be attributed to long periods when sea levels were generally lower than at present; higher sea levels relative to land surface caused the transition zone to be shallower in Virginia and North Carolina than in Maryland and New Jersey.

The broad saltwater-freshwater transition zone is attributed to the mixing of freshwater and saltwater caused by large-scale sea-level fluctuations, probably during the late Tertiary and Quaternary. Mixing of freshwater with seawater predominates in North Carolina, whereas mixing with brine is more significant from Virginia to New Jersey. The most likely origin of the brine is from the leaching of evaporitic strata beneath the Continental Shelf and the westward movement of the brines, initially during basinal compaction and subsequently during periods of sea-level rise.

INTRODUCTION

PURPOSE AND SCOPE

Salty ground water underlies freshwater in the eastern part of the northern Atlantic Coastal Plain. This report describes the occurrence of salty ground water in the northern Atlantic Coastal Plain and defines the transition zone between the deepest known freshwater and the underlying saltwater. The area studied includes the Coastal Plain from North Carolina to Long Island, N.Y., and part of the adjacent Continental Shelf. The report also discusses the chemical nature and origin of the saltwater-freshwater transition zone. The area of study is shown in figure 1.

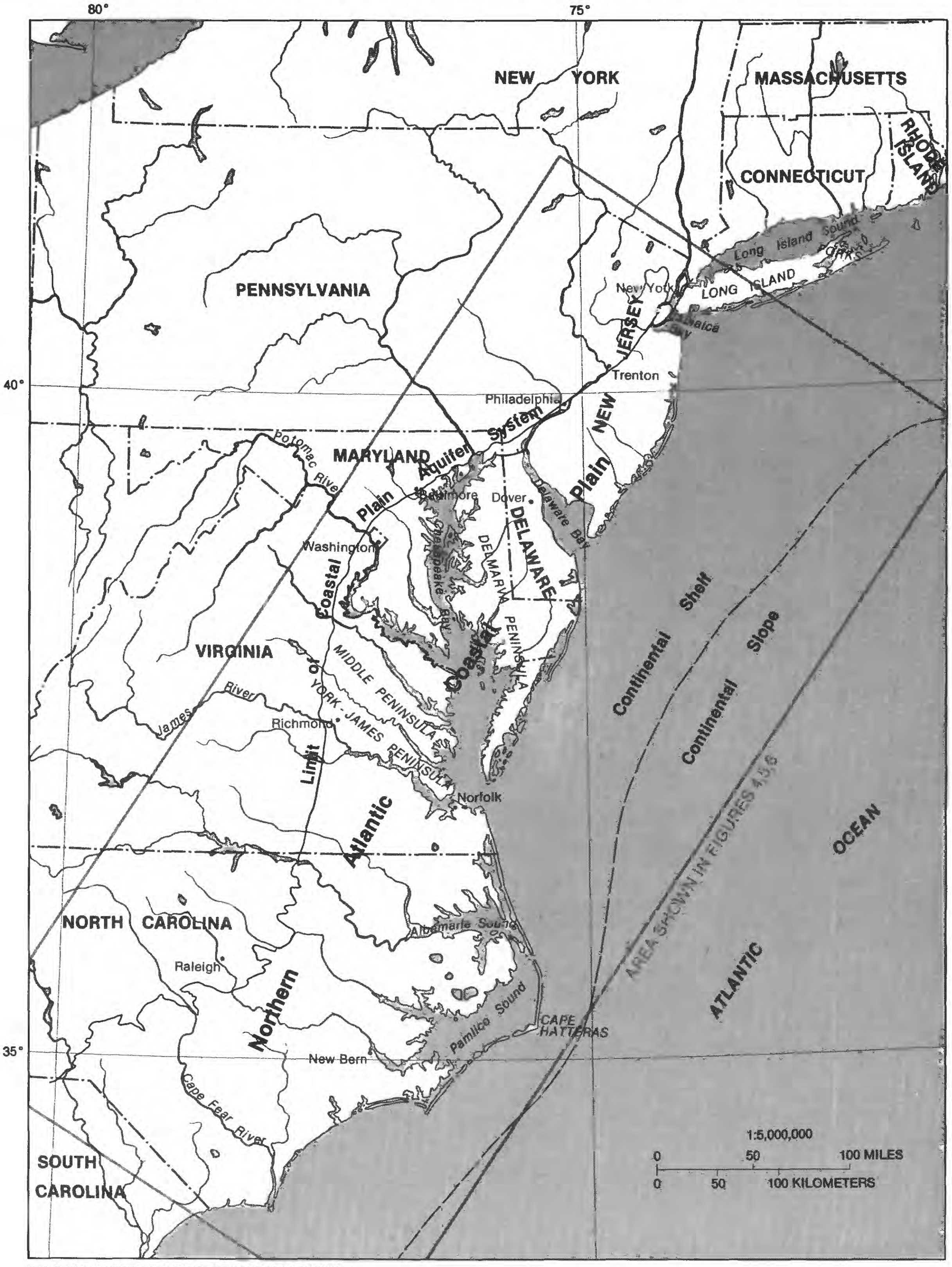
This report is part of a U.S. Geological Survey study entitled "Regional Aquifer-System Analysis." Meisler (1980) described the purpose, scope, and organization of that study.

PREVIOUS INVESTIGATIONS

Saltwater in the Atlantic Coastal Plain has been studied for many years. Sanford (1911, p. 77-86) summarized data on saltwater and on the distribution of strata that contain saltwater. He indicated that areas of saltwater are numerous, that they occur in "low ground," and that they can generally be found near the ocean or other large body of saltwater. Sanford concluded that the likelihood of "finding freshwater is better to the west rather than the east of any particular saltwater well."

Barksdale and others (1958, p. 110-111) delineated the "boundary between salt water and fresh water" in the Raritan and Magothy Formations of New Jersey and Delaware. The delineation was largely theoretical, based on freshwater heads and the specific gravity of saltwater rather than on chemical analyses. Perlmutter and others (1959) and Lusczynski and Swarzenski (1966) defined a body of salty ground water in southwestern Long Island by means of detailed subsurface exploration and chemical analyses.

Back (1966, p. A7) delineated "salt- and fresh-water interfaces in the Cretaceous and Tertiary deposits" from New Jersey to Virginia. He also depicted the



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NATIONAL ATLAS, 1970, 1:7,500,000

FIGURE 1.—Location of the northern Atlantic Coastal Plain.

three-dimensional distribution of the major ions in a series of fence diagrams. Upson (1966) studied the relation of freshwater to salty ground water from Long Island to Maryland. Manheim and Horn (1968) showed the distribution of salinity in 28 wells along the Atlantic Coast from Long Island, N.Y., to Key West, Fla.

Cushing and others (1973) delineated the base of freshwater, defined as less than or equal to 1,000 milligrams per liter (mg/L) dissolved solids, on the Delmarva Peninsula of Delaware, Maryland, and Virginia. Contour maps showing the depth of the 250 mg/L chloride concentration in the Coastal Plain of Virginia and North Carolina were constructed by Larson (1981, pl. 2) and by Heath and others (1975, fig. 8.20), respectively. The State Water Control Board of the Commonwealth of Virginia (1978, p. 44; 1979, p. 57) contoured the depth to "the 250 mg/L salt concentration" in southeastern Virginia. Meisler (1981) contoured the depth below sea level to chloride concentrations of 250, 1,000, 10,000, and 18,000 mg/L in the Coastal Plain from North Carolina to New Jersey and beneath part of the adjacent Continental Shelf.

Water that is fresher than seawater was discovered beneath the Continental Shelf from Maryland to Massachusetts by the Atlantic Margin Coring Project (Hathaway and others, 1976; 1979) and by test drilling on Nantucket Island, Mass. (Kohout and others, 1976; 1977).

Meisler and others (1984) used a computer model to analyze the effect of eustatic sea-level changes on the development of the saltwater-freshwater transition zone in New Jersey and beneath the adjacent Continental Shelf. They also described some of the geochemical processes occurring within the transition zone from North Carolina to New Jersey.

ACKNOWLEDGMENTS

The author is grateful to the many individuals and organizations that helped furnish data for this report. These include Rick Bower and P.J. Smith, Virginia State Water Control Board, and Kenneth Woodruff, Delaware Geological Survey. The following U.S. Geological Survey personnel provided data for specific areas: LeRoy L. Knobel for Maryland; Herbert T. Hopkins and Jerry D. Larson for Virginia; Ronald W. Coble, Mike D. Winner, Jody D. Eimers, and O. Bruce Lloyd for North Carolina; Allen L. Zack and Ivan S. Roberts for South Carolina; and Frank T. Manheim for the Continental Shelf. Research stations of the North Carolina Department of Natural Resources and Economic Development provided the most comprehensive data available on saltwater in the study area.

Special thanks go to Kenneth Schwarz, Maryland Geological Survey, for his guidance in the interpretation of borehole geophysical logs, and to Harry A. Farsett, U.S. Geological Survey, for the computer storage and plotting of the data.

METHODS OF STUDY

Chloride concentrations generally increase with increasing depth within the saltwater-freshwater transition zone. Contour maps (pls. 2-6) defining the zone were constructed to show the depth below sea level to water containing chloride concentrations of 250, 1,000, 5,000, 10,000, and 18,000 mg/L. Chloride, rather than dissolved solids (DS), defines the transition zone; sodium bicarbonate water containing DS in excess of 1,000 mg/L occurs in the freshwater zone but does not indicate the transition to saltwater.

The lowest chloride concentration, 250 mg/L, was selected because it was the drinking-water standard recommended by the U.S. Public Health Service (1962). The highest chloride concentration selected, 18,000 mg/L, is the approximate chloride concentration of seawater, a potential source of salty ground water.

The 5,000-mg/L chloride concentration approximates the chloride concentration of salty ground water that contains 10,000 mg/L DS. Ground water containing more than 10,000 mg/L DS is not a safe source of drinking water (U.S. Congress, 1980, p. 42502) and is unusable for most purposes. "Federal regulations permit the injection of waste water in strata containing more than 10,000 mg/L of dissolved solids, provided water of better quality is not degraded by the injection" (Davis, 1984, p. 9). Hence, the map delineating the depth to water containing 5,000 mg/L chloride (pl. 4) can be used in evaluations of potential sites for wastewater injection.

The analysis of the development of the saltwater-freshwater transition zone is based largely on (1) a comparison of the depth of the zone with predevelopment heads and location of ground-water discharge areas, (2) simulations of a cross-sectional finite-difference model described in Meisler and others (1984), and (3) evaluation of the history of sea-level fluctuations and marine emergence and submergence. Interpretation of the geochemistry is based largely on the study of graphs that show the relation of ion concentration to chloride concentration, described more fully in Meisler and others (1984).

Graphs showing the relation of chloride concentration to depth of sampling point below sea level were constructed for about 60 wells, each sampled at several depths. Selected graphs are shown in figure 2. The graphs, supplemented by chloride-concentration data

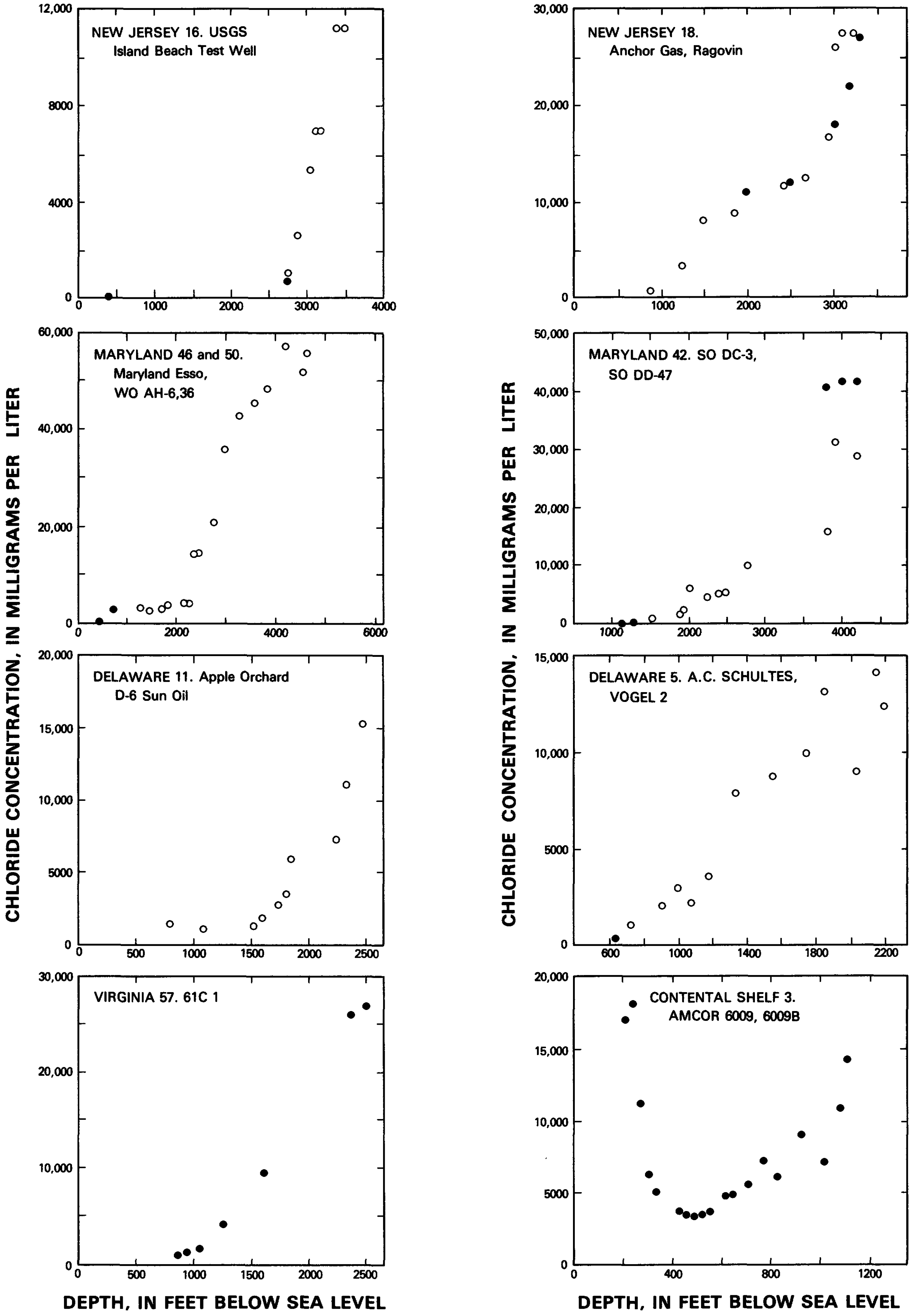

FIGURE 2.—Relation of chloride concentration to sampling depth in selected wells.

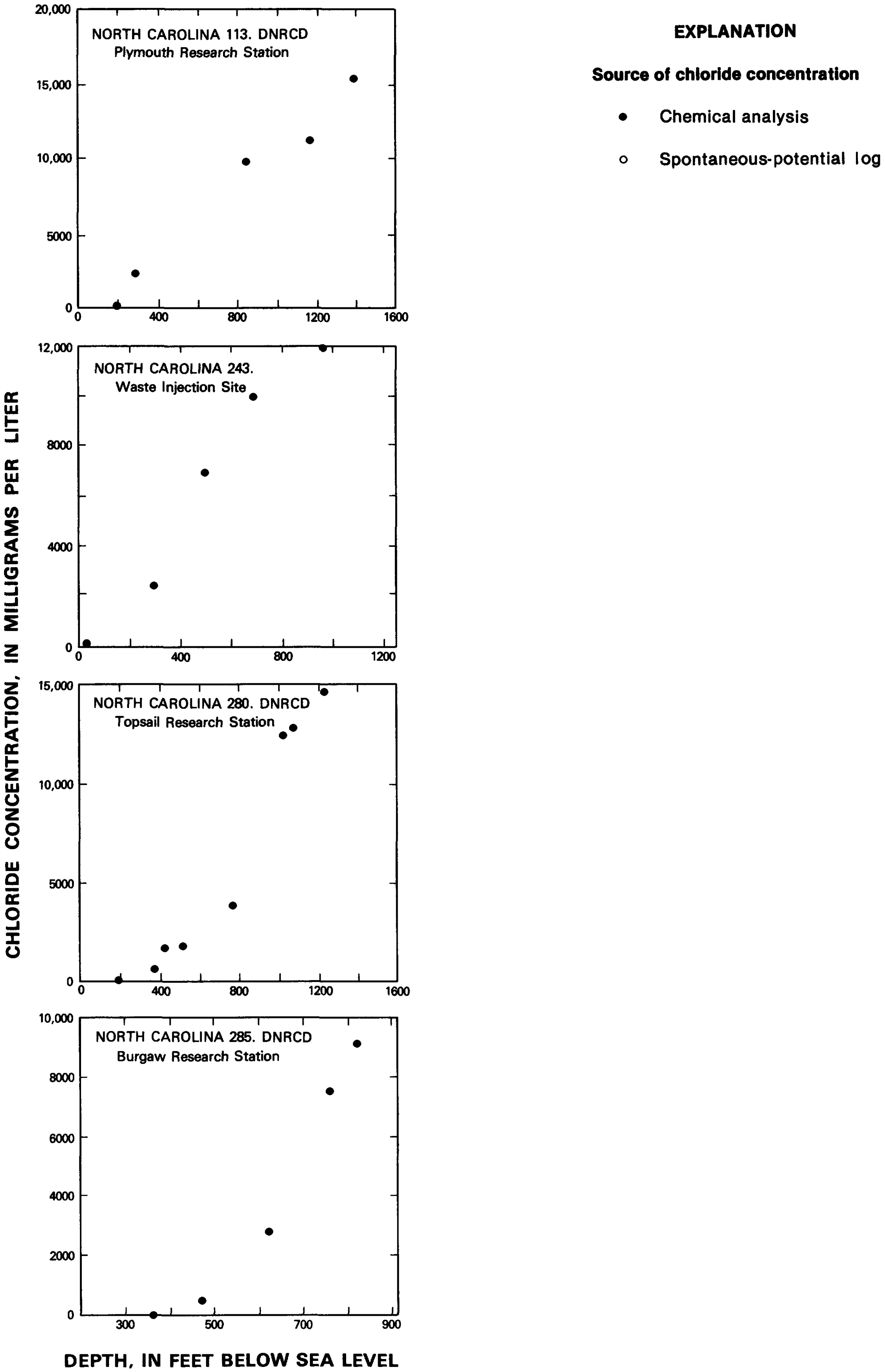

FIGURE 2.—Continued.

from about 440 wells, most sampled at one or two depths, provided the basis for construction of the contour maps showing depth to the specified chloride concentrations (pls. 2-6) and the hydrogeologic sections showing the vertical distribution of chloride concentrations (fig. 3). Depths to the specified concentrations at the 60 wells were obtained either directly from the graphs or by extrapolation of the graphed chloride-depth relation. Depths at the 440 additional wells were estimated or extrapolated using the chloride-depth graphs of nearby wells.

SOURCES OF DATA

Information on the 503 wells used in this report is given in table 1 (at end of report). Included are the chloride concentration, sampling depth, well identification, date of sample collection, and the publication or other reference of the tabulated information. Locations of the wells are shown in plate 1.

Chloride-concentration data are derived from four sources: (1) chemical analyses of water pumped from 489 wells; (2) analyses of pore fluids squeezed from clay cores of 9 wells, including 7 from the Atlantic Margin Coring Project (Hathaway and others, 1976; Frank T. Manheim, U.S. Geological Survey, written commun., 1980); (3) chloride concentrations computed from calibrated borehole spontaneous-potential (SP) logs of 11 wells; and (4) reported chloride concentrations estimated from borehole resistivity logs of 5 wells (Richard J. Mandle, U.S. Geological Survey, written commun., 1979).

Of the four sources of chloride-concentration data, chemical analyses of pumped water are the most accurate and reliable. Analyses of pore fluids squeezed from cores are less accurate because of the extremely small sample size and the possible contamination of the core by drilling fluids. However, a comparison of the chloride concentrations in squeezed pore water and pumped samples from the same well in two wells (Virginia 79 and Maryland 32, table 1) suggests that the pore-water analyses can reliably provide approximate chloride concentrations.

Interpretation of borehole SP logs is probably the least reliable of the four sources of chloride-concentration data used in this report. A discussion of the problems associated with water-quality interpretations of SP logs is given by Keys and MacCary (1971, p. 26-28). A comparison of chemical analyses and SP-log interpretations at three wells in the study area (New Jersey 16 and 18, and Maryland 42, table 1) indicates that the SP-log interpretations can provide a general indication of chloride concentrations. Interpretation of borehole resistivity logs also provides a general indication of chloride concentration. However, their use in this study is neither extensive nor significant.

Depths to chloride concentrations of 5,000, 10,000, and 18,000 mg/L shown in plates 4-6 are based on all four sources. Depths to chloride concentrations of 250 and 1,000 mg/L shown in plates 2 and 3 are based primarily on chemical analyses.

INTERPRETATION OF SP LOGS

The computation of chloride concentrations from SP curves is based largely on the theory and procedures outlined in the publications of the Schlumberger Well Surveying Corporation[1] (1972; 1978). The relation of the SP curve to resistivity of the ground water is given by the following equation (1972, p. 78):

$$SP = -K \log \frac{Rmfe}{Rwe}, \qquad (1)$$

where

SP (spontaneous potential) is the deflection of the SP curve from the shale baseline, in millivolts;

K is a constant approximated by $(60 + 0.133T)$, where T is the formation-water temperature, in degrees Fahrenheit;

$Rmfe$ is the equivalent resistivity of the drilling mud filtrate, in ohm-meters; and

Rwe is the equivalent resistivity of the ground water, in ohm-meters.

Rmfe was obtained by using the following equation (1978, p. 6):

$$Rmfe = 0.85\ Rmf, \qquad (2)$$

where *Rmf* is the true resistivity of the drilling mud filtrate, in ohm-meters. *Rwe* was obtained from equation 1 and converted to *Rw*, formation-water resistivity, using graph SP-2 in the publication of the Schlumberger Well Surveying Corporation (1978, p. 7) for water that has an *Rwe* of less than 0.8 ohm-meter and, presumably, is of the sodium chloride type. Figure 13.3 described in the Schlumberger publication (1972, p. 79) was used for water that has an *Rwe* of 0.8 ohm-meter or greater and, presumably, contains significant concentrations of sodium bicarbonate. *Rw*, in ohm-meters, was converted to its reciprocal, specific conductance, in micromhos per centimeter. Chloride con-

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[1] The use of commercial or brand names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

centrations were then estimated from the linear relation of chloride to specific conductance developed using chemical analyses of ground water in the study area.

OCCURRENCE OF SALTY GROUND WATER

DISTRIBUTION

The transition zone between freshwater and underlying salty ground water is depicted in a series of maps (pls. 2-6) showing the depth to chloride concentrations of 250, 1,000, 5,000, 10,000, and 18,000 mg/L. The vertical distribution of chloride concentrations is shown in a series of hydrogeologic sections (fig. 3).

NORTH CAROLINA TO NEW JERSEY

The upper part of the transition zone (250 and 1,000 mg/L chloride, pls. 2, 3) is generally shallowest in North Carolina and deepens northward, attaining its greatest depths in Maryland and New Jersey. It deepens inland from the coast except in New Jersey, where it is deepest near the coast and becomes shallower southwestward toward Delaware Bay.

The contours in plates 2 and 3 delineate five large areas where the upper part of the transition zone is relatively shallow: (1) Delaware Bay and adjacent southwestern New Jersey and eastern Delaware; (2) the eastern coast of the Delmarva Peninsula of Delaware, Maryland, and Virignia; (3) Lower Chesapeake Bay and adjacent parts of the York-James and Middle Peninsulas, Va.; (4) Albemarle Sound to eastern Pamlico Sound, N.C.; and (5) the Cape Fear River, N.C.

The lower part of the transition zone (10,000 and 18,000 mg/L chloride; pls. 5, 6) is shallowest in North Carolina and deepens northward, attaining its greatest depths in Maryland and New Jersey. It deepens inland from the coast in the area from northern North Carolina to Maryland. In New Jersey, however, it is deepest near the coast and becomes shallower southwestward toward Delaware Bay. Also, from Maryland it becomes shallower northeastward across Delaware toward Delaware Bay. In North Carolina, an area where the lower part of the transition zone is relatively shallow extends from the mouth of Albemarle Sound southwestward to the city of New Bern. The transition zone deepens both eastward and westward from this area. Another area in North Carolina where the transition zone (pls. 4, 5) is relatively shallow is near the Cape Fear River.

Ground water containing less than 5,000 mg/L chloride (pl. 4, fig. 3) extends 55 mi from the New Jersey coast, but extends lesser distances from the coast farther south as the depth to saltwater decreases. Although the distances are not known, they are probably no more than a few miles in southern Virginia and North Carolina.

The thickness of the transition zone, between concentrations of 250 and 18,000 mg/L chloride, can be estimated from a comparison of plates 2 and 6. The thickness ranges from 1,800 to 2,200 ft in Delaware and New Jersey, from 400 to 2,200 ft in Maryland, from 1,400 to 2,200 ft in Virginia, and from 800 to 1,600 ft in North Carolina. These values contrast with those reported from several other areas. In the Biscayne aquifer in Miami, Fla., the transition zone between concentrations of 250 and 18,000 mg/L chloride is about 50 ft thick (Kohout, 1960, fig. 4). In the Magothy aquifer in southwestern Long Island, the transition zone between concentrations of 40 and 15,000 mg/L is generally 100 to 200 ft thick; no concentrations as high as 18,000 mg/L have been reported (Lusczynski and Swarzenski, 1966, pls. 2, 3). In these two areas, the salty ground water is in hydraulic connection with seawater. In the Southeast Georgia Embayment, the thickness of the transition between dissolved- solids concentrations that correspond roughly to chloride concentrations of 500 and 18,000 mg/L is about 2,000 ft (Manheim and Paull, 1981, figs. 2, 3). In that area, the dissolved solids delineate a regional saltwater body that is not in direct hydraulic connection with nearby seawater.

Maps depicting chloride concentrations at the tops of three hydrogeologic units are presented in figures 4-6. The contours of equal chloride concentration are based on the maps showing the depth to specified chloride concentrations (pls. 3-6). The tops of the hydrogeologic units shown in figure 3 were delineated by Henry Trapp, Jr. (U.S. Geological Survey, written commun., 1984). From lowest to highest, the units are (1) predominantly nonmarine Cretaceous aquifers, (2) predominantly marine and marginal marine Cretaceous aquifers, and (3) lower Tertiary aquifers. As shown in figures 4-6, chloride concentrations increase seaward and downdip (structure is shown in fig. 3) in each of the hydrologic units. Also, concentrations are greatest in the deepest hydrologic unit (predominantly nonmarine Cretaceous aquifers) and least in the shallowest unit (lower Tertiary aquifers).

LONG ISLAND

No saltwater is shown north of southeastern New Jersey in plates 2-6 because the deepest Coastal Plain aquifers in east-central New Jersey and western and central Long Island, N.Y., contain freshwater. Saltwater does occur in the Magothy aquifer in southwestern Long Island; however, it is underlain by freshwater in the Lloyd aquifer (Perlmutter and others,

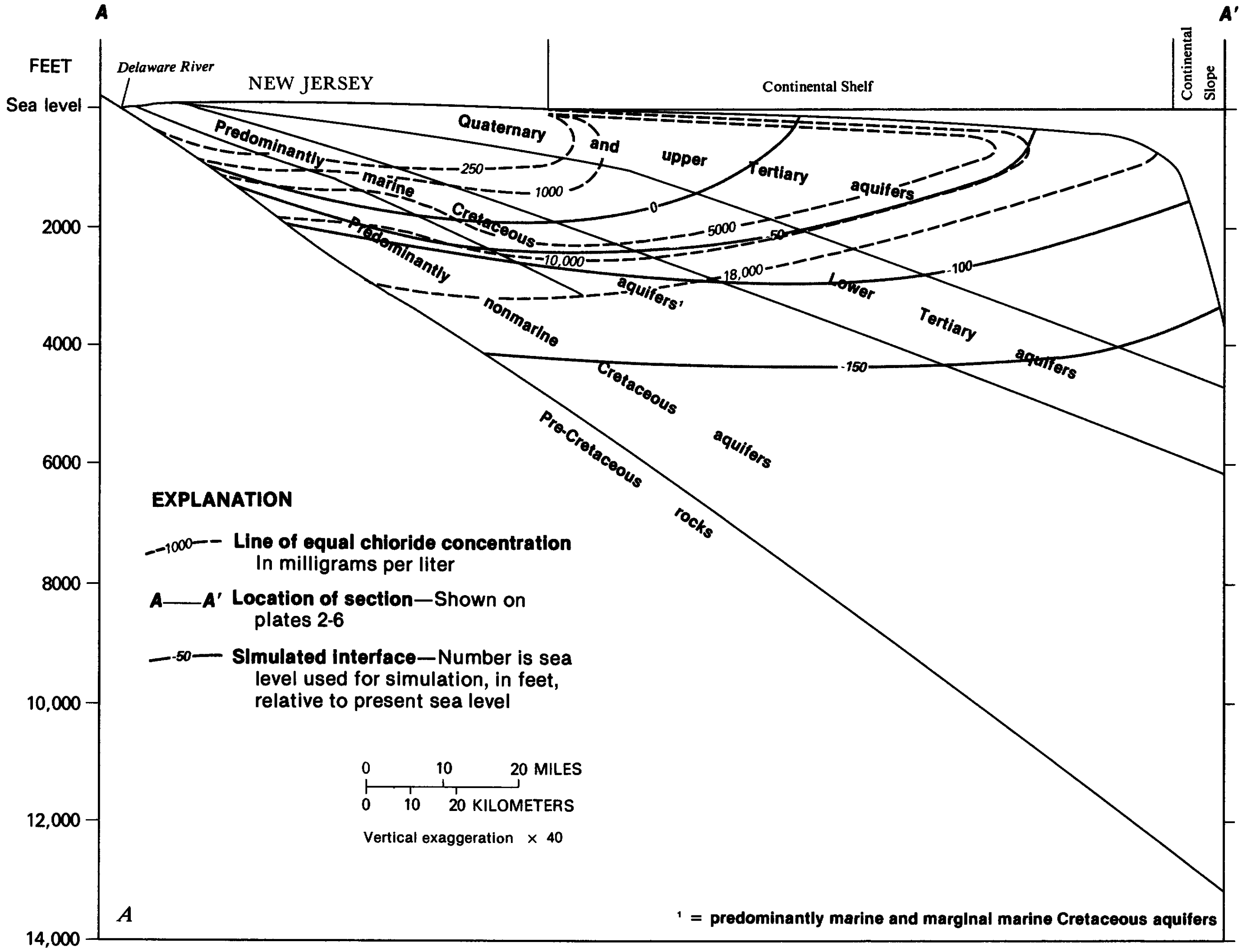


FIGURE 3A.—Hydrogeologic section showing chloride concentrations in New Jersey and on the Continental Shelf.

1959). This is possible because the two aquifers are separated by relatively impermeable clays of the Raritan Formation. Lusczynski and Swarzenski (1966, p. 1) considered this saltwater to represent an extension "from a main body of salty water that lies seaward of the barrier beaches." The wedge shape of the saltwater body in the Magothy aquifer and the distribution of chloride concentrations, however, indicate that the saltwater is hydraulically connected to Jamaica Bay and is unrelated to the regional saltwater-freshwater transition zone delineated in plates 2-6 and figure 3.

Saltwater also occurs in parts of the glacial aquifer and the Magothy aquifer in the Forks of eastern Long Island (Nemickas and Koszalka, 1982; Prince, 1987). Nemickas and Koszalka have inferred that the underlying Lloyd aquifer also contains saltwater, but no reliable analyses are available to substantiate this. The configuration of the base of freshwater (250 mg/L chloride) on the South Fork delineated by Nemickas and Koszalka (1982) suggests that the saltwater is hydraulically connected to the surrounding seawater.

RELATION TO FRESHWATER FLOW

Areas where the upper part of the transition zone (250 and 1,000 mg/L chloride, pls. 2, 3) is relatively shallow coincide with several areas of major fresh-ground-water discharge, such as Delaware Bay, lower Chesapeake Bay, Albemarle Sound, and the Cape Fear River. Earlier investigators noted similar relationships

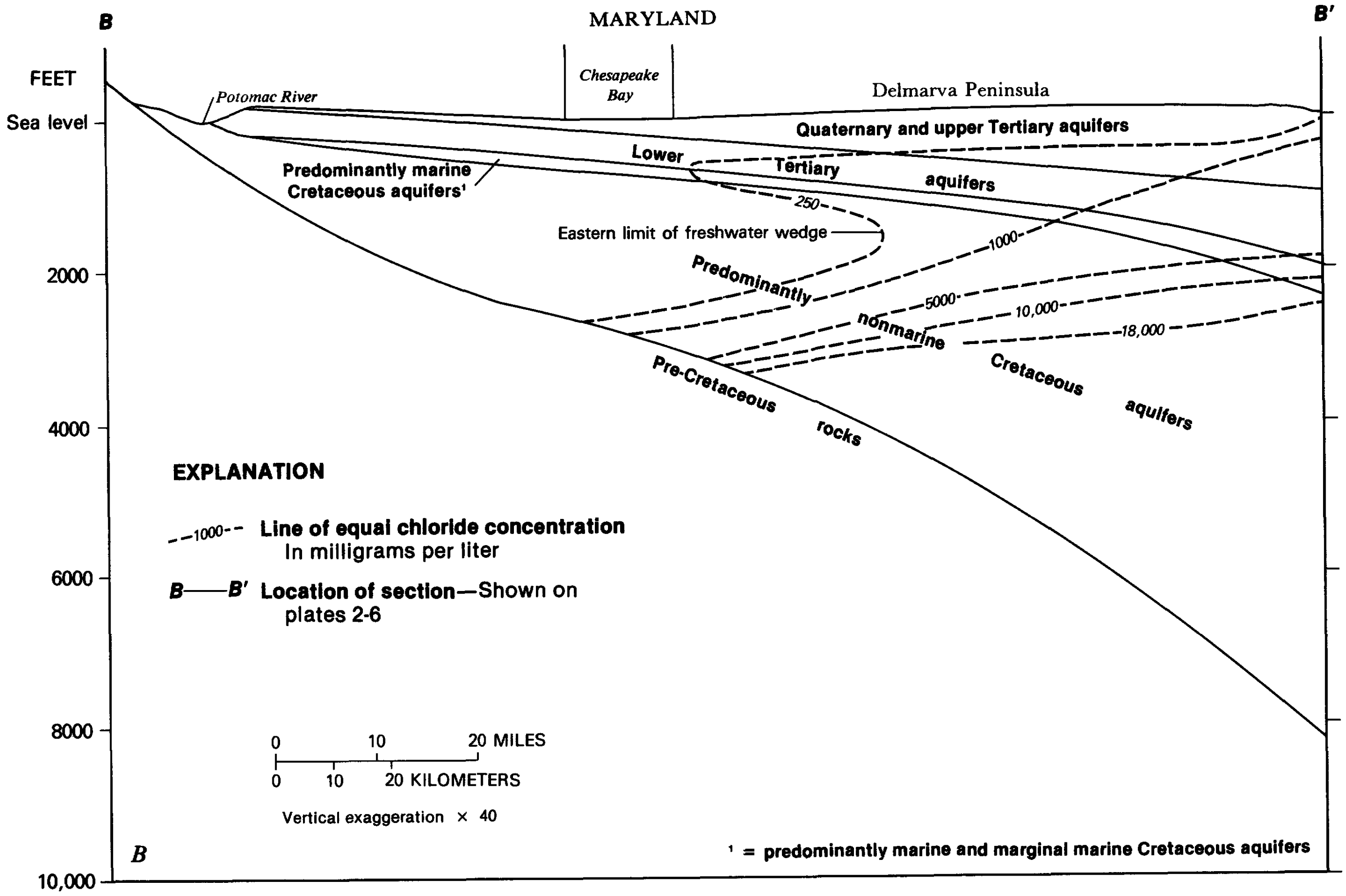


FIGURE 3*B*.—Hydrogeologic section showing chloride concentrations in Maryland.

between the occurrence of saltwater and the fresh-ground-water flow system. Back (1966, p. 40) stated that the position of the deep saltwater (350 mg/L chloride) "is determined by the relative head distribution in the freshwater and in the saltwater." Upson (1966, p. C242) concluded that

> * * * the circulation pattern of fresh ground water in general and the location of discharge zones in particular control the locations of salt-water boundaries in coastal regions. * * * Theoretically, equilibrium between fresh water and sea water in a coastal region requires that the hydraulic head of the fresh water be at least high enough to balance the head of salt water in the vicinity, considering the difference in density * * *.

Hence, higher heads maintain the saltwater at greater depths in recharge areas, and lower heads maintain the saltwater at lesser depths in discharge areas.

EFFECT OF SEA-LEVEL CHANGES

The natural (predevelopment) flow pattern of fresh ground water does not appear to control completely the location of the entire saltwater-freshwater transition zone. Predevelopment heads are probably not high enough to account for the relatively great depths to the transition zone, especially the 10,000- and 18,000-mg/L chloride concentrations (pls. 5, 6), in Maryland and along the coast of New Jersey. Nor do the heads appear to account for the wedge of relatively fresh ground water (compared with seawater) that extends 55 mi from the New Jersey coast (fig. 3, section *A-A'*).

A cross-sectional computer model was used by Meisler and others (1984) to evaluate the postulated effect of eustatic sea-level changes on the development and location of the saltwater-freshwater transition zone in southern New Jersey and, offshore, beneath the Continental Shelf. The model simulates, using finite-difference techniques, the Coastal Plain aquifer system as a highly anisotropic porous medium in which steady-state freshwater flow is separated from static saltwater by a sharp interface. Freshwater pressure at the simulated interface equals the pressure exerted by a column of static seawater.

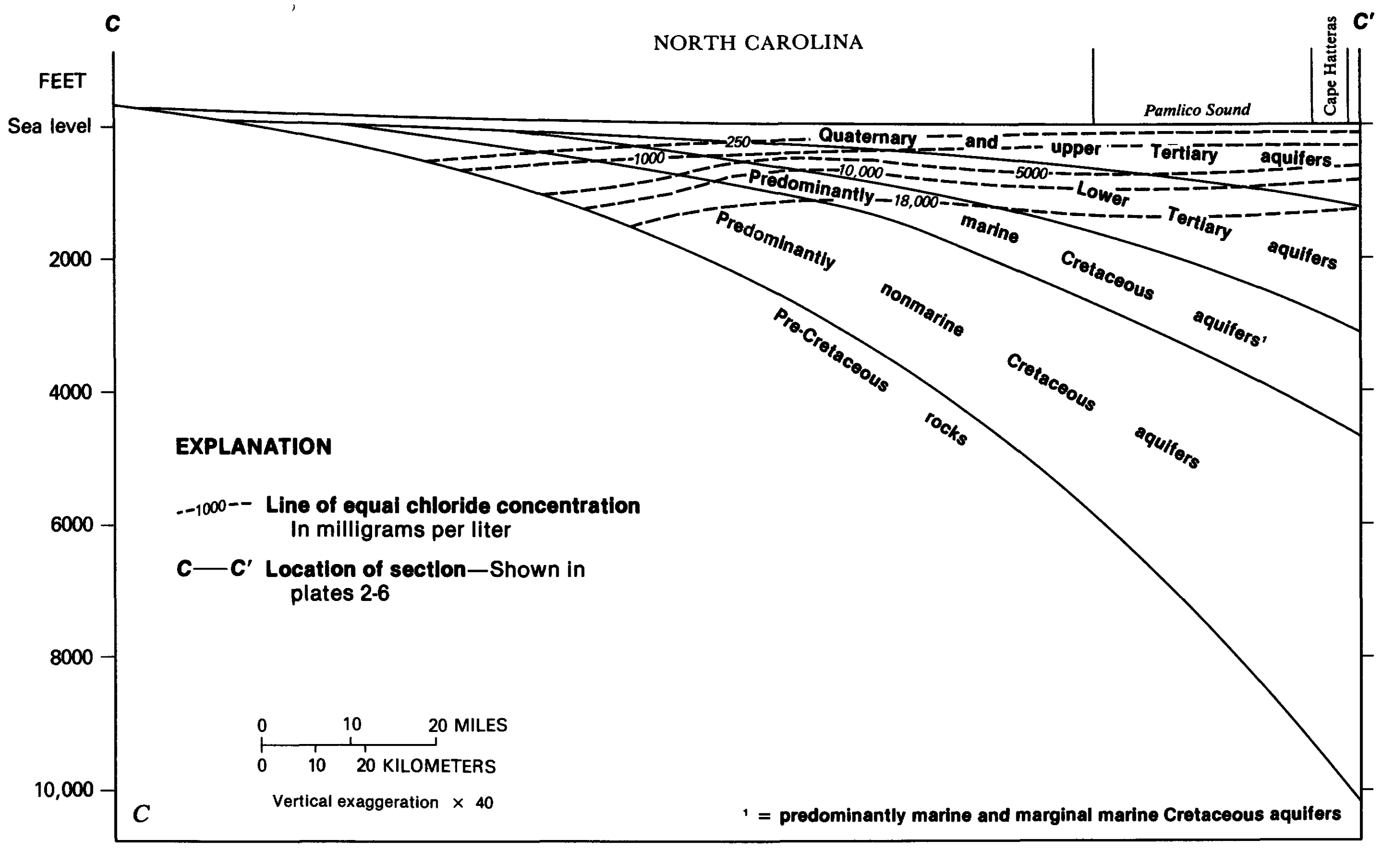


FIGURE 3C.—Hydrogeologic section showing chloride concentrations in North Carolina.

The model tested the sensitivity of the location of a simulated saltwater-freshwater interface to both anisotropy (ratio of lateral to vertical hydraulic conductivity) and elevation of sea level. Model runs demonstrate that increasing anisotropy causes the simulated interface to be shallower and to extend farther offshore. Lowering of sea level causes the simulated interface to be deeper and also to extend farther offshore, as shown in figure 3A. Simulations using the most probable distribution of lateral hydraulic conductivity and a constant anisotropic ratio of 30,000 give the following results: (1) the center of the saltwater-freshwater transition zone (10,000-mg/L chloride concentration) in southern New Jersey, including both the deep zone along the coast and the shallow zone beneath Delaware Bay, generally lies between the interfaces simulated for sea levels of 50 and 100 ft below present sea level; and (2) the center of the transition zone east of the New Jersey coast is very close to the interface simulated for a sea level of 50 ft below present sea level (fig. 3A).

These results suggest that the location of the saltwater-freshwater transition zone in southern New Jersey (including Delaware Bay) and beneath the Continental Shelf probably reflects long-term sea levels of about 50 to 100 ft below present sea level. The average sea level for the Quaternary was probably in this range; however, because of the likelihood of extremely slow water-particle velocities, the location of the transition zone probably reflects average sea-level conditions for a longer period, possibly back to the Miocene (Meisler and others, 1984). Consequently, the relatively shallow transition zone in the vicinity of Delaware Bay indicates that the bay has probably been a significant discharge area for much of that period.

Farther south, in southeastern Virginia and North Carolina, the saltwater-freshwater transition zone is generally shallower, and ground water that is fresher than seawater probably does not extend more than a few miles offshore. Here, predevelopment heads are probably high enough to maintain the position of the lower part of the transition zone, thus suggesting that

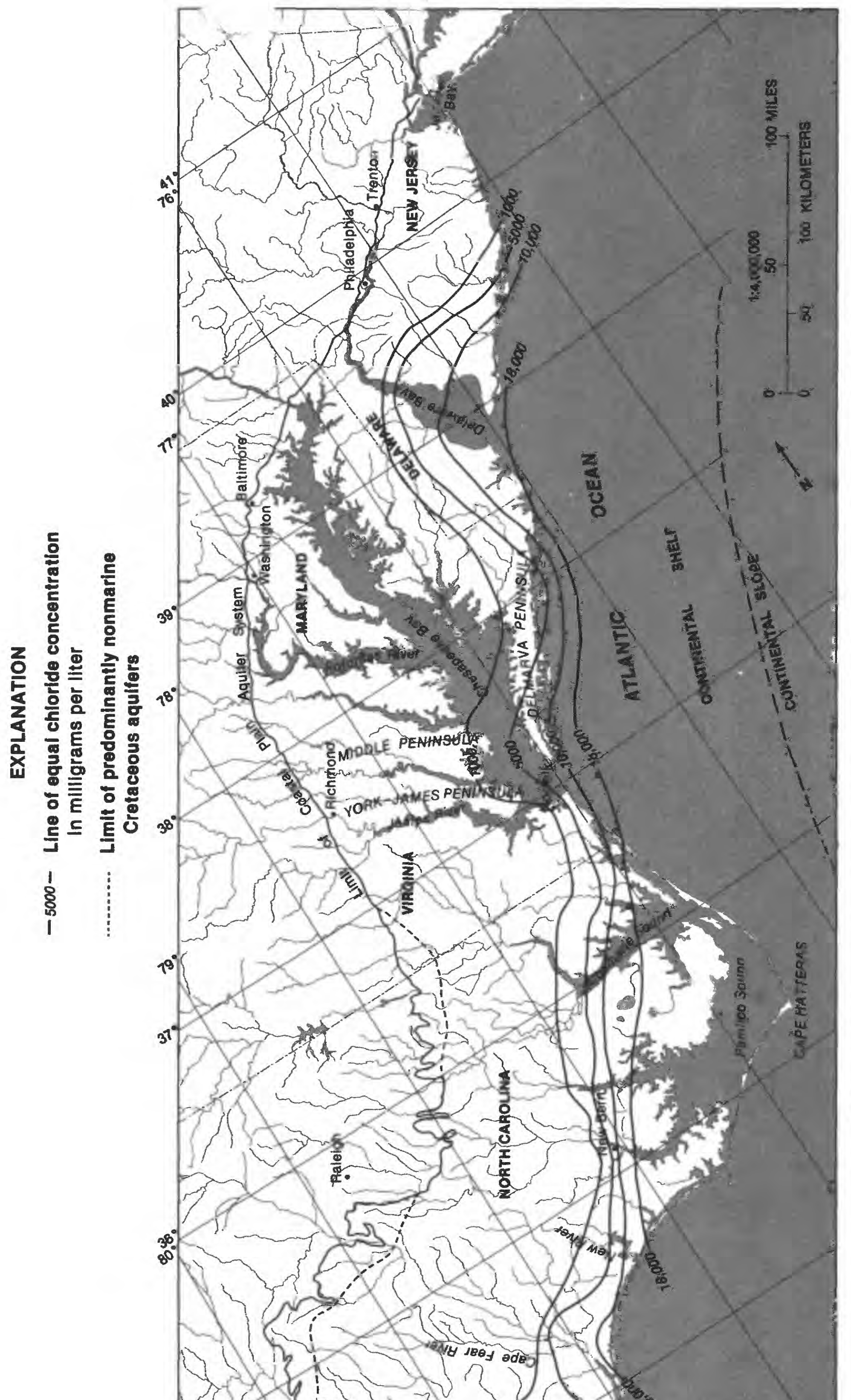


FIGURE 4.—Chloride concentrations at the top of the predominantly nonmarine Cretaceous aquifers.

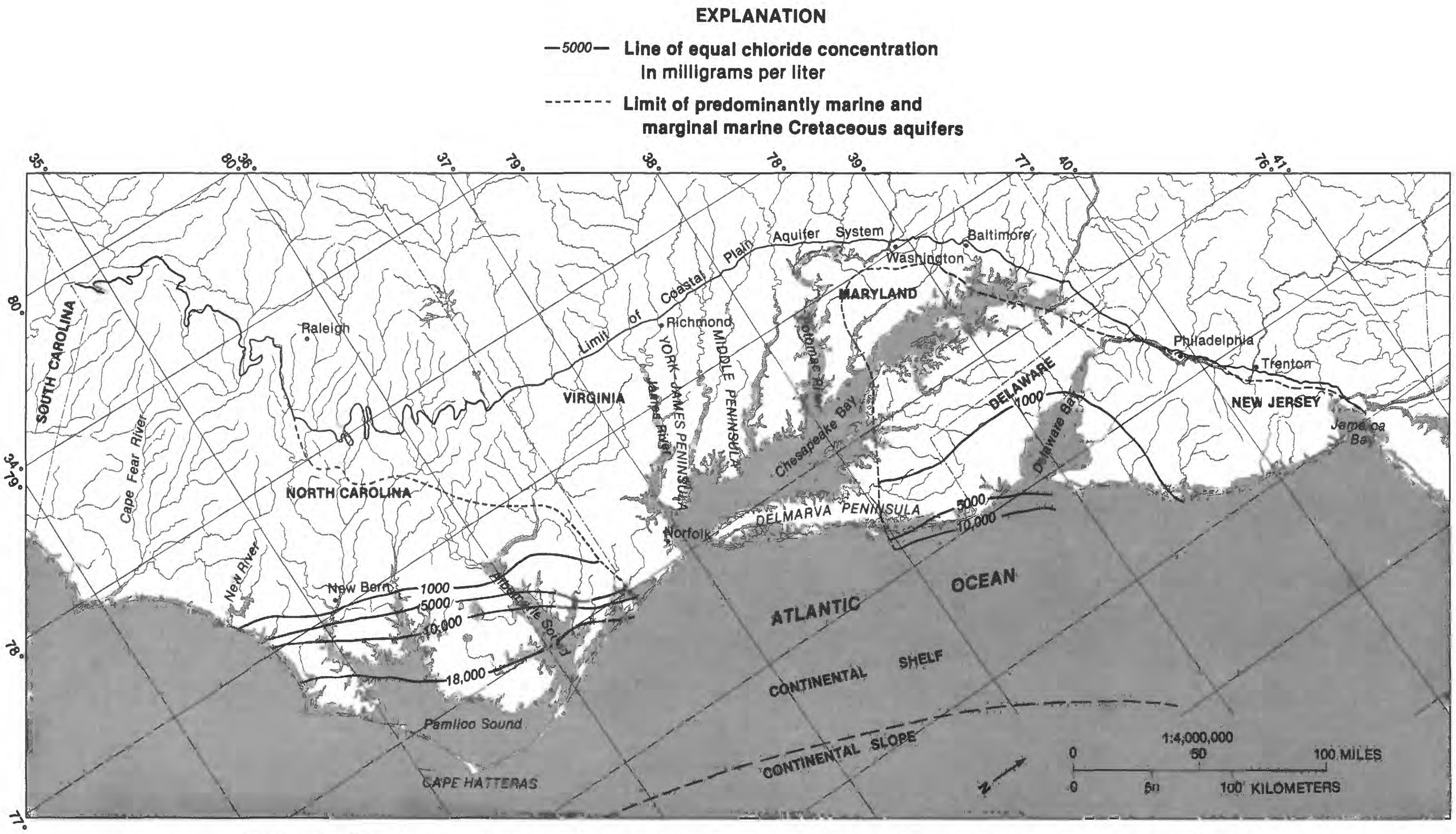


FIGURE 5.—Chloride concentrations at the top of the predominantly marine and marginal marine Cretaceous aquifers.

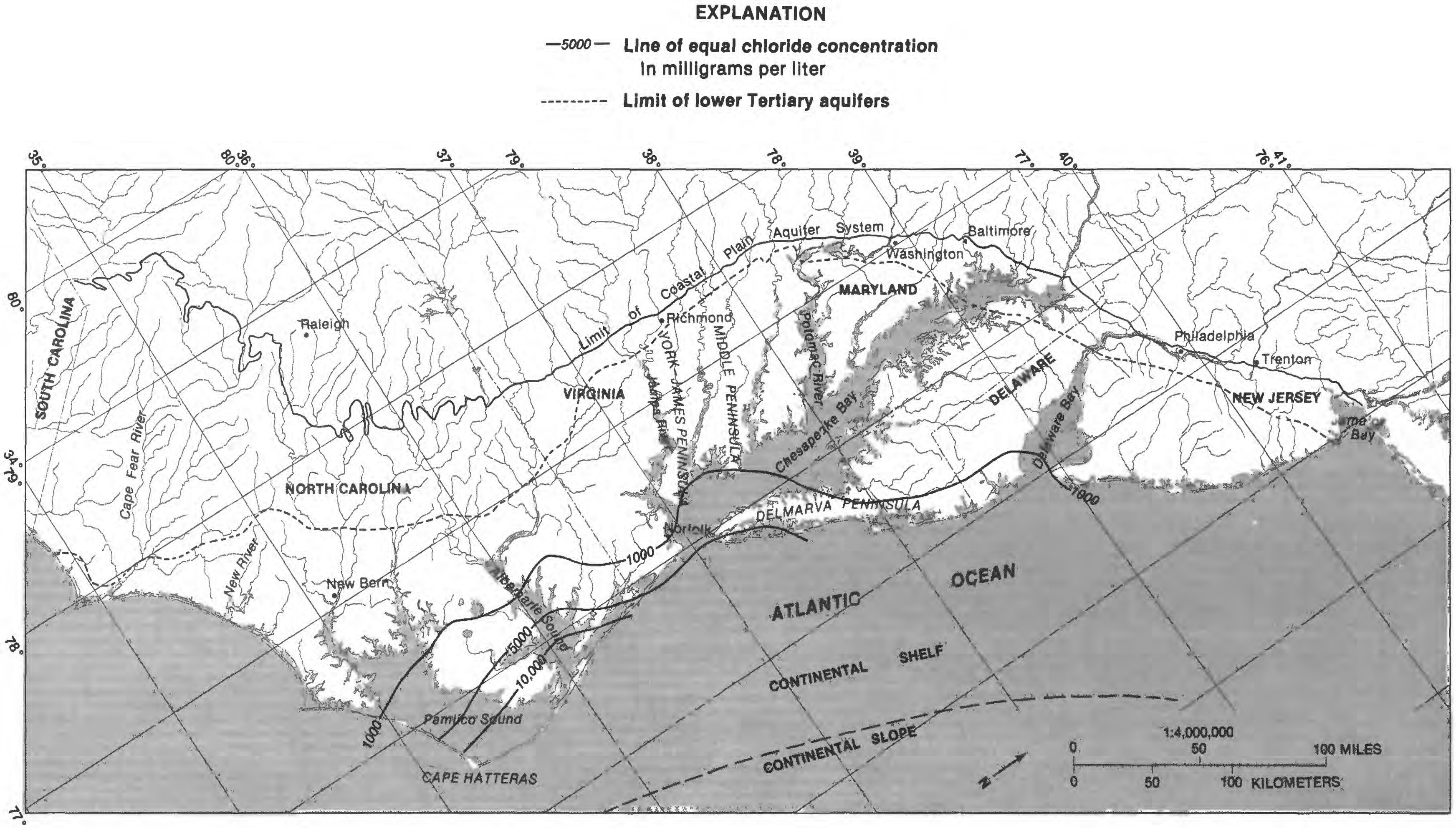


FIGURE 6.—Chloride concentrations at the top of the lower Tertiary aquifers.

sea levels similar to those of the present could account for the distribution of salty ground water.

The disparity in long-term sea level between New Jersey and Maryland on the one hand and the area south of Maryland on the other probably reflects differing geologic histories from the Miocene to the present. Brown and others (1972, p. 51-54), in describing the depositional environments of middle and upper Miocene and post-Miocene rocks, indicate that marine depositional environments were generally more prevalent to the south. Discussing strata of the middle Miocene unit, they state (p. 51): "They are chiefly marine to marginal marine, but are nonmarine in some wells along the inner margin of the Coastal Plain in Maryland and to the north. * * * In Delaware and New Jersey, the unit is marginal marine to nonmarine." Regarding the late Miocene unit, they state (p. 52): "In North Carolina and Virginia the unit is chiefly marine whereas it is chiefly marginal marine to the north of Virginia." They also indicate (p. 53) that the post-Miocene unit is chiefly nonmarine; however, in the area in North Carolina that is underlain by salty ground water the post-Miocene sediments are marginal marine.

Southwest of the New River in southern North Carolina, particularly near the Cape Fear River, chloride concentrations of 5,000 and 10,000 mg/L (pls. 4, 5) are present at relatively shallow depths—from 400 to 1,200 ft below sea level. However, because of high heads in this area, generally from 60 to more than 100 ft above sea level, little or no saltwater should be present under equilibrium conditions. The saltwater is probably related to a period when sea level in this area was significantly higher than at present, and there has not been sufficient time for the saltwater to be flushed out. Zullo and Harris (1979, p. 38) indicate an extensive marine transgression in this area in the early Pliocene. Later, in the early(?) Pleistocene, the sea transgressed over the part of the area lying at lower elevations southwest of the Cape Fear River. A fuller understanding of this apparently residual saltwater requires further investigation.

DEVELOPMENT OF THE SALTWATER-FRESHWATER TRANSITION ZONE

Computer simulations indicate that the position of the saltwater-freshwater transition zone is sensitive to sea-level elevation (Meisler and others, 1984). Hence, the transition zone tends to move upward and inland during periods of rising sea level and downward and seaward during periods of falling sea level. L.R. Zellmer (unpublished Master's thesis, Development and Application of a Pleistocene Sea Level Curve to the Coastal Plain of Southeastern Virginia, College of William and Mary, 1979) has shown that eight sea-level fluctuations of more than 200 ft in amplitude have taken place during the past 900,000 years. Indeed, major sea-level changes have recurred through the Tertiary and Quaternary Periods (Vail and others, 1977). These sea-level fluctuations provide a mechanism for the circulation of saltwater and the development of the transition zone in the northern Atlantic Coastal Plain, probably from the late Tertiary to the present (Meisler and others, 1984). Hence, cyclic movement of saltwater responding to the sea-level fluctuations caused the saltwater and freshwater to mix, producing a broad transition zone in which saltier water predominates in the deeper and seaward parts and fresher water predominates in the shallower and landward parts. In addition, in some areas such as southeastern North Carolina, seawater that infiltrated during marine transgressions and that had not been completely flushed out probably contributed to the development of the transition zone.

GEOCHEMISTRY

INTERPRETATION OF ION CONCENTRATIONS

A study of chemical analyses of ground-water samples from the northern Atlantic Coastal Plain supports the interpretation that the saltwater-freshwater transition zone was produced by the mixing of fresh ground water with salty ground water of either brine or seawater origin (Meisler and others, 1984). Evidence for mixing is based on graphs that show the relation between concentrations of several ions and concentrations of chloride (Meisler and others, 1984, figs. 10-16).

Plots of concentrations of calcium plus magnesium, sodium, potassium, sulfate, and bicarbonate (fig. 7) generally indicate mixing of seawater with a fresh sodium bicarbonate water in North Carolina. Chemical analyses and locations of the sample sites are given by Meisler and others (1984, table 2, fig. 1). The presence of a brine beneath the transition zone in the vicinity of Pamlico and Albemarle Sounds is indicated by the interpretation of borehole geophysical logs (Meisler, 1981) and by a chemical analysis from the Esso 1 Hatteras Light well (table 1, well 88). The chloride concentration in this analysis is almost four times that of seawater.

In the area from Virginia to New Jersey, numerous water samples contain chloride (table 1) and other ions in greater concentrations than occur in seawater. Hence, the transition zone in this area cannot be explained entirely by the mixing of seawater and freshwater. Concentrations of calcium plus magnesium, sodium, potassium, sulfate, and bicarbonate

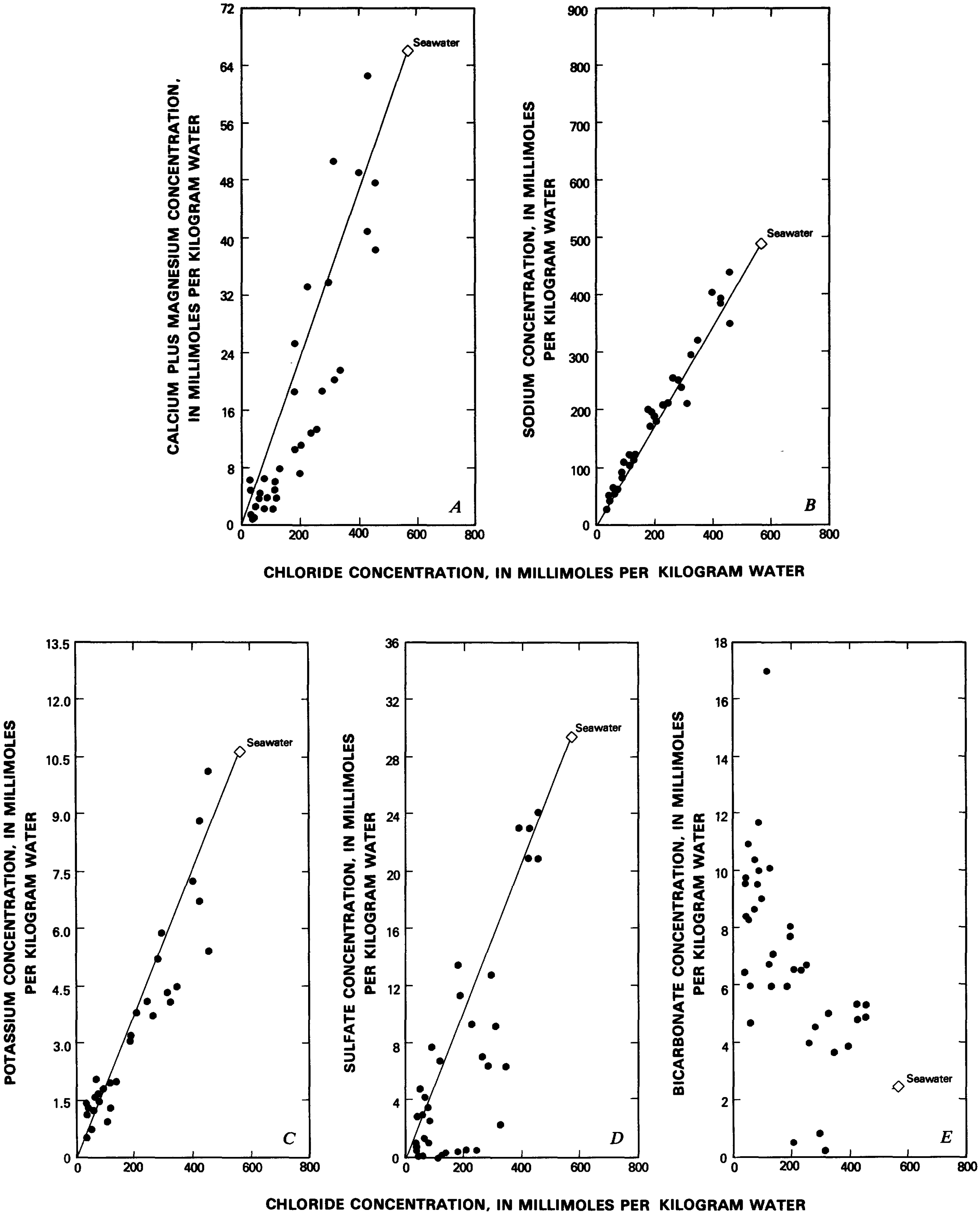


FIGURE 7.—Relation of concentrations of selected ions to chloride concentrations in ground water from North Carolina: *A*, calcium plus magnesium; *B*, sodium; *C*, potassium; *D*, sulfate; *E*, bicarbonate. Lines denote seawater-freshwater mixing curve.

are plotted as a function of chloride in figure 8. The occurrence of ion concentrations that are greater than those in seawater and the deviation of the ion concentrations from the seawater-freshwater mixing curves suggest that the saltwater-freshwater transition zone is largely a mixture of a fresh sodium bicarbonate water with brine. However, the ion-concentration plots suggest that processes other than simple mixing of brine and freshwater are occurring. These probably include (1) mixing with a third end member—seawater—particularly in the upper part of transition zone, and (2) ion exchange, by which the solution becomes enriched with calcium in the more concentrated waters and with sodium and potassium in the more dilute waters.

Composition of the brine, although unknown, is suggested by analyses of the most saline water samples shown in figure 8. Hence, the brine has a chloride concentration several times that of seawater and also differs from seawater in having higher concentrations of calcium and sodium and lower concentrations of magnesium, potassium, sulfate, and bicarbonate. Also, the brine has a significantly higher ratio of calcium to total cation concentration and lower ratios of magnesium, sodium, and potassium to total cation concentration.

Analyses of water from the transition zone within the Magothy Formation in Long Island (Lusczynski and Swarzenski, 1966, table 2) indicate that the water is a simple mixture of seawater and freshwater.

ORIGIN OF THE BRINE

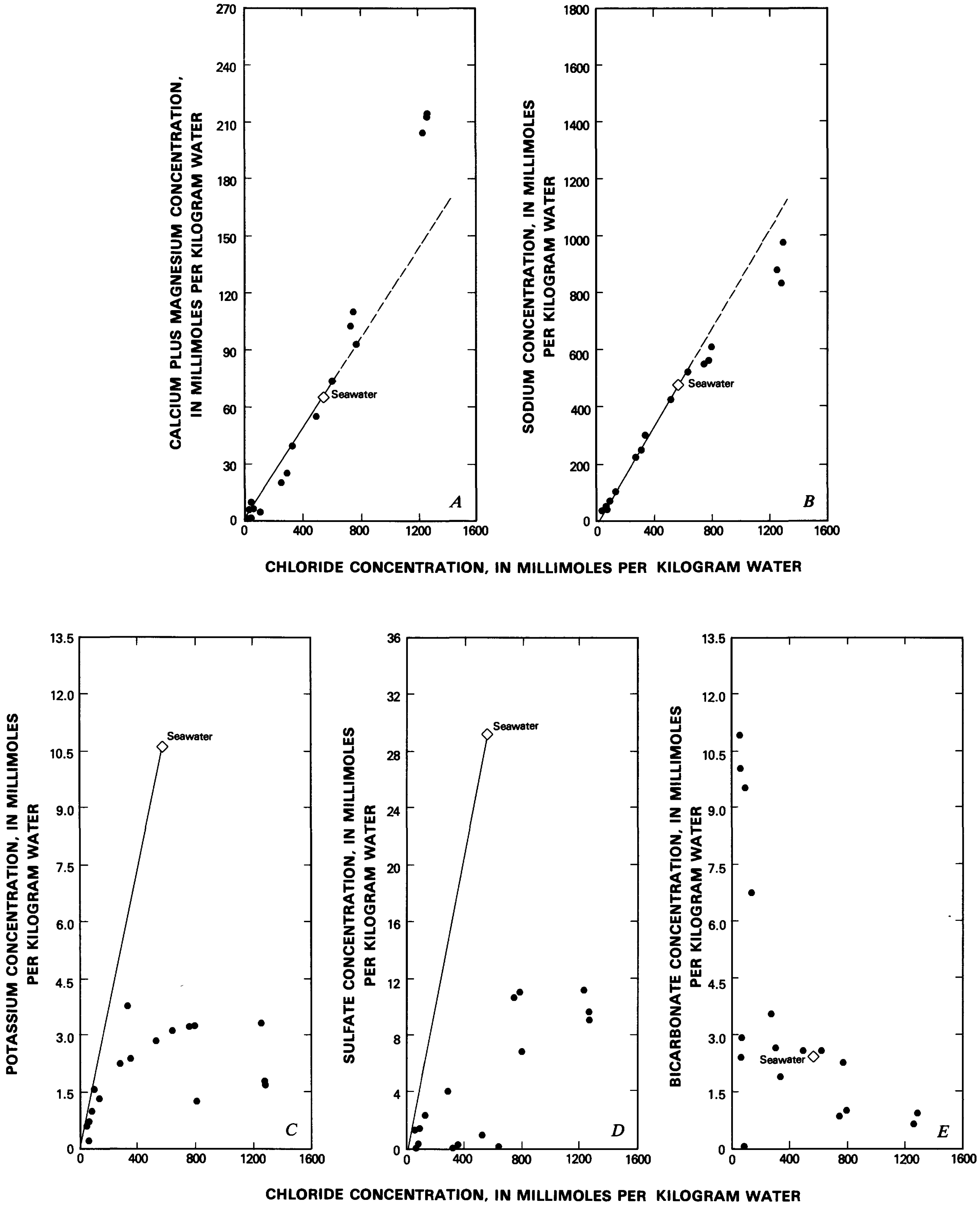
The origin of brines in sedimentary sequences of the northern Atlantic Coastal Plain is controversial. Two possible sources are (1) concentration of dissolved solids through reverse chemical osmosis and membrane filtration, and (2) the leaching of evaporitic strata. Graf (1982) discussed the role of overpressuring in driving reverse chemical osmosis and hence forming of brines in sedimentary sequences. He stated (p. 1442), "Three of the most important mechanisms [are] rapid sedimentation of fine grained materials, tectonic compression, and abnormally high thermal gradients." The second of these mechanisms, tectonic compression, has not been of sufficient magnitude to cause overpressuring in the northern Atlantic Coastal Plain. In relation to the third mechanism, typical measured geothermal gradients of 1.3 °F per 100 ft depth in the COST B-2 well (Robbins, 1977, p. 44-45) on the outer Continental Shelf and 1.5 °F per 100 ft depth in the 3,300-ft-deep well DO-CE 88 in Maryland (Trapp and others, 1984, p. 17) are not abnormally high.

As to the first mechanism Bredehoeft and Hanshaw (1968) evaluated the creation and maintenance of fluid pressures through the process of continuous sedimentation. They concluded (p. 1097) that in the Gulf Coast, "a sedimentation rate of 500 $m/10^6$ yr [1,600 $ft/10^6$ yr] (reasonable for the Gulf Coast) will create fluid pressures approaching lithostatic in a sedimentary column that has a hydraulic conductivity of 10^{-8} cm/sec [3.3×10^{-11} ft/sec], or lower." In the northern Atlantic Coastal Plain, however, sedimentation rates have generally been 80 to 160 $ft/10^6$ yr in the outer Continental Shelf and considerably lower on the emerged Coastal Plain. Head measurements in wells on the Coastal Plain and reported pressure measurements in several offshore oil test wells do not indicate excess fluid pressures. These data suggest that any potential excess pressure due to rapid sedimentation has been dissipated laterally updip or toward the Continental Slope and Rise.

Manheim and Horn (1968, p. 229-233), in their discussion of the origin of the Atlantic Coastal Plain brines, concluded that (1) leaching of evaporitic strata along with updip movement of the brines caused by "basinal compaction or other forces" account for the present distribution of brine, and (2) "membrane-filtration phenomena do not play an important role in the formation of concentrated brines in the Atlantic Continental Margin."

Drilling and borehole geophysical data (Mattick and Bayer, 1980, p. 8) have indicated the presence of evaporitic strata of probable Early and Middle Jurassic age beneath the Continental Shelf and Slope. Based on the evidence discussed above, the most likely source of brine in the Atlantic Coastal Plain is the leaching of these evaporitic strata. Because of the predominantly marine environment of the Continental Shelf and Slope during most of the Early and Middle Jurassic, water of marine origin has probably been the principal leaching agent. Burial of the evaporites by several thousand feet of carbonate sediments prevented freshwater from reaching the evaporites during periods of emergence in the Late Jurassic and later. The brine thus formed advanced landward, initially because of basinal compaction and subsequently because of major sea-level rises. Diffusion of the salt vertically through the sediments above the evaporites, as postulated by Manheim and Hall (1976, p. 699), probably provided a larger source from which the brine could migrate laterally.

FIGURE 8.—Relation of concentrations of selected ions to chloride concentrations in ground water from Virginia to New Jersey: *A*, calcium plus magnesium; *B*, sodium; *C*, potassium; *D*, sulfate; *E*, bicarbonate. Lines denote seawater-freshwater mixing curve; dashed where extended.


CALCIUM PLUS MAGNESIUM CONCENTRATION, IN MILLIMOLES PER KILOGRAM WATER
0
30
60
90
120
150
180
210
240
270
Seawater
A
SODIUM CONCENTRATION, IN MILLIMOLES PER KILOGRAM WATER
0
200
400
600
800
1000
1200
1400
1600
1800
Seawater
B
0
400
800
1200
1600
CHLORIDE CONCENTRATION, IN MILLIMOLES PER KILOGRAM WATER
POTASSIUM CONCENTRATION, IN MILLIMOLES PER KILOGRAM WATER
0
1.5
3.0
4.5
6.0
7.5
9.0
10.5
12.0
13.5
Seawater
C
SULFATE CONCENTRATION, IN MILLIMOLES PER KILOGRAM WATER
0
4
8
12
16
20
24
28
32
36
Seawater
D
BICARBONATE CONCENTRATION, IN MILLIMOLES PER KILOGRAM WATER
0
1.5
3.0
4.5
6.0
7.5
9.0
10.5
12.0
13.5
Seawater
E
0
400
800
1200
1600
CHLORIDE CONCENTRATION, IN MILLIMOLES PER KILOGRAM WATER

SUMMARY AND CONCLUSIONS

Salty ground water underlies freshwater in the eastern part of the northern Atlantic Coastal Plain from New Jersey to North Carolina. Chloride concentrations generally increase with depth within a transition zone between the deepest freshwater and the underlying saltwater. The zone, which is delineated by chloride concentrations of 250 to 18,000 mg/L, ranges from 400 to 2,200 ft in thickness.

The saltwater-freshwater transition zone is generally shallowest in North Carolina and deepens northward to Maryland and the coast of New Jersey. Also, it generally deepens inland from the coast, except locally in North Carolina and in New Jersey, where it is deepest along the coast and becomes shallower toward Delaware Bay. Large areas where the upper part of the transition zone is relatively shallow commonly coincide with areas of major fresh-ground-water discharge such as Delaware Bay, lower Chesapeake Bay, Albemarle Sound, and the Cape Fear River.

Ground water containing less than 5,000 mg/L chloride extends 55 mi from the New Jersey coast and lesser distances from the coast farther south. In southeastern Virginia and North Carolina, water containing less than 5,000 mg/L chloride probably does not extend more than a few miles offshore.

The greater depth of the transition zone in Maryland and New Jersey and the occurrence offshore of ground water that is considerably fresher than seawater probably reflect generally lower sea levels that prevailed during the late Tertiary and Quaternary Periods. Farther south, particularly in North Carolina and Virginia, generally higher sea levels associated with greater submergence and more prevalent marine conditions caused the transition zone to be shallower.

The broad saltwater-freshwater transition zone developed as a result of cyclic movement of saltwater responding to large-scale sea-level fluctuations probably during the late Tertiary and Quaternary Periods. Repeated advance and retreat of the salty ground water caused the saltwater and freshwater to mix. In North Carolina, the mixing of seawater with a fresh sodium bicarbonate water appears to predominate, whereas from Virginia to New Jersey, the mixing of fresh sodium bicarbonate water with a sodium calcium brine is more significant.

The origin of brines is controversial. The most likely source in the northern Atlantic Coastal Plain is the leaching of evaporitic strata of probable Early Jurassic age beneath the Continental Shelf. Another possible source of brines in sedimentary sequences—the concentration of dissolved solids through membrane filtration—does not appear to be significant in the northern Atlantic Coastal Plain. The brines probably advanced landward during basinal compaction as well as during sea-level rises.

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TABLE 1

TABLE 1.—*Data used to construct chloride-depth maps*

[Letters E, Q, R, SP, and SQ refer to the source of the chloride-concentration data, as follows: E, estimated from dissolved-solids content or specific conductance of fluids from cores; Q, chemical analysis; R, estimated from resistivity log; SP, estimated from spontaneous-potential log; SQ, chemical analysis of fluids from cores]

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)	Sample depth (feet below sea level)	Collection date	Reference
		CONTINENTAL SHELF			
1.	AMCOR 6011	16,200 SQ	103	8-17-76	Hathaway and others, 1976
		16,200 SQ	241	8-17-76	do
		8,000 E	306	8-17-76	do
		820 SQ	305	8-17-76	do
		1,800 SQ	337	8-17-76	do
		1,600 SQ	460	8-17-76	do
		1,000 SQ	523	8-17-76	do
		1,160 SQ	585	8-17-76	do
		1,350 SQ	648	8-17-76	do
		2,090 SQ	710	8-17-76	do
		8,100 SQ	802	8-17-76	do
		2,720 SQ	895	8-17-76	do
		1,800 E	926	8-17-76	do
2.	AMCOR 6020	14,950 SQ	154	9-13-76	do
		12,800 SQ	211	9-13-76	do
		10,900 SQ	240	9-13-76	do
		4,020 SQ	272	9-13-76	do
3.	AMCOR 6009, 6009B	17,000 SQ	213	8- -76	do
		18,200 SQ	243	8- -76	do
		11,260 SQ	273	8- -76	do
		6,340 SQ	304	8- -76	do
		5,140 SQ	335	8- -76	do
		3,700 SQ	335	8- -76	do
		3,790 SQ	429	8- -76	do
		3,520 SQ	460	8- -76	do
		3,170 SQ	460	8- -76	do
		3,390 SQ	491	8- -76	do
		3,530 SQ	522	8- -76	do
		3,770 SQ	554	8- -76	do
		4,830 SQ	616	8- -76	do
		4,960 SQ	647	8- -76	do
		5,640 SQ	709	8- -76	do

TABLE 1.—*Data used to construct chloride-depth maps*—Continued

[Letters E, Q, R, SP, and SQ refer to the source of the chloride-concentration data, as follows: E, estimated from dissolved-solids content or specific conductance of fluids from cores; Q, chemical analysis; R, estimated from resistivity log; SP, estimated from spontaneous-potential log; SQ, chemical analysis of fluids from cores]

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)	Sample depth (feet below sea level)	Collection date	Reference
CONTINENTAL SHELF - Continued					
3. AMCOR 6009, 6009B, continued		7,330 SQ	771	8- -76	Hathaway and others, 1976
		6,190 SQ	832	8- -76	do
		9,070 SQ	926	8- -76	do
		7,210 SQ	1,018	8- -76	do
		10,970 SQ	1,081	8- -76	do
		14,270 SQ	1,112	8- -76	do
4. AMCOR 6010		17,600 SQ	276	8-15-76	do
		15,800 SQ	335	8-15-76	do
		14,000 SQ	397	8-15-76	do
		15,500 SQ	522	8-15-76	do
		14,600 SQ	585	8-15-76	do
		13,900 SQ	772	8-15-76	do
		13,400 SQ	832	8-15-76	do
		13,200 SQ	957	8-15-76	do
		13,500 SQ	1,019	8-15-76	do
		13,400 SQ	1,081	8-15-76	do
		14,100 SQ	1,144	8-15-76	do
		18,000 SQ	1,237	8-15-76	do
5. AMCOR 6021		17,600 E	1,001	9-16-76	do
		18,000 E	1,013	9-16-76	do
		18,400 E	1,028	9-16-76	do
		18,100 E	1,072	9-16-76	do
		18,000 E	1,196	9-16-76	do
		18,000 E	1,258	9-16-76	do
		18,200 E	1,414	9-16-76	do
		18,000 E	1,502	9-16-76	do
		18,000 E	1,634	9-16-76	do
		18,000 E	1,728	9-16-76	do
		18,200 E	1,821	9-16-76	do
6. AMCOR 6008		14,800 SQ	98	8-08-76	do
		13,500 SQ	128	8-08-76	do
		8,600 SQ	158	8-08-76	do
		4,500 SQ	188	8-08-76	do
		230 SQ	259	8-08-76	do
		1,500 SQ	304	8-08-76	do
		200 E	335	8-08-76	do
		880 SQ	366	8-08-76	do

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)	Sample depth (feet below sea level)	Collection date	Reference
CONTINENTAL SHELF - Concluded					
8. AMCOR 6007		20,000 E	308	8- -76	Hathaway and others, 1976
		15,800 E	364	8- -76	do
		13,300 E	426	8- -76	do
		13,200 E	457	8- -76	do
		13,900 E	488	8- -76	do
		14,800 E	519	8- -76	do
		15,100 E	582	8- -76	do
		15,400 E	645	8- -76	do
		16,400 E	707	8- -76	do
		17,000 E	766	8- -76	do
		17,800 E	829	8- -76	do
		18,000 E	891	8- -76	do
		17,500 E	986	8- -76	do
		18,400 E	1,018	8- -76	do
		17,000 E	1,049	8- -76	do
DELAWARE					
1. CD 33-2		218 Q	80	6-28-55	Woodruff, 1969
2. CD 43-11		38 Q	88	6-28-55	Files of U.S. Geological Survey
3. DC 53-23		4 Q	550	8-25-54	Woodruff, 1969
4. EC 15-3		19 Q	170	6-29-55	Files of U.S. Geological Survey
5. GD 33-4B		308 Q	640	12-06-66	Woodruff, 1969
5. A.C. Schultes, Vogel 2		1,100 SP	725	4- -61	Files of U.S. Geological Survey
		2,100 SP	910	4- -61	do
		3,000 SP	1,000	4- -61	do
		2,200 SP	1,080	4- -61	do
		3,600 SP	1,180	4- -61	do
		7,900 SP	1,340	4- -61	do
		8,800 SP	1,560	4- -61	do
		10,000 SP	1,750	4- -61	do
		13,200 SP	1,860	4- -61	do
		9,000 SP	2,040	4- -61	do
		14,200 SP	2,160	4- -61	do
		12,400 SP	2,200	4- -61	do

TABLE 1.—*Data used to construct chloride-depth maps*—Continued

[Letters E, Q, R, SP, and SQ refer to the source of the chloride-concentration data, as follows: E, estimated from dissolved-solids content or specific conductance of fluids from cores; Q, chemical analysis; R, estimated from resistivity log; SP, estimated from spontaneous-potential log; SQ, chemical analysis of fluids from cores]

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
DELAWARE - Concluded						
6. HC 55-14		20	Q	113	6-20-74	Files of U.S. Geological Survey
7. ID 31-26		1,070	Q	1,100	3-24-70	Woodruff, 1969
8. KD 51-5		7	Q	450	3-30-70	Files of U.S. Geological Survey
9. ME 15-29		64	Q	480	5-13-68	Woodruff, 1969
		535	Q	640	5-12-68	do
		541	Q	780	2-20-68	do
10. NC 13-3		2	Q	340	9-18-70	Files of U.S. Geological Survey
		108	Q	560	10-13-70	do
		266	Q	700	9-15-70	do
11. Apple Orchard D-6 Sun Oil		1,400	SP	800	10- -39	do
		1,000	SP	1,090	10- -39	do
		1,200	SP	1,540	10- -39	do
		1,800	SP	1,610	10- -39	do
		2,800	SP	1,750	10- -39	do
		3,500	SP	1,820	10- -39	do
		6,000	SP	1,860	10- -39	do
		7,400	SP	2,250	10- -39	do
		11,200	SP	2,340	10- -39	do
		15,400	SP	2,480	10- -39	do
12. OI 35-27		37	Q	248	10-13-76	do
13. QJ 41-2		29	Q	350	8-05-71	do
14. QH 54-4		33	Q	300	11-03-78	do
15. RJ 22-6		21	Q	290	5-11-77	do
15. RJ 22-5		460	Q	450	5-11-77	do

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
		MARYLAND				
1. Ohio Oil, Hammond 1		1,000	SP	1,190	1- -45	Files of U.S. Geological Survey
		1,200	SP	1,240	1- -45	do
		1,500	SP	1,330	1- -45	do
		2,800	SP	1,450	1- -45	do
		1,500	SP	1,620	1- -45	do
		1,800	SP	1,710	1- -45	do
		4,300	SP	1,940	1- -45	do
		9,000	SP	2,100	1- -45	do
		8,000	SP	2,220	1- -45	do
		14,000	SP	2,510	1- -45	do
		17,500	SP	2,720	1- -45	do
		17,500	SP	2,920	1- -45	do
		19,000	SP	3,050	1- -45	do
		17,500	SP	3,190	1- -45	do
		16,000	SP	3,350	1- -45	do
		38,000	SP	3,460	1- -45	do
		37,000	SP	3,750	1- -45	do
2. BA GE-2		18	Q	590	6-30-43	do
3. BA GF-139		5	Q	600	1-24-44	do
4. BA GF-35		13	Q	665	7-16-43	do
5. KE AC-20		1,000	Q	550	12-02-77	do
		500-1,500	R	970	11- -77	do
6. CE EE-29		16	Q	440	8-01-78	do
		1-20	R	1,360	7-20-78	do
7. KE BE-43		2	Q	215	12-07-78	do
		1,500-4,000	R	1,500	10-27-78	do
8. KE BG-33		47	Q	635	10-25-78	do
		50-500	R	1,230	9-22-78	do
9. KE CB-36		32	Q	1,450	4-20-78	do
10. QA BE-16		3	Q	480	9-23-70	do
10. QA BE-15		473	Q	1,140	7-28-78	do
		2,580	Q	1,340	8-06-70	do

TABLE 1.—*Data used to construct chloride-depth maps*—Continued

[Letters E, Q, R, SP, and SQ refer to the source of the chloride-concentration data, as follows: E, estimated from dissolved-solids content or specific conductance of fluids from cores; Q, chemical analysis; R, estimated from resistivity log; SP, estimated from spontaneous-potential log; SQ, chemical analysis of fluids from cores]

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
		MARYLAND - Continued				
11.	AA CC-78	1	Q	684	1-15-62	Files of U.S. Geological Survey
12.	AA CC-114	2	Q	800	10-28-76	do
13.	AA CC-105	2	Q	1,040	7-08-73	do
14.	PG CE-16	1	Q	780	11-08-35	do
15.	AA CG-22	5	Q	1,730	9-26-78	do
16.	KE DB-40	10	Q	1,013	12-05-78	do
		1-20	R	1,760	11-17-78	do
17.	QA EB-110	13	Q	2,550	3-04-80	do
18.	TA CB-89	2	Q	1,350	8-03-53	do
19.	TA CE-67	2	Q	900	9-16-65	do
20.	TA CE-5	2	Q	1,120	3-11-49	do
21.	TA DC-2	6	Q	530	2-05-54	do
22.	CH EE-78	31	Q	1,100	6-16-78	do
23.	PG EC-29	61	Q	750	6-06-63	do
24.	CH CE-37	2	Q	1,150	11-09-73	do
25.	PG HF-40	1	Q	840	1-24-75	do
26.	PG HF-31	1	Q	1,010	6-14-73	do
		5	Q	1,500	1973	do
27.	CA CC-56	1	Q	740	1-26-74	do
28.	CA FD-54	2	Q	580	10-11-78	do
29.	SM FF-36	2	Q	590	10-29-75	do
30.	SM GG-14	2	Q	680	11-30-66	do
31.	DO DB-4	2	Q	530	10-15-65	do
32.	DO CE-84	2	Q	1,250	5-09-74	do
32.	DO CE-82	2	Q	1,300	10-05-71	do
32.	DO CE-88	2	Q	1,414	7-31-81	do
		3	Q	1,814	6-23-81	do
		120	Q	2,270	5-28-81	do
		140	Q	2,640	4-16-81	do
		2,200	Q	2,825	3-26-81	do
		27,800	Q	3,179	2-28-81	do
33.	DO EC-3	59	Q	390	2-17-54	do
34.	DO FC-8	49	Q	400	4-28-65	do
35.	DO DF-11	65	Q	500	4-29-65	do
36.	DO DH-7	170	Q	300	12-09-52	do
		580	Q	540	4-23-70	do

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
MARYLAND - Continued						
37. DO FE-14		195	Q	500	2-26-54	Files of U.S. Geological Survey
38. WI DB-56		1,200	Q	1,000	6-24-77	do
39. SO BB-1		250	Q	670	12-08-52	do
40. SO CC-1		315	Q	730	5-09-51	do
40. SO CC-7		6	Q	1,120	4-03-70	do
41. SO EA-11		11	Q	1,000	2-06-70	do
42. SO DC-3		42	Q	1,130	11-02-66	do
		110	Q	1,280	10-26-66	do
42. SO DD-47		41,000	Q	3,800	7-05-79	do
		42,000	Q	4,000	6-28-79	do
		42,000	Q	4,200	6-23-79	do
		800	SP	1,520	6-04-79	do
		1,500	SP	1,880	6-04-79	do
		2,100	SP	1,930	6-04-79	do
		6,100	SP	2,020	6-04-79	do
		4,500	SP	2,250	6-04-79	do
		5,100	SP	2,390	6-04-79	do
		5,500	SP	2,490	6-04-79	do
		10,000	SP	2,770	6-04-79	do
		16,000	SP	3,820	6-04-79	do
		31,400	SP	3,920	6-04-79	do
		29,000	SP	4,200	6-04-79	do
43. WO DG-10		21	Q	300	12-20-71	do
44. WI CG-35		326	Q	500	1941	do
45. WO DD-10		52	Q	300	5-27-52	do
46. Maryland Esso		3,200	SP	1,270	12-12-46	do
		2,500	SP	1,430	12-12-46	do
		3,000	SP	1,700	12-12-46	do
		3,700	SP	1,830	12-12-46	do
		4,000	SP	2,160	12-12-46	do

TABLE 1.—*Data used to construct chloride-depth maps*—Continued

[Letters E, Q, R, SP, and SQ refer to the source of the chloride-concentration data, as follows: E, estimated from dissolved-solids content or specific conductance of fluids from cores; Q, chemical analysis; R, estimated from resistivity log; SP, estimated from spontaneous-potential log; SQ, chemical analysis of fluids from cores]

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)	Sample depth (feet below sea level)	Collection date	Reference
		MARYLAND - Concluded			
46. Maryland Esso, continued		4,200 SP	2,240	12-12-46	Files of U.S. Geological Survey
		14,200 SP	2,370	12-12-46	do
		14,800 SP	2,460	12-12-46	do
		21,000 SP	2,750	12-12-46	do
		36,000 SP	2,960	12-12-46	do
		43,000 SP	3,280	12-12-46	do
		45,700 SP	3,580	12-12-46	do
		48,700 SP	3,840	12-12-46	do
		57,400 SP	4,210	12-12-46	do
		52,000 SP	4,540	12-12-46	do
		55,800 SP	4,640	12-12-46	do
47. WO DG-5		60 Q	140	9-10-53	do
48. WO EF-3		47 Q	160	9-10-53	do
49. Socony Vacuum,	Bethards 1	1,100 SP	1,700	8-26-45	do
		3,200 SP	1,910	8-26-45	do
		7,000 SP	2,140	8-26-45	do
		9,000 SP	2,230	8-26-45	do
		10,000 SP	2,350	8-26-45	do
		12,000 SP	2,630	8-26-45	do
		22,000 SP	2,840	8-26-45	do
		24,500 SP	2,990	8-26-45	do
		24,500 SP	3,100	8-26-45	do
		26,000 SP	3,320	8-26-45	do
50. WO AH-36		170 Q	420	10-03-75	do
50. WO AH-6		296 Q	460	7-24-69	do
		2,710 Q	700	7-14-69	do
51. SM DF-84		2 Q	760	1- -83	do
		260 SQ	1,835	12- -82	do
		170 SQ	1,990	12- -82	do
		540 SQ	2,245	12- -82	do
		750 SQ	2,395	12- -82	do
		730 SQ	2,500	12- -82	do
52. CH BE-57		26 Q	1,470	6-12-85	do

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
		NEW JERSEY				
1.	E.I. duPont Repauno 20	150	Q	100	9-01-59	Files of U.S. Geological Survey
2.	Mobil Oil Greenwich 41	110	Q	225	8-15-67	do
3.	Shell Oil Co 1	165	Q	330	4-14-79	do
4.	Mantua WC 3	38	Q	240	3-07-70	do
5.	Del Monte Corp 6	216	Q	260	4-05-60	do
6.	Swedesboro WD 2	155	Q	210	8-14-79	do
7.	So Jersey WS Co 3	150	Q	210	9-29-72	do
8.	Penns Grove WC-Layne 1	223	Q	330	9-29-72	do
9.	Pennsville Twp WD 2	110	Q	200	9-22-77	do
10.	E.I. duPont Courses Landing 2B	138	Q	500	5-01-67	do
10.	E.I. duPont Courses Landing 1A	176	Q	610	5-01-67	do
11.	Point Airy Obs	188	Q	590	4-12-63	do
12.	Woodstown Boro WD 2	210	Q	640	8-29-79	do
13.	Salem Obs Well 2	32	Q	90	5-10-76	do
13.	Salem Obs Well 3	700	Q	330	9-02-65	do
13.	Salem Obs Well 1	1,900	Q	700	6-06-78	do
14.	Clayton Boro WRD 3	142	Q	640	11-05-76	do
15.	New Brooklyn Park Obs	4	Q	720	5-01-61	do
		283	Q	1,330	4-27-72	do
16.	USGS Island Beach Test Well	6	Q	390	11-17-77	Gill and others, 1963
		780	Q	2,730	5-24-67	do
		1,100	SP	2,740	5-07-62	Files of U.S. Geological Survey
		2,700	SP	2,860	5-07-62	do
		5,400	SP	3,030	5-07-62	do
		7,000	SP	3,090	5-07-62	do
		7,000	SP	3,170	5-07-62	do
		11,300	SP	3,370	5-07-62	do
		11,300	SP	3,480	5-07-62	do
17.	Salem Nuclear Gen Station 5	18	Q	800	10-07-76	do
17.	Public Service Test 1	300	Q	1,240	9-09-80	do
18.	Anchor Gas, Ragovin	11,000	Q	1,980	10-22-74	do
		12,000	Q	2,490	10-15-74	do
		18,000	Q	3,010	10-08-74	do
		22,000	Q	3,180	10-01-74	do
		27,000	Q	3,310	9-24-74	do

TABLE 1.—*Data used to construct chloride-depth maps*—Continued

[Letters E, Q, R, SP, and SQ refer to the source of the chloride-concentration data, as follows: E, estimated from dissolved-solids content or specific conductance of fluids from cores; Q, chemical analysis; R, estimated from resistivity log; SP, estimated from spontaneous-potential log; SQ, chemical analysis of fluids from cores]

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
		NEW JERSEY - Concluded				
18.	Anchor Gas, Ragovin, continued	600	SP	860	10-31-64	Files of U.S. Geological Survey
		3,300	SP	1,230	10-31-64	do
		8,000	SP	1,480	10-31-64	do
		8,700	SP	1,840	10-31-64	do
		11,600	SP	2,410	10-31-64	do
		12,400	SP	2,660	10-31-64	do
		16,700	SP	2,940	10-31-64	do
		25,900	SP	3,030	10-31-64	do
		27,400	SP	3,110	10-31-64	do
		27,400	SP	3,240	10-31-64	do
19.	Wildwood Pines 2	90	Q	350	4-21-66	do
19.	Wildwood Pines 1	200	Q	880	8-22-61	do
20.	Anchor Gas, Dickinson 1	1,300	SP	1,840	7-14-63	do
		1,500	SP	2,100	7-14-63	do
		6,400	SP	2,210	7-14-63	do
		10,300	SP	2,420	7-14-63	do
		10,300	SP	2,580	7-14-63	do
		11,600	SP	2,690	7-14-63	do
		21,000	SP	3,010	7-14-63	do
		28,800	SP	3,110	7-14-63	do
		28,800	SP	3,680	7-14-63	do
		32,200	SP	3,910	7-14-63	do
		38,100	SP	4,360	7-14-63	do
		22,100	SP	5,200	7-14-63	do
		22,100	SP	5,380	7-14-63	do
21.	Atlantic City	330	Q	1,020	1888	Thompson, 1928
22.	Warren Grove	210	Q	1,515	11- -82	Files of U.S. Geological Survey
		300	Q	1,785	11- -82	do
23.	Well 33-106	460	Q	360	10-10-80	Fusillo and Voronin, 1981
24.	E.I.duPont, Leggette Test Hole #2	560	Q	910	10- -66	Files of U.S. Geological Survey
		NEW YORK				
1.	N5227	11	Q	1,250	2-11-77	Files of U.S. Geological Survey
2.	S21091T	14	Q	1,910	5-08-72	do
3.	S52162	13	Q	1,670	7-22-74	do

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
		NORTH CAROLINA				
1.	Gates 2	140	Q	270	10-07-53	Brown, 1959
2.	Gates 41	148	Q	370	3-02-54	do
3.	Hertford 28	48	Q	380	12-28-48	do
4.	Hertford 13	15	Q	380	3-12-54	do
5.	Gates 46	178	Q	450	1953	do
7.	Gates 36	61	Q	290	10-22-46	do
8.	Gates 20	65	Q	320	10-02-43	do
8.	Gates 21	512	Q	380	3-02-54	do
9.	Gates 15	62	Q	520	9-03-48	do
10.	DNRCD Sunbury Research Station, C-15-s-4,5	67	Q	525	12-10-74	Files of U.S. Geological Survey
		300	Q	850	12-11-74	do
11.	Gates 11	50	Q	500	10-08-53	Brown, 1959
12.	Pasquotank 11	321	Q	620	8-31-62	Harris and Wilder, 1966
13.	Pasquotank T1-62	404	Q	570	7-16-62	do
14.	DNRCD Morgans Corner Res. Sta., C-12-r-3	1,800	Q	390	10-30-75	Files of U.S. Geological Survey
		1,200	Q	450	8-20-75	do
		590	Q	630	7-24-75	do
		310	Q	800	7-17-75	do
		1,400	Q	1,000	6-26-75	do
		1,800	Q	1,130	6-19-75	do
		4,200	Q	1,300	6-12-75	do
		8,400	Q	1,460	6-04-75	do
15.	Pasquotank 14	697	Q	440	1961 ?	Harris and Wilder, 1966
16.	Perquimans 11	1,540	Q	600	5-18-62	do
18.	Hertford 58	5	Q	210	5-25-48	Brown, 1959
19.	Hertford 66	14	Q	300	10-08-53	do
20.	Bertie 21	14	Q	250	9-27-55	do
21.	Bertie 26	4	Q	280	9-28-55	do
22.	DNRCD Cremo Res. Sta., G-19-b-4,5,6	45	Q	340	12- -73	Files of U.S. Geological Survey
		280	Q	500	11- -73	do
		1,900	Q	760	8- -73	do
		3,200	Q	970	8-14-73	do
23.	Hertford 48	8	Q	230	3-31-54	Brown, 1959
24.	Chowan 39	434	Q	420	8-27-54	Lloyd, 1968
25.	Chowan 60	530	Q	400	1-12-63	do
26.	Chowan 76	247	Q	400	1-02-64	do
27.	Chowan 100	235	Q	420	7-17-62	do

TABLE 1.—*Data used to construct chloride-depth maps*—Continued

[Letters E, Q, R, SP, and SQ refer to the source of the chloride-concentration data, as follows: E, estimated from dissolved-solids content or specific conductance of fluids from cores; Q, chemical analysis; R, estimated from resistivity log; SP, estimated from spontaneous-potential log; SQ, chemical analysis of fluids from cores]

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
		NORTH CAROLINA - Continued				
28.	Chowan 113	161	Q	350	10-21-64	Lloyd, 1968
28.	Chowan 111	334	Q	360	8-12-62	do
29.	Chowan 134	53	Q	240	8-04-65	do
30.	Chowan 9	1,000	Q	200	10-05-62	do
		835	Q	370	10-03-62	do
		500	Q	530	10-02-62	do
		1,200	Q	810	10-01-62	do
31.	Chowan 22	530	Q	410	8-27-63	do
32.	Chowan 49	732	Q	440	7-12-63	do
33.	Perquimans 4	984	Q	340	1-04-62	Harris and Wilder, 1966
34.	Perquimans 8	1,050	Q	270	8-30-62	do
35.	Perquimans 14	1,340	Q	300	1961	do
36.	Perquimans 19	28	Q	80	8-14-58	do
		2,310	Q	310	8-14-58	do
		2,470	Q	410	8-13-58	do
37.	Chowan 89	196	Q	290	7-23-62	Lloyd, 1968
38.	Perquimans 22	979	Q	320	3-06-62	Harris and Wilder, 1966
39.	Chowan 154	100	Q	260	7-11-64	Lloyd, 1968
		300	Q	310	7-09-64	do
		494	Q	410	7-02-64	do
40.	DNRCD Elizabeth City Res. Sta., D-11-v-5	140	Q	50	4-23-75	Files of U.S. Geological Survey
		340	Q	120	4-23-75	do
		2,900	Q	450	4-23-75	do
41.	Pasquotank 139	99	Q	100	7-18-74	Robison, 1977
42.	Pasquotank 55	84	Q	900	11-26-32	Lohman, 1936
43.	Pasquotank 78	665	Q	100	7-01-62	Harris and Wilder, 1966
44.	Pasquotank 114	3,250	Q	470	12-19-32	Lohman, 1936
45.	Pasquotank 38	3,290	Q	1,120	5-01-62	Harris and Wilder, 1966
46.	Camden 41	456	Q	120	1-08-62	do
47.	Camden 42	41	Q	120	7-01-61	do
48.	Camden 74	520	Q	130	8-01-59	do
49.	Camden 54	744	Q	120	3-01-57	do
49.	Camden 53	1,210	Q	130	?	do
50.	Currituck 67	240	Q	80	7-13-60	do
51.	Camden 58	1,240	Q	150	4-27-62	do

NORTH CAROLINA - Continued

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
52.	Pasquotank 122	191	Q	120	?	Harris and Wilder, 1966
53.	Pasquotank 97	530	Q	110	7-18-62	do
54.	Pasquotank 109	230	Q	90	2-07-62	do
55.	Pasquotank 110	495	Q	90	5-08-62	do
56.	Currituck 99	24	Q	90	3-28-62	do
57.	Currituck 110	67	Q	120	5-19-60	do
58.	Duck, G-4-f-2	14	Q	70	1-23-74	Files of U.S. Geological Survey
		700	Q	120	1-17-74	do
		3,100	Q	240	1-16-74	do
		8,600	Q	400	1-09-74	do
		7,300	Q	480	1-07-74	do
59.	Duck, G-4-n-2	77	Q	80	2-21-74	do
		660	Q	100	2-19-74	do
60.	Duck Wood, G-4-x-1	780	Q	100	11-01-72	do
		2,900	Q	190	11-01-72	do
		4,710	Q	230	10-31-72	do
		6,640	Q	300	10-31-72	do
		6,480	Q	360	10-27-72	do
		1,970	Q	460	11-01-72	do
61.	H-4-u-2	140	Q	260	1972 ?	Peek and others, 1972
		390	Q	320	1972 ?	do
		1,420	Q	390	1972 ?	do
62.	J-3-a-1,2	1,700	Q	50	1972 ?	do
		656	Q	200	1972 ?	do
		1,275	Q	320	1972 ?	do
		4,700	Q	420	1972 ?	do
63.	DNRCD Causeway Research Station, J-3-h-2	90	Q	200	5-25-72	Files of U.S. Geological Survey
		828	Q	300	5-25-72	do
64.	Montes Airport, I-4-v-2	238	Q	270	8-29-72	do
		2,050	Q	360	8-29-72	do
65.	Skico, J-3-f-2	43	Q	200	7-13-72	do
		1,480	Q	320	7-13-72	do

TABLE 1.—*Data used to construct chloride-depth maps*—Continued

[Letters E, Q, R, SP, and SQ refer to the source of the chloride-concentration data, as follows: E, estimated from dissolved-solids content or specific conductance of fluids from cores; Q, chemical analysis; R, estimated from resistivity log; SP, estimated from spontaneous-potential log; SQ, chemical analysis of fluids from cores]

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
		NORTH CAROLINA - Continued				
66.	J-3-y-2	80	Q	190	6-22-72	Peek and others, 1972
		980	Q	300	6-13-72	do
		4,780	Q	410	6-09-72	do
67.	J-3-w-3	44	Q	180	1962	Nelson, 1964
71.	Martin 4	9	Q	180	7- -60	Wyrick, 1966
72.	Bertie 79	110	Q	300	6- -73	Robison, 1977
73.	Bertie 65	42	Q	330	5-71-49	Brown, 1959
73.	Bertie 64	137	Q	350	9-27-55	do
74.	Bertie 59	23	Q	200	6- -54	do
75.	Bertie 70	85	Q	360	3-29-50	do
76.	Bertie 72	24	Q	390	9-27-55	do
77.	Chowan 207	150	Q	270	8-12-64	Lloyd, 1968
78.	Chowan 257	282	Q	190	6-14-63	do
79.	Chowan 234	155	Q	290	7- -60	do
		1,350	Q	340	7- -60	do
80.	Chowan 54	85	Q	280	1-16-54	Brown, 1959
80.	Chowan 53	106	Q	350	5-24-27	do
81.	Chowan 273	271	Q	230	11-18-64	Lloyd, 1968
81.	Chowan 41	710	Q	260	10-21-42	Brown, 1959
81.	Chowan 303	82	Q	130	9-15-62	Lloyd, 1968
		2,310	Q	240	9-14-62	do
		2,340	Q	340	9-14-62	do
		3,360	Q	590	9-13-62	do
		4,140	Q	680	9-11-62	do
82.	Chowan 232	230	Q	270	11-18-64	do
83.	Martin 84	6	Q	240	8- -60	Wyrick, 1966
84.	Martin 95	4	Q	270	8- -60	do
85.	Martin 136	174	Q	230	8- -60	do
86.	Martin 152	15	Q	190	7- -60	do
87.	Chowan 311	900	Q	230	bef. 45	Lloyd, 1968
		2,400	Q	270	bef. 45	do
		3,000	Q	380	bef. 45	do
88.	Esso #1 Hatteras Light	78,000	Q	6,500	1946	Manheim and Horn, 1968
89.	Martin 58	28	Q	220	7- -60	Wyrick, 1966

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
		NORTH CAROLINA - Continued				
90.	Martin 110	50	Q	310	8- -60	Wyrick, 1966
91.	Martin 129	104	Q	280	7- -60	do
92.	Martin 145	88	Q	340	7- -60	do
93.	Martin 160	30	Q	280	8- -60	do
93.	Martin 161	63	Q	270	7- -60	do
94.	MAR-P-7	146	Q	400	2- -57	Brown and others, 1972
		315	Q	440	2- -57	do
		450	Q	480	2- -57	do
		380	Q	540	2- -57	do
		1,500	Q	600	2- -57	do
95.	Martin 220	99	Q	360	7- -60	Wyrick, 1966
95.	Martin 240	183	Q	390	7- -60	do
96.	Martin 235	25	Q	260	7- -60	do
97.	Martin 190	75	Q	380	8- -60	do
98.	Martin 229	14	Q	240	8- -60	do
98.	Martin 230	388	Q	260	7- -60	do
99.	Martin 386	9	Q	100	7- -60	do
100.	Martin 397	10	Q	110	7- -60	do
101.	Martin 404	15	Q	140	7- -60	do
102.	J-16-o-1	251	Q	140	9-27-55	Nelson, 1964
103.	J-16-p-2	66	Q	175	9-27-55	do
104.	J-15-p-2	13	Q	250	8-20-63	do
105.	I-14-w-1	234	Q	370	8-20-63	do
106.	J-13-c-3	400	Q	350	1-09-53	do
107.	J-12-c-2	1,040	Q	470	9-19-62	do
108.	J-12-n-2	758	Q	370	8-20-63	do
109.	I-10-y-3	113	Q	100	9- -62	do
110.	DNRCD Newlands Res. Sta., J-11-v-4,5,6,8	123	Q	190	4-28-76	Files of U.S. Geological Survey
		3,200	Q	570	7-15-75	do
		13,000	Q	860	7-14-76	do
		16,000	Q	1,280	4-08-76	do
111.	J-7-g-2	490	Q	90	1962	Nelson, 1964
112.	DNRCD Manns Harbor Res. Sta., J-5-j-1	244	Q	260	9-26-72	Files of U.S. Geological Survey
		1,410	Q	330	9-25-72	do

TABLE 1.—*Data used to construct chloride-depth maps*—Continued

[Letters E, Q, R, SP, and SQ refer to the source of the chloride-concentration data, as follows: E, estimated from dissolved-solids content or specific conductance of fluids from cores; Q, chemical analysis; R, estimated from resistivity log; SP, estimated from spontaneous-potential log; SQ, chemical analysis of fluids from cores]

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
		NORTH CAROLINA - Continued				
113.	DNRCD Plymouth Res. Sta., K-17-a-3,4	210	Q	190	9-16-81	Files of U.S. Geological Survey
		2,400	Q	280	9-14-81	do
		9,950	Q	840	6-10-80	do
		11,400	Q	1,160	1980 ?	do
		15,500	Q	1,380	1980 ?	do
116.	Pitt 44	101-250	Q	125	6-11-64	Sumsion, 1970
117.	Pitt 219	111	Q	400	9-28-56	Robison, 1977
118.	Pitt 16	85	Q	420	9-28-56	Brown, 1959
119.	Greene 13	10	Q	200	11-11-53	do
120.	DNRCD Marietta Res. Sta., BB-45-m-2	130	Q	420	1971	Files of U.S. Geological Survey
121.	Greene 52	30	Q	300	1-04-55	Brown, 1959
122.	Pitt 244	1-10	Q	300	12-16-63	Sumsion, 1970
123.	Pitt 86	101-250	Q	350	6-15-64	do
124.	DNRCD Bethel Research Station, L-24-b-3	4	Q	130	3-11-80	Files of U.S. Geological Survey
		380	Q	300	2-27-80	do
		800	Q	500	2-21-80	do
125.	Pitt 181	26-100	Q	360	5-08-64	Sumsion, 1970
126.	Pitt 25	8	Q	320	2-27-56	Brown, 1959
126.	Pitt 26	320	Q	570	7-02-56	do
127.	Pitt 407	1-10	Q	360	2- -66	Sumsion, 1970
128.	Pitt 258	1-10	Q	250	1-20-64	do
129.	Pitt 261	34	Q	450	7- -65	do
130.	Pitt 276	11-25	Q	370	5-25-64	do
131.	Pitt 64	15	Q	450	5-03-55	Brown, 1959
132.	Lenoir 5	11	Q	270	12-07-43	LeGrand, 1960
133.	Pitt 114	101-250	Q	310	4-28-64	Sumsion, 1970
134.	Pitt 123	101-250	Q	360	5-08-64	do
135.	Pitt 128	101-250	Q	380	11-13-63	do
136.	Pitt 139	101-250	Q	380	4-27-64	do
		1-10	Q	430	?	do
137.	BEA-T-24	21	Q	230	1963	Brown and others, 1972
		490	Q	320	1963	do
		1,060	Q	540	1963	do
		2,220	Q	710	1963	do
138.	Beaufort 69	52	Q	300	3-30-54	Brown, 1959
139.	Pitt 330	26-100	Q	370	11-21-63	Sumsion, 1970
140.	Craven 24	12	Q	510	10-16-62	Floyd and Long, 1970
		67	Q	640	10-19-62	do

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
	NORTH CAROLINA - Continued					
141.	DNRCD Wilmar Res. Sta., P-21-k-5,9	222	Q	660	11- -68	Files of U.S. Geological Survey
		470	Q	820	10- -68	do
142.	DNRCD Cox Crossroads Res. Sta., P-19-m-3,4,5	10	Q	240	7- -67	do
		840	Q	360	6- -67	do
		4,100	Q	550	5- -67	do
143.	L-16-f-1	8	Q	190	8-20-63	Nelson, 1964
144.	Beaufort 8	15	Q	380	3-08-55	Brown, 1959
145.	Belhaven 29	386	Q	370	10-07-66	Lloyd and Floyd, 1968
		765	Q	400	10-05-66	do
		6,720	Q	540	9-29-66	do
146.	Beaufort 14	19	Q	210	3-18-55	Brown, 1959
147.	Belhaven 54	28	Q	250	1966	? Lloyd and Floyd, 1968
148.	DNRCD Belhaven Res. Sta., N-15-h-10,11	168	Q	300	4- -73	Files of U.S. Geological Survey
		820	Q	360	4- -73	do
		2,460	Q	400	4- -73	do
148.	Belhaven 187	3,540	Q	460	7-25-66	Lloyd and Floyd, 1968
149.	Beaufort 31	65	Q	220	4-21-54	Brown, 1959
150.	Beaufort 29	98	Q	200	1-06-42	do
150.	Belhaven 183	186	Q	260	4-29-65	Lloyd and Floyd, 1968
151.	DNRCD Bath Research Station 0-17-i-3,4	226	Q	280	2- -73	Files of U.S. Geological Survey
		1,500	Q	470	9- -66	do
152.	0-17-t-1	52	Q	240	12-22-67	do
153.	Beaufort 32	382	Q	260	4-21-54	Brown, 1959
154.	DNRCD Winsteadville Res. Sta., 0-15-n-4,5	155	Q	400	11- -76	Files of U.S. Geological Survey
		7,480	Q	600	11- -76	do
155.	P-14-f-2	809	Q	420	2- -74	Nelson, 1976; Peek and others, 1974
156.	DNRCD Lee Creek Res. Sta., P-17-h-4,5,6	200	Q	310	8- -66	Files of U.S. Geological Survey
		2,960	Q	460	6- -66	do
		9,700	Q	900	6- -66	do
157.	DNRCD South Side Ferry Landing Res. Sta., P-16-o	120	Q	300	11- -67	do
158.	L-9-f-2	212	Q	130	9- -62	Nelson, 1964
159.	N-10-n-2	308	Q	100	8-20-62	do
160.	DNRCD Hydeland Res. Sta., 0-10-w-1,2,3	240	Q	150	2- -75	Files of U.S. Geological Survey
		1,625	Q	680	4- -75	do
		7,150	Q	850	3- -75	do
		17,000	Q	1,240	2- -75	do

TABLE 1.—*Data used to construct chloride-depth maps*—Continued

[Letters E, Q, R, SP, and SQ refer to the source of the chloride-concentration data, as follows: E, estimated from dissolved-solids content or specific conductance of fluids from cores; Q, chemical analysis; R, estimated from resistivity log; SP, estimated from spontaneous-potential log; SQ, chemical analysis of fluids from cores]

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
		NORTH CAROLINA - Continued				
161.	L-5-s-2	44	Q	80	1962	Nelson, 1964
167.	DNRCD Clarendon Res. Sta., DD-42-n-2	14	Q	135	3-22-76	Files of U.S. Geological Survey
		88	Q	320	3-16-76	do
		1,240	Q	460	3-15-76	do
		1,360	Q	490	3-09-76	do
		1,540	Q	540	3-08-76	do
		3,325	Q	620	3-02-76	do
		3,360	Q	680	2-25-76	do
		3,593	Q	750	2-19-76	do
168.	Q-27-r-3	36	Q	550	4-09-54	Nelson and Barksdale, 1965
169.	Q-27-s-4	3	Q	400	5-21-62	do
170.	Q-26-p-1	10	Q	470	5-21-62	do
171.	DNRCD Nakina Res. Sta., EE-39-o-5	15	Q	240	2-11-77	Files of U.S. Geological Survey
		260	Q	290	2-10-77	do
		1,260	Q	420	2-09-77	do
		1,340	Q	520	2-03-77	do
		4,160	Q	650	12-15-76	do
172.	Q-26-x-1	9	Q	400	5-21-62	Nelson and Barksdale, 1965
173.	Craven 3	3	Q	140	2-05-53	LeGrand, 1960
174.	Craven 431	42	Q	770	9-25-64	Floyd and Long, 1970
175.	Craven 266	20	Q	230	2-10-64	do
		319	Q	350	2-07-64	do
176.	Craven 136	25	Q	280	1-24-64	do
		302	Q	420	1-23-64	do
177.	Craven 221	7	Q	170	2-27-63	do
		1,100	Q	320	3-03-63	do
		1,020	Q	460	3-13-63	do
178.	Craven 175	202	Q	620	8-20-62	do
		1,600	Q	790	8-13-62	do
179.	Craven 258	380	Q	310	6-19-63	do
		510	Q	360	6-19-63	do
180.	Craven 311	79	Q	310	6-26-63	do
		914	Q	350	6-24-63	do
		430	Q	600	7-05-63	do
		254	Q	760	7-04-63	do
		618	Q	850	7-02-63	do

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
		NORTH CAROLINA - Continued				
181.	DNRCD Waccamaw School Res. Sta., FF-38-j-6	350	Q	130	4-14-77	Files of U.S. Geological Survey
		300	Q	190	4-13-77	do
		680	Q	280	4-07-77	do
182.	Jones 22	6	Q	120	11-13-54	LeGrand, 1960
183.	DNRCD Bay City Res. Sta., R-17-i-2,3	170	Q	440	2-13-75	Files of U.S. Geological Survey
		1,700	Q	600	1975	do
184.	R-18-u-3	6	Q	200	8-24-61	Nelson, 1964
185.	S-17-j-5	12	Q	200	8-24-61	do
186.	DNRCD Arapahoe Res. Sta., S-18-u-4,8,12	6	Q	180	3-23-72	Files of U.S. Geological Survey
		120	Q	340	5-19-72	do
		2,500	Q	450	1973	do
		10,400	Q	730	9-22-72	do
187.	DNRCD Hobucken Res. Sta., Q-15-u-2,4,5	125	Q	550	9- -74	do
		1,370	Q	720	10-16-74	do
		15,400	Q	960	10-16-74	do
188.	R-14-e-1	19	Q	360	8-24-61	Nelson, 1964
189.	Q-14-r-1	158	Q	400	1975	Files of U.S. Geological Survey
190.	T-16-s-2	16	Q	210	8-24-61	Nelson, 1964
191.	Brunswick 30	1,070	Q	360	5-03-60	Blankenship, 1965
204.	Robeson 55	3	Q	400	1- -50	Schipf, 1961
205.	Duplin 21	3	Q	150	2-10-47	LeGrand, 1960
206.	Craven 531	7	Q	180	10-01-75	Robison and Mann, 1977
207.	Craven 61	12	Q	140	9-03-41	LeGrand, 1960
208.	Carteret 80	12	Q	200	10-08-52	do
209.	Ct-133	44	Q	350	6-17-77	Winner, 1978
210.	Ct-131	8	Q	410	6-16-77	do
211.	Ct-86	15	Q	350	6-16-77	do
213.	Carteret 83	10	Q	250	10-08-52	LeGrand, 1960
214.	Carteret 126	8	Q	330	9-18-75	Robison and Mann, 1977
215.	Carteret 44	43	Q	220	7-23-38	LeGrand, 1960
216.	Carteret 36	17	Q	180	7-31-41	do
217.	Sampson 38	165	Q	300	4-15-38	Pusey, 1960

TABLE 1.—*Data used to construct chloride-depth maps*—Continued

[Letters E, Q, R, SP, and SQ refer to the source of the chloride-concentration data, as follows: E, estimated from dissolved-solids content or specific conductance of fluids from cores; Q, chemical analysis; R, estimated from resistivity log; SP, estimated from spontaneous-potential log; SQ, chemical analysis of fluids from cores]

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
		NORTH CAROLINA - Continued				
218.	Sampson 56	5	Q	400	7-17-58	Pusey, 1960
219.	Horry 337, Eagles Nest, South Carolina	370	Q	300	5-22-74	Zack, 1980
220.	DNRCD Chinquipin Res. Sta., W-29-d-8	12	Q	510	10- -82	Files of U.S. Geological Survey
		420	Q	670	10- -82	do
		480	Q	730	10- -82	do
221.	Onslow 130	26	Q	500	10-23-64	Robison and Mann, 1977
222.	Onslow 24	30	Q	150	8-15-49	LeGrand, 1960
223.	Onslow 54	2,450	Q	550	?	do
224.	Onslow 110	74	Q	350	4-03-41	do
225.	Onslow 119	47	Q	120	10-24-41	do
226.	Onslow 122	35	Q	280	5-19-48	do
227.	Pender 71	19	Q	140	10-03-75	Robison and Mann, 1977
229.	DNRCD Deppe Research Station, V-23-x-2	16	Q	250	10-10-79	Files of U.S. Geological Survey
		1,000	Q	380	10-08-79	do
		85	Q	590	10-02-79	do
		700	Q	840	9-20-79	do
235.	Pender 75	7	Q	220	8-22-75	Robison and Mann, 1977
236.	Pender 38	12	Q	200	3-10-54	LeGrand, 1960
237.	Pender 64	650	Q	320	2-04-53	do
239.	DNRCD Ivanhoe Research Station, Y-34-p-1	70	Q	240	1-04-78	Files of U.S. Geological Survey
		94	Q	300	12-29-77	do
		690	Q	420	12-27-77	do
240.	Pender 43	4	Q	80	3-10-54	LeGrand, 1960
241.	Bladen 12	145	Q	75	12-30-54	Blankenship, 1965
242.	DNRCD White Lake Prison Res. Sta., Y-38-b-6	60	Q	290	12-09-75	Files of U.S. Geological Survey
243.	Waste Injection Site Well 14	6	Q	30	2-25-72	Leenheer and others, 1976
243.	Waste Injection Site Well 15	2,350	Q	290	2-26-72	do
		6,950	Q	490	3-05-72	do
243.	Waste Injection Site Well 8	1,0000	Q	680	6-13-73	do
243.	Waste Injection Site Well 11	1,2000	Q	950	5-10-73	do
244.	New Hanover 87	47	Q	190	8-06-65	Bain, 1970
		3,350	Q	290	8-12-65	do
		8,780	Q	560	8-02-65	do
245.	New Hanover 420	31	Q	90	5-04-76	Robison and Mann, 1977
246.	New Hanover 255	107	Q	160	4-20-65	Bain, 1970

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
		NORTH CAROLINA - Continued				
247.	New Hanover 256	136	Q	150	4-20-65	Bain, 1970
248.	New Hanover 262	109	Q	160	4-21-65	do
249.	New Hanover 347	38	Q	120	1965 ?	do
		2,860	Q	310	9-02-65	do
		8,310	Q	600	8-30-65	do
250.	New Hanover 94	37	Q	190	11-05-47	LeGrand, 1960
251.	New Hanover 411	26	Q	150	2-08-63	Bain, 1970
252.	Brunswick 73	110	Q	150	8-20-75	Robison and Mann, 1977
253.	Bladen 23	4	Q	160	4-30-60	Blankenship, 1965
254.	Bladen 6	4	Q	420	3-09-54	do
255.	DNRCD Lake Waccamaw Res. Sta., CC-38-b-7,8	26	Q	370	11-27-74	Files of U.S. Geological Survey
		70	Q	450	11-27-74	do
		3,100	Q	620	11-18-74	do
256.	Columbus 55	7	Q	220	5-04-55	Blankenship, 1965
257.	Columbus 82	9	Q	250	11-18-75	Robison and Mann, 1977
258.	Columbus 39	210	Q	100	?	Blankenship, 1965
259.	Brunswick 67	1,020	Q	220	12-23-54	do
260.	DNRCD Bear Pen Res. Sta., EE-36-k-2	3,040	Q	80	10-31-73	Files of U.S. Geological Survey
		1,200	Q	260	1-09-74	do
		1,900	Q	470	10-29-73	do
		2,500	Q	580	10-18-73	do
		6,350	Q	680	10-17-73	do
		6,800	Q	980	12-10-73	do
261.	Brunswick 50	235	Q	230	2-07-54	Blankenship, 1965
262.	Columbus 14	486	Q	170	5-04-60	do
263.	Brunswick 40	760	Q	280	5-03-60	do
264.	DNRCD Sunset Harbor Res. Sta., GG-34-s-2	19	Q	70	7- -74	Files of U.S. Geological Survey
		1,710	Q	290	1974	do
		2,082	Q	680	4-08-74	do
		6,300	Q	1,010	1974 ?	do
		5,780	Q	1,140	3-28-74	do
		8,250	Q	1,270	5-21-74	do
265.	Brunswick 4	1,550	Q	210	3-17-57	Blankenship, 1965
265.	Brunswick 1	8,100	Q	1,530	3-07-57	do

TABLE 1.—*Data used to construct chloride-depth maps*—Continued

[Letters E, Q, R, SP, and SQ refer to the source of the chloride-concentration data, as follows: E, estimated from dissolved-solids content or specific conductance of fluids from cores; Q, chemical analysis; R, estimated from resistivity log; SP, estimated from spontaneous-potential log; SQ, chemical analysis of fluids from cores]

Well location number shown in plate 1		Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
			NORTH CAROLINA - Continued				
267.	DNRCD Calabash Res. Sta.,	HH-39-j-2	60	Q	10	?	Files of U.S. Geological Survey
			560	Q	300	4-28-82	do
			520	Q	550	5-16-73	do
			540	Q	600	5-03-73	do
			3,800	Q	770	7-18-73	do
			3,600	Q	990	4-10-75	do
			3,700	Q	1,100	3-16-73	do
			4,500	Q	1,210	3-01-73	do
269.	Ocracoke Electric Corp	HY-31	2,670	Q	600	2-01-57	do
270.	Moore's Creek Natl.Mil.Park,	PEN-TI-65	200	Q	180	12-17-65	Brown and others, 1972
			1,320	Q	310	12-06-65	do
			10,000	Q	570	12-03-65	do
271.	DNRCD Atlantic Res. Sta.,	V-12-i-3,4	170	Q	415	1981	Files of U.S. Geological Survey
			450	Q	815	3-04-81	do
			8,270	Q	1,105	2-24-81	do
			12,500	Q	1,330	2-04-81	do
272.	DNRCD Big Flatty Creek Res. Sta.,	G-9-c-4	1,900	Q	150	7-28-76	do
			4,600	Q	600	7-08-76	do
273.	DNRCD Scuppernong Res. Sta.,	J-13-d-3	540	Q	350	5-10-77	do
			7,500	Q	550	4-20-78	do
			16,000	Q	920	3-13-78	do
274.	DNRCD New Lake Res. Sta.,	M-12-1-3	5,100	Q	650	9-26-78	do
			13,000	Q	840	8-31-78	do
275.	DNRCD Gum Neck Res. Sta.,	L-10-a-3	2,900	Q	650	11-04-76	do
			5,800	Q	770	2-18-77	do
276.	DNRCD Whortonsville Res. Sta.,	S-15-y-2	1,000	Q	550	10-06-77	do
			12,000	Q	1,050	9-15-77	do
277.	DNRCD Clark Research Station,	S-22-j-6	920	Q	310	5-31-79	do
			880	Q	500	7-12-79	do
			180	Q	700	7-17-79	do
			8,800	Q	1,160	2-21-79	do
278.	DNRCD Como Research Station,	B-20-u-6	49	Q	440	6-24-81	do
			200	Q	500	5-06-81	do
			380	Q	560	3- -81	do
			1,100	Q	720	4-29-81	do

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
		NORTH CAROLINA - Continued				
279.	DNRCD Parkville Res. Sta., E-13-m-3	1,800	Q	110	2-09-77	Files of U.S. Geological Survey
		1,700	Q	330	2-02-77	do
		1,600	Q	420	1-26-77	do
		1,600	Q	600	1-13-77	do
		1,700	Q	820	1-11-77	do
		3,800	Q	1,010	1-05-77	do
280.	DNRCD Topsail Res. Sta., BB-28-j-3	12	Q	190	8-02-83	do
		622	Q	370	7-28-83	do
		1,700	Q	420	7-21-83	do
		1,800	Q	510	7-15-83	do
		3,800	Q	770	6-09-83	do
		12,400	Q	1,030	5-31-83	do
		12,800	Q	1,080	5-09-83	do
		14,600	Q	1,240	4-26-83	do
281.	DNRCD Folkstone Res. Sta., Y-25-q-2	16	Q	270	1982	do
		22	Q	380	1982	do
		266	Q	460	1982	do
		1,600	Q	720	1982	do
		2,700	Q	910	1982	do
282.	DNRCD Comfort Res. Sta., U-26-j-2	3	Q	440	7-16-79	do
		500	Q	730	6-27-79	do
283.	DNRCD Bladenboro Res. Sta., Z-41-u-2	14	Q	130	10-14-75	do
		360	Q	300	10- -75	do
		466	Q	360	10-06-75	do
284.	DNRCD Kelly Research Station, AA-35-n-1	110	Q	310	6-08-81	do
		240	Q	430	6-01-81	do
		1,200	Q	510	5-19-81	do
		2,300	Q	590	4-30-81	do
285.	DNRCD Burgaw Research Station, Y-30-s-5	30	Q	360	11- -81	do
		520	Q	470	11- -81	do
		2,800	Q	620	10- -81	do
		7,500	Q	760	10- -81	do
		9,100	Q	820	10- -81	do
286.	DNRCD Grissettown Res. Sta., GG-38-k-3	60	Q	10	11-16-77	do
		940	Q	230	11-08-77	do
		840	Q	310	11-03-77	do

TABLE 1.—*Data used to construct chloride-depth maps*—Continued

[Letters E, Q, R, SP, and SQ refer to the source of the chloride-concentration data, as follows: E, estimated from dissolved-solids content or specific conductance of fluids from cores; Q, chemical analysis; R, estimated from resistivity log; SP, estimated from spontaneous-potential log; SQ, chemical analysis of fluids from cores]

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
		NORTH CAROLINA - Concluded				
287.	BER-P-4	220	Q	140	1962	Brown and others, 1972
		285	Q	170	1962	do
		1,870	Q	270	1962	do
		1,995	Q	290	1962	do
		VIRGINIA				
1.	55P 8	2	Q	800	1-28-77	Files of U.S. Geological Survey
2.	56N 7	2	Q	450	1-28-77	do
3.	59M 2	3	Q	540	2-27-41	do
4.	60L 18	10	Q	710	12-03-79	do
5.	59K 21	3	Q	630	12-04-79	do
6.	58L 5	3	Q	530	6-09-48	do
7.	59K 13	5	Q	740	5-15-53	do
8.	59K 12	16	Q	670	5-15-53	do
9.	60J 5	390	Q	670	1-19-76	do
10.	63L 4	150	Q	1,020	9-23-71	do
11.	66M 2	66	Q	230	5-30-55	do
12.	Chincoteague 4	64	Q	200	6-01-70	do
13.	66M 5	17	Q	220	4-06-55	do
14.	66M 9	12	Q	180	9-25-75	do
15.	65K 20	55	Q	240	9-21-71	do
16.	64K 3	12	Q	180	12-31-06	do
17.	64K 5	9	Q	240	9-11-75	do
18.	64J 1	1,600	Q	370	10-27-70	do
19.	64J 4	690	Q	240	12-12-45	do
20.	64H 2	29	Q	200	4-05-55	do
21.	63G 9	20	Q	130	5-26-54	do
22.	63F 1	21	Q	430	10-26-70	do
23.	63F 10	14	Q	190	9-11-75	do
24.	56M 10	2	Q	510	6-20-73	do
25.	56J 13	160	Q	920	7-27-73	do

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
		VIRGINIA - Continued				
26. 56J 11		132	Q	840	3-28-63	Files of U.S. Geological Survey
		920	Q	1,220	3-28-63	do
27. 58K 7		6	Q	600	11-01-68	do
28. 58J 3		187	Q	610	1-13-70	do
29. 58J 11		10	Q	450	1-16-80	do
30. 58J 9		464	Q	650	1-13-70	do
31. 59J 8		830	Q	640	1-26-80	do
32. 60J 6		1,820	Q	810	6-01-18	do
33. 59C 1		89	Q	610	9-24-70	do
34. 58H 3		290	Q	580	6-27-69	do
34. 58H 2		355	Q	720	5-18-48	do
35. 59G 14		1,800	Q	710	8-04-50	do
36. 59G 4		1,540	Q	420	6-19-80	do
37. 59G 12		1,110	Q	400	7-08-69	do
38. 54G 11		120	Q	400	3-30-73	do
39. 54G 8		210	Q	270	8-11-69	do
40. 55F 13		12	Q	440	8-11-69	do
41. 56H 20		99	Q	480	2-02-79	do
42. 57G 23		55	Q	370	2-05-79	do
43. 56F 18		27	Q	370	12-21-77	do
44. 57F 8		330	Q	380	6-02-78	do
44. 57F 2		350	Q	390	11-29-72	do
45. 58F 38		350	Q	350	7-15-71	do
45. 58F 42		240	Q	440	7-14-71	do
46. 57F 16		2,150	Q	1,170	5-03-77	do
47. 58F 9		408	Q	480	7-07-42	do
48. 59D 20		690	Q	800	7-07-70	do
49. 57E 4		3	Q	990	1-24-42	do
50. 56E 1		4	Q	310	7-30-69	do
51. 59D 2		16	Q	580	2-22-71	do
52. 59D 1		194	Q	510	9-24-70	do
53. 59C 14		180	Q	590	6-27-69	do
54. 59C 7		185	Q	650	1-20-77	do
		400	Q	790	1-20-77	do
		1,270	Q	1,030	1-20-77	do

TABLE 1.—*Data used to construct chloride-depth maps*—Continued

[Letters E, Q, R, SP, and SQ refer to the source of the chloride-concentration data, as follows: E, estimated from dissolved-solids content or specific conductance of fluids from cores; Q, chemical analysis; R, estimated from resistivity log; SP, estimated from spontaneous-potential log; SQ, chemical analysis of fluids from cores]

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
		VIRGINIA - Continued				
55.	60C 8	227	Q	640	3-04-70	Files of U.S. Geological Survey
56.	60C 7	369	Q	800	8-09-68	do
57.	61C 1	964	Q	850	1-24-68	do
		1,300	Q	930	2-21-68	do
		1,380	Q	950	1-22-68	do
		1,680	Q	1,040	1-22-68	do
		4,200	Q	1,260	1-20-68	do
		9,560	Q	1,620	1-17-68	do
		26,000	Q	2,370	12-18-67	do
		26,900	Q	2,500	12-16-67	do
58.	SWCB 234-66	2,584	Q	760	6-18-79	Siudyla and others, 1981
59.	57C 15	21	Q	500	11-28-67	Files of U.S. Geological Survey
60.	58C 1	132	Q	800	7-31-69	do
61.	58C 11	135	Q	820	2-24-76	do
		190	Q	930	2-24-76	do
		375	Q	1,050	2-24-76	do
		1,340	Q	1,220	2-24-76	do
62.	58B 11	15	Q	620	4-21-75	do
63.	57B 6	15	Q	610	5-06-75	do
64.	SWCB 234-146	1,653	Q	630	2-04-76	Siudyla and others, 1981
65.	60B 4	146	Q	510	11-03-77	Files of U.S. Geological Survey
65.	60B 3	392	Q	810	11-03-77	do
66.	55B 29	3	Q	280	6-27-69	do
67.	55B 23	34	Q	370	10-09-68	do
68.	55A 3	450	Q	700	3-18-77	do
69.	55B 39	65	Q	800	9-22-75	do
70.	56A 11	77	Q	760	8-24-77	do
71.	56A 1	250	Q	600	6-19-72	do
		400	Q	690	6-19-72	do
		1,300	Q	960	6-19-72	do

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
		VIRGINIA - Continued				
72. 56A 5		29	Q	450	6-27-72	Files of U.S. Geological Survey
73. 56A 12		32	Q	530	6-30-77	do
73. 56A 10		2,250	Q	1,010	6-29-77	do
74. 57A 6		30	Q	590	3-01-77	do
		71	Q	760	3-01-77	do
		456	Q	920	3-01-77	do
75. 58A 2		24	Q	420	4-18-72	do
		360	Q	670	4-18-72	do
76. 66M 1		22,000	SP	620	4-12-71	do
		2,400	SP	1,020	4-12-71	do
		3,000	SP	1,170	4-12-71	do
		3,400	SP	1,810	4-12-71	do
		2,600	SP	1,880	4-12-71	do
		6,000	SP	1,950	4-12-71	do
		8,000	SP	2,230	4-12-71	do
		13,200	SP	2,290	4-12-71	do
		9,000	SP	2,510	4-12-71	do
		15,400	SP	2,620	4-12-71	do
		13,200	SP	2,800	4-12-71	do
77. 58F 3		240	Q	280	6-25-68	do
		2,038	Q	590	6-25-68	do
		1,929	Q	740	6-25-68	do
		1,485	Q	1,020	6-25-68	do
		1,762	Q	1,270	6-25-68	do
		2,045	Q	1,430	6-25-68	do
		700	SP	610	6-25-68	do
		1,000	SP	860	6-25-68	do
		1,400	SP	960	6-25-68	do
		1,900	SP	1,030	6-25-68	do
		2,400	SP	1,270	6-25-68	do
		2,200	SP	1,430	6-25-68	do

TABLE 1.—*Data used to construct chloride-depth maps*—Continued

[Letters E, Q, R, SP, and SQ refer to the source of the chloride-concentration data, as follows: E, estimated from dissolved-solids content or specific conductance of fluids from cores; Q, chemical analysis; R, estimated from resistivity log; SP, estimated from spontaneous-potential log; SQ, chemical analysis of fluids from cores]

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
		VIRGINIA - Continued				
78.	Fort Monroe, Well No. 9	4,978	Q	945	1906	Cederstrom, 1957
79.	58H 4	830	SQ	380	11-04-81	Files of U.S. Geological Survey
		670	SQ	800	11-10-81	do
		740	SQ	940	11-11-81	do
		520	SQ	1,080	11-14-81	do
		750	Q	1,230	8-25-82	do
		2,800	SQ	1,700	12-08-81	do
80.	SWCB 234-65	1,555	Q	1,040	6-06-79	Siudyla and others, 1981
81.	61A 1	1,450	Q	740	2-04-76	Files of U.S. Geological Survey
82.	56A 9	100	Q	530	5-30-75	do
		580	Q	680	5-29-75	do
		610	Q	730	5-28-75	do
83.	57A 2	42	Q	560	7-06-72	do
84.	60C 1	450	Q	740	3-20-69	do
84.	60C 5	582	Q	740	1-17-68	do
84.	60C 3	540	Q	800	3-20-69	do
85.	60C 6	368	Q	750	6-13-69	do
86.	60C 9	268	Q	690	8-23-68	do
87.	61D 2	1,900	Q	980	12-06-79	do
88.	59D 3	1,680	Q	800	8-05-40	do
89.	60E 4	950	Q	140	11-05-47	do
90.	60G 1	93	Q	150	6-01-43	do
91.	60H 3	28	Q	100	6-01-18	do
92.	59H 1	520	Q	540	2-12-80	do
93.	59G 2	2,500	Q	600	12-31-06	do
94.	56G 10	176	Q	300	12-12-10	do
95.	59J 3	294	Q	480	2-12-80	do
96.	68M 1	282	Q	255	10-17-67	do
97.	68M 2	1,940	Q	170	5-30-55	do
		1,710	Q	210	5-30-55	do
98.	59J 10	530	Q	620	1-16-80	do
99.	58F 8	491	Q	580	7-07-42	do
100.	58F 1	420	Q	410	4-28-72	do
101.	58F 6	390	Q	430	10-15-18	do
102.	57G 1	107	Q	200	1910	do
		453	Q	400	3-20-67	do
103.	58F 18	400	Q	390	5-28-75	do

Well location number shown in plate 1	Local well identifier	Chloride (mg/L as Cl)		Sample depth (feet below sea level)	Collection date	Reference
		VIRGINIA - Concluded				
104. 56G 13		100	Q	290	7-08-71	Files of U.S. Geological Survey
105. 57G 37		94	Q	330	7-08-71	do
106. 57G 40		380	Q	410	7-26-71	do
107. 57G 13		280	Q	340	12-19-72	do
108. 57G 31		225	Q	350	2-07-41	do
109. 59C 12		221	Q	620	10-07-74	do
110. 60B 2		370	Q	810	5-30-75	do
111. 58B 5		19	Q	600	7-15-69	do
112. 55B 36		190	Q	820	9-23-75	do