Beach-Area Water Supplies Between Ocean City, Maryland and Rehoboth Beach, Delaware

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1619-T

Prepared in cooperation with the Maryland Department of Geology, Mines and Water Resources

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By TURBIT H. SLAUGHTER

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

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BEACH-AREA WATER SUPPLIES BETWEEN OCEAN CITY, MARYLAND, AND REHOBOTH BEACH, DELAWARE

By Turbit H. Slaughter [1]

ABSTRACT

The potential for water-supply development of the aquifers along the ocean beach between Ocean City, Md., and Rehoboth Beach, Del., is good. The ocean beach, the easternmost segment of the Coastal Plain province, is underlain by unconsolidated sand, gravel, silt, clay, shale, and shell beds which overlie deeply buried southeastward-sloping consolidated rocks. At Rehoboth Beach the estimated thickness of the sediments is about 6,500 feet, and at Ocean City about 8,500 feet. The sediments are of Triassic, Cretaceous, Tertiary, and Quaternary age. Only sands and gravels in the uppermost 300 feet of the sediments are used at present (1959) as a source of ground water.

At Ocean City the major aquifers are formations of the Pleistocene, Pliocene(?), and upper part of the Miocene Series. The Pocomoke and Manokin aquifers in the Miocene Series are the most productive. Some wells ending in the Manokin aquifer are capable of sustained yields of 500 gpm.

At Rehoboth Beach large amounts of ground water are obtained from wells ending in sand and gravel of the Pleistocene Series. Some of these wells yield as much as 700 gpm. Only water for domestic use is obtained from the deeper Pocomoke and Manokin aquifers.

Along the ocean front in Maryland, iron is common in the ground water in concentrations sufficient to be objectionable. In the Fenwick Island area, saline or brackish water is present locally. Generally, in Delaware the sands of the Pleistocene Series yield water of good quality. However, at Rehoboth Beach public-supply wells had to be relocated inland because of salt-water infiltration into the aquifers. In the deeper aquifers salt water may be expected below depths of 700 to 900 feet.

INTRODUCTION

The purpose of this paper is to summarize the occurrence, quantity, and quality of the ground water in the ocean-beach area between Ocean City, Md., and Rehoboth Beach, Del. This area is the ocean playground for many people from the metropolitan areas of Philadelphia, Wilmington, Baltimore, and the District of Columbia.

[1] Geologist, Maryland Department of Geology, Mines and Water Resources.

Recent engineering studies made for the State of Delaware of the ocean-beach area from the Maryland-Delaware line to Bethany Beach indicate that the number of private and commercial buildings has increased threefold since 1954.[2] It is predicted, on the basis of these studies, that within the period 1957–62, building should increase by 100 percent. The Maryland ocean-front development is also expanding. The population of Ocean City, Md., about 1,200 in the winter, increases to an estimated 50,000 during the summer months, and reaches nearly 100,000 on holiday weekends.

The author expresses his appreciation to Dr. Johan J. Groot, State Geologist of Delaware, for his suggestions, and to Dr. William C. Rasmussen of the U.S. Geological Survey, formerly District Geologist in charge of the cooperative ground-water investigations in Delaware, for his advice.

COASTAL PLAIN GEOLOGY

The ocean beach is the easternmost frontier of the Coastal Plain province, of which Worcester County, Md., and Sussex County, Del., are a part (Eardley, 1951, p. 75).

Underlying the Coastal Plain are quartz sand, greensand, gravel, silt, clay, shale, and shell beds. These sediments lie upon a southeastward-sloping rock mass of Precambrian and Paleozoic age often referred to as the "basement complex" (fig. 1). At Rehoboth Beach the estimated thickness of the Coastal Plain sediments is about 6,500 feet, whereas at Ocean City, 27 miles south, it is about 8,500 feet. This is an increase in thickness of 180 feet per mile, measured northwestward from Ocean City along the dip of the rocks. The geologic formations that lie within this huge wedge-shaped mass of unconsolidated material are of Triassic, Cretaceous, Tertiary, and Quaternary age. At present, only the upper 300-foot section of this wedge has been penetrated by producing wells along the ocean shore, and only the upper part of the Tertiary System and the full thickness of the Quaternary System have been explored for water.

Following are the stratigraphic and hydrologic units underlying the Maryland-Delaware beach area from the surface down to known salt-water-producing sands, adapted from Rasmussen and Slaughter (1955) and Marine and Rasmussen (1955).

[2] B. E. Beavin Company, 1957, Ocean Highway, Fenwick Island to Bethany Beach, Delaware: Engineering report prepared for Delaware State Highway Dept.

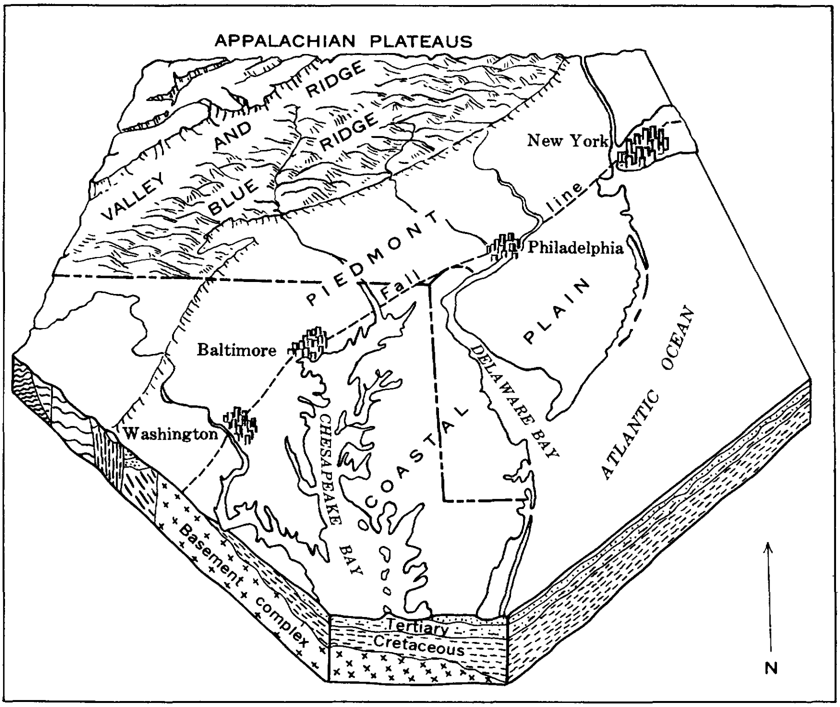

FIGURE 1.—Schematic block diagram of geomorphic provinces of Maryland, Delaware, and vicinity. After Rasmussen and Andreasen, 1959, fig. 1.

System	Series	Unit	Subunit	Thickness (feet)[1]	Lithology
Quaternary	Pleistocene			65–125	Gravel and sand
Tertiary	Pliocene(?)			15– 25	Gravel and sand
	Miocene	Yorktown and Cohansey(?) Formations, undifferentiated	Upper aquiclude	18– 60	Silt
			Pocomoke aquifer	36– 52	Sand
			Lower aquiclude	43– 59	Silt
			Manokin aquifer	30– 79	Sand
		St. Marys Formation		200–250	Clay and silt
		Choptank Formation		200–260	Sand and clay
		Calvert Formation		450–700	Diatomaceous silt and sand
	Eocene	Piney Point Formation (salt-water aquifer)		50–200	Glauconitic quartz sand

[1] Maryland only.

PRINCIPLES OF THE OCCURRENCE OF GROUND WATER ALONG THE OCEAN SHORE

Nature continually replenishes the supply of ground water. Rainwater and snowmelt filter downward under the influence of gravity into the soil zone, and a part of this water finally reaches the water table. The amount of precipitation that becomes ground water is determined by natural laws operating as part of the hydrologic cycle. The average precipitation along the ocean beach is about 45 inches per year; of this amount, as much as half or a little more of the precipitation may become ground water (Rasmussen and Andreasen, 1959). Most of this is discharged by ground-water runoff to natural drainage systems and by evapotranspiration to the atmosphere. A part of it passes beneath the coast to discharge into the sea offshore.

Systematic measurements of water levels in observation wells, selected on the basis of geologic and geographic considerations, illustrate the relation between wet and dry periods and the response to these conditions. Shallow observation wells, especially those penetrating dune sand, show an almost immediate response to precipitation. Periods of drought are indicated by slow but sustained declines in the water levels in shallow wells.

Ground water can be produced in quantity only from water-saturated permeable earth materials called aquifers. Water-yielding sediments may be separated into two main categories: the unconfined or water-table aquifers in which infiltrating water has free access to the water table, and the confined or artesian aquifers which are enclosed above and below by impermeable or semipermeable beds. Hydrologically, it is possible for water-table and artesian aquifers to act as a single water-yielding unit when geologic conditions permit. Semi-artesian conditions can exist when sediments which are unconfined in one locality are overlain nearby by a confining bed, or are overlain by a "leaky" confining bed of moderately low rather than extremely low permeability.

In the beach area, the water-table aquifers are formations of the Pleistocene and Pliocene(?) Series which, where coexistent, function hydrologically as a single unit. Beneath the Pleistocene and Pliocene(?) formations lie two artesian aquifers, parts of the Yorktown and Cohansey (?) Formations (figs. 2, 3). These aquifers, the Pocomoke and the Manokin, occur beneath the Maryland beach area. They consist of beds of sand and gravel which rise toward the northwest, following the regional structure. They are found at progressively shallower depths northward along the beach in Delaware.

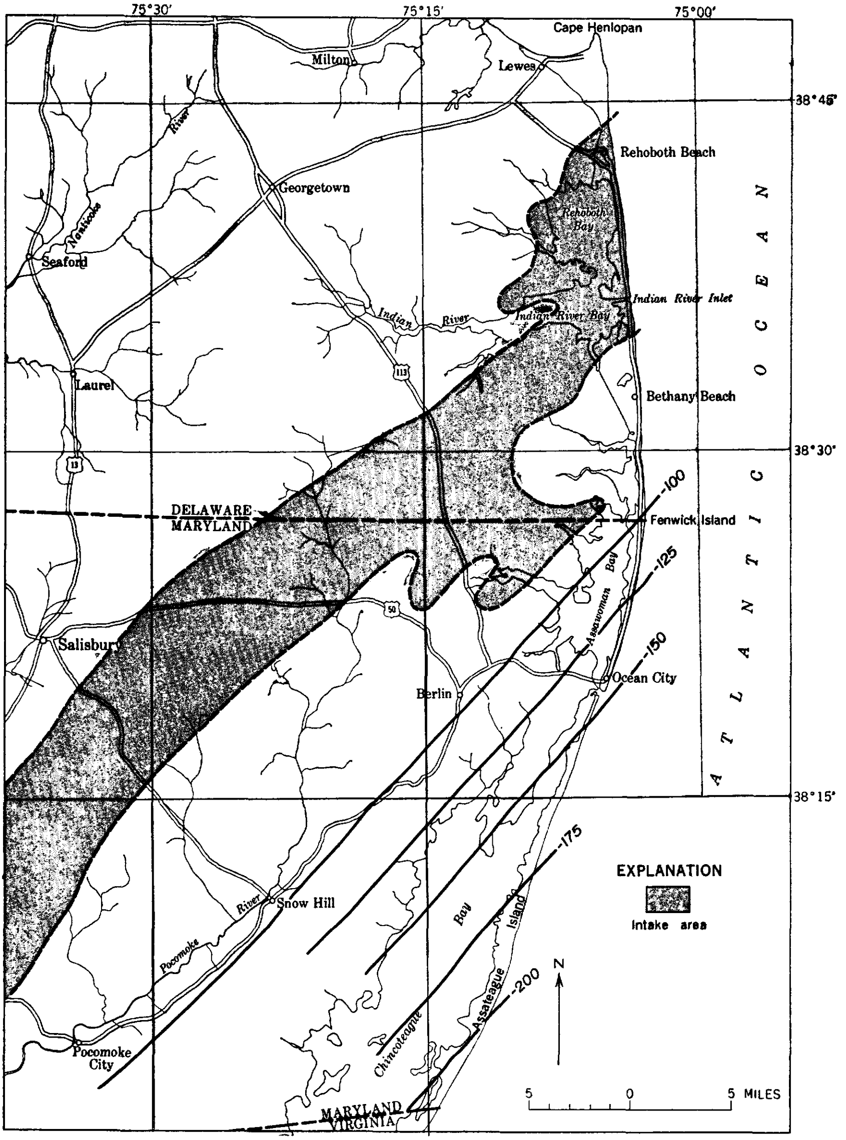

FIGURE 2.—Intake area of the Pocomoke aquifer and contours indicating the top of the aquifer as it dips southeastward beneath the upper aquiclude.

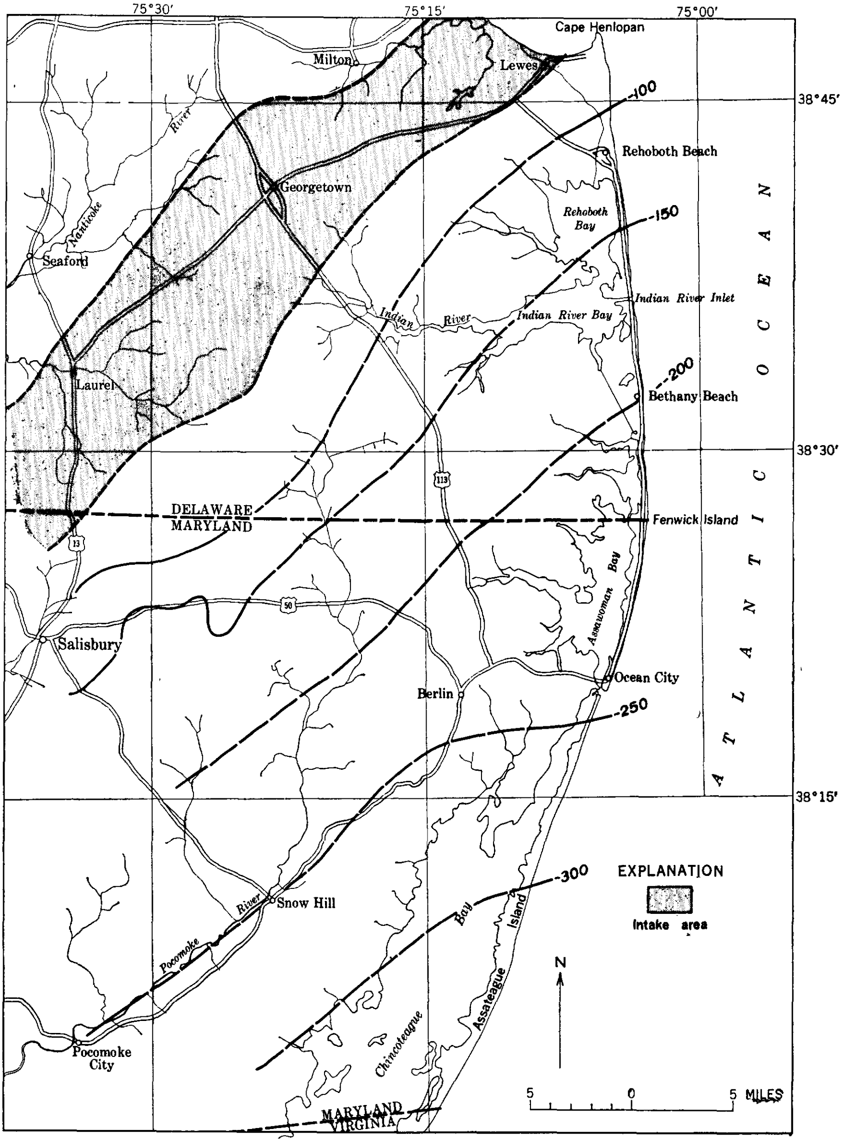

FIGURE 3.—Intake area of the Manokin aquifer and contours indicating the top of the aquifer as it dips southeastward beneath the lower aquiclude.

QUANTITY OF GROUND WATER

Large-scale municipal pumping at Ocean City, Md., is from the Pocomoke and Manokin aquifers, where certain wells are capable of sustained yields of 150 and 500 gallons per minute, respectively. The average daily pumpage at Ocean City is about 600,000 gallons. In Delaware, large supplies are obtained from wells in the Pleistocene Series that are capable of producing up to 700 gallons per minute. At Rehoboth Beach, average daily pumpage is about 400,000 gallons. The Pocomoke and Manokin aquifers are used for only small supplies in Delaware.

Controlled aquifer tests are made in order to determine hydraulic characteristics of aquifers, proper spacing of wells, and the rates at which water can be produced (Brown, 1953). The hydraulic characteristics of an aquifer are called the coefficients of transmissibility and storage. Essentially, transmissibility is the product of the average field coefficient of permeability and the saturated thickness of an aquifer. The field coefficient of permeability is a measure of the capacity of a unit cross section of the rocks to transmit water under a hydraulic gradient. The volume of water yielded by gravity drainage from saturated water-bearing materials in proportion to the total volume of those materials is called the specific yield, commonly expressed as percentage of the volume of materials involved. In unconfined or water-table aquifers, the coefficient of storage is approximately equal to the specific yield and generally ranges from 0.01 to 0.3. In confined (artesian) aquifers, however, the coefficient of storage is much smaller and generally ranges from 0.00001 to 0.001. Because the coefficient of storage of water-table aquifers is much larger than that of artesian aquifers, it is frequently possible for water-table aquifers to produce large amounts of water without great drawdown or without developing a "radius of influence" of more than a few thousand feet. Artesian wells commonly have greater drawdowns because the water must be drawn from a greater volume of the aquifer, and the influence of pumping on water levels may extend for several miles.

Aquifer tests at Ocean City indicate thatt he Manokin aquifer is the most productive, the Pocomoke aquifer is next, and the aquifer of Pleistocene and Pliocene(?) age is the poorest. In Delaware, however, the aquifer of Pleistocene and Pliocene(?) age appears to be the most productive.

QUALITY OF GROUND WATER

The variable quality of ground water along the ocean front has caused considerable concern. In some places the iron content of the water is high enough to be objectionable, whereas in others the chloride content is high. Along the Maryland ocean front the presence of varying amounts of iron in ground water seems to be the most common complaint. Toward Fenwick Island on the Maryland side, saline water is present locally. At Fenwick Island, brackish water that contains an objectionable amount of iron has been found in sands of the Pleistocene Series at depths ranging from near the surface to about 90 feet. At Bethany Beach, good water in adequate supply is obtainable from the sands of Pleistocene age. Dewey Beach, about a mile south of Rehoboth Beach, has an adequate supply of fresh water furnished by domestic wells; but at Rehoboth Beach, salt water has infiltrated the shallow sands, necessitating relocation of the municipal well field inland west of the Lewes and Rehoboth Canal. Wells tapping sands of the Pleistocene Series on the mainland opposite Little Assawoman, Indian River, and Rehoboth Bays produce fresh water.

SALT-WATER CONTAMINATION

Infiltration of brackish water through natural processes or through induced infiltration caused by large-scale pumping is the most critical ground-water problem along the Maryland-Delaware ocean beach. In Maryland to date [1959], large-scale pumping at Ocean City from the Pocomoke and Manokin aquifers has not caused salt-water infiltration. A layer of gray clay 20 to 40 feet thick overlies the shallow water-producing sands in the Ocean City area, forming a protective seal against salt-water contamination (pl. 1). In addition, fresh water under a higher artesian head in the recharge belt of the Pocomoke and Manokin aquifers helps to keep a salt-water front from moving toward the centers of pumping in areas along the shore.

Northward in the vicinity of Fenwick Island, Del., local clay beds near the surface are apparently thin and interrupted, allowing downward movement of salt water in response to density differences wherever the fresh-water head is not great enough to prevent such movement. The salt water may encroach from either the ocean or the inland bays. An inadequate clay seal coupled with large-scale pumping of water has probably permitted salt-water encroachment into the sands of the Pleistocene Series at Rehoboth Beach. Although the Lewes and Rehoboth Canal is believed to be the source of the salt-water contamination in the Lewes area, in the Rehoboth area the salt water may have come directly from the ocean.

POTENTIAL OF DEEPER AQUIFERS

About 4 miles north of Ocean City on the Isle of Wight, a well drilled to a depth of 1,706 feet in 1914 yielded water having a chloride content of 2,550 parts per million. The top of the water-bearing sand, which is probably the Piney Point Formation of late Eocene age, is about 1,150 feet below sea level at Rehoboth and 1,600 feet at Fenwick Island. An old well at Lewes obtained fresh water at depths of 400, 625, and 750 feet, but at depths of 911 and 1,080 feet the water was of unsatisfactory chemical quality. Salt water has even been found inland at Bishopville, Md., about 8 miles west of Fenwick Island, at a depth of 640 feet in a sand of the lower part of the Choptank Formation of Miocene age. The top of the Choptank Formation is estimated to be about 400 feet below sea level at Rehoboth Beach and a little more than 700 feet at Ocean City. More reliable information on the quantity and quality of water from the deeper untapped aquifers below a depth of about 300 feet can be ascertained best by additional drilling and sampling of the water.

SUMMARY

The potentialities for water-supply development of the ground-water resources of the Maryland-Delaware beach area are good.

In Maryland, large supplies can be developed from the Manokin and Pocomoke aquifers. In Delaware, with the exception of Rehoboth Beach where salt-water infiltration has necessitated moving the well field inland, large supplies can generally be developed from the shallower sands of the Pleistocene Series, and possibly from deeper sands of the Miocene Series not yet tested. At Bethany Beach, especially, the shallow sands may be a potential source of large supplies of ground water because the geologic conditions are favorable for preventing salt-water contamination.

Inland from the bays on both the Maryland and Delaware mainlands, large supplies can be obtained from sands of the Pleistocene and Pliocene(?) Series.

Those responsible for the development, operation, and maintenance of ground-water supplies in the Maryland-Delaware beach areas should make use of all ground-water data available from well drillers and the State and Federal Governments as an aid in determining such factors as the optimum spacing of wells, the effects of new wells on existing ones, the maximum safe pumping rates, and the prevention of salt-water encroachment into producing aquifers. Test wells, test pumping, and water analyses should precede substantial ground-water developments in the beach area.

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