MARYLAND GEOLOGICAL SURVEY

Kenneth N. Weaver, Director

REPORT OF INVESTIGATIONS NO. 17

WATER RESOURCES OF DORCHESTER AND TALBOT COUNTIES, MARYLAND

with Special Emphasis on the Ground-water Potential of the Cambridge and Easton Areas

By

Frederick K. Mack, Wayne E. Webb,

and Richard A. Gardner

Prepared
in cooperation with
U.S. Geological Survey
and the
City of Easton
City of Cambridge
County of Dorchester
County of Talbot

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ABSTRACT

The available ground water in Dorchester and Talbot Counties exceeds by many times the present consumption. However, the supply of fresh surface water is small.

The two counties occupy a low-lying plain along the eastern shore of Chesapeake Bay. Drainage is by two large tidal rivers, the Choptank and the Nanticoke, and by many small creeks directly tributary to Chesapeake Bay. Much of the two-county area is poorly drained and coastal swamps are common.

A thick section of Coastal Plain sediments including sands, silts, clays, and minor gravel beds overlies the crystalline basement rocks, which are found at depths of 2,200 to 4,200 feet. To date, only the upper 1,500 feet of sediment have been explored. The known aquifers include the Patapsco Formation, upper Cretaceous sands (primarily the Magothy Formation), the Aquia, Piney Point, and Calvert Formations, which are Tertiary in age, and the Pleistocene deposits. The most important artesian aquifer, the Piney Point Formation, has a transmissibility of 30,000 to 45,000 gpd per foot (gallons per day per foot) in the Cambridge area, but does not exist in some parts of Talbot County. The Pleistocene deposits form a very productive water-table aquifer in northeastern Dorchester County, where the transmissibility is very high (95,000 to 175,000 gpd per foot) and where many wells are capable of yielding more than 1,000 gpm (gallons per minute).

Water use, excluding withdrawals for cooling electric power generators, averaged 11 mgd (million gallons per day) in 1960, of which 10 mgd was ground water and 1 mgd was surface water. Ground water is used for public water supplies at the cities of Cambridge and Easton and at five villages. It is also used by several small industries, mainly food processing plants. Cambridge obtains over 80 percent of its average supply of 3.5 mgd from the Piney Point Formation and the remainder from the Magothy Formation. Easton obtains most of its average supply of about 0.9 mgd from Cretaceous sands and the remainder from the Aquia and Calvert Formations.

Estimates, made of the long-term yield of individual aquifers by using field-determined values for the coefficients of transmissibility and storage, indicate that large additional quantities of water are available from the aquifers currently being pumped. The additional water would be obtained by lowering pumping levels to greater depths, a practice which will increase pumping costs and may cause subsidence of the land surface. The theoretical estimates show that a total of 11 mgd could be obtained from the Piney Point and Magothy aquifers at Cambridge and that a total of 5 mgd could be obtained from the Cretaceous and Aquia aquifers in the Easton area.

The development of surface-water supplies is limited by the low relief, which precludes the construction of reservoirs, and by the high salinity of water in the major streams, all of which are estuaries of Chesapeake Bay. At present, surface water is used for cooling at a thermal power plant on the Nanticoke River and for a small amount of irrigation.

The quality of water ranges from water with low mineral content, satisfactory for most uses without treatment, to the moderately saline water (specific conductance greater than 5,000 micromhos) in the major streams and Chesapeake Bay. Water in the small streams in the topographically high areas and most ground water are characterized by low concentrations of dissolved solids—less than 500 mg/l (milligrams per liter). Ground water from the Piney Point and Aquia Formations is hard (hardness averages 142 mg/l) in the northwestern part of the area but is softer (hardness averages about 30 mg/l) and higher in dissolved solids towards the southeast.

INTRODUCTION

This report describes the findings of a 2-year investigation of the water resources of Dorchester and Talbot Counties. Emphasis is placed on an evaluation of the ground-water resources, as ground water is the principal source of fresh water in the two-county area. Funds were furnished by the U.S. Geological Survey, Maryland Geological Survey, Dorchester County, Talbot County, city of Easton, and city of Cambridge. Field studies, data analysis, and report preparation were by personnel of the U.S. Geological Survey. Field investigations were made from July 1964 to December 1966.

Purpose of Investigation

This study was made to obtain information needed to provide for the proper planning and future development of water resources in Dorchester and Talbot Counties. Demands for water are expected to increase in the future as they have in the past. Several questions regarding future water supplies for the two counties result from the rising demands. Briefly, these questions are concerned with:

1. The availability and sources of both ground water and surface water for industrial and urban development.
2. The extent and hydraulic properties of the waterbearing formations, particularly the quantity of water available from them on a long-term basis.
3. The chemical quality of ground water and surface water and the effect of quality on the usefulness of each type of water.
4. Predictions of future water requirements of the cities of Cambridge and Easton and estimates of how their requirements can be matched by sources available.

Early studies in the area were made by Darton (1896), and Clark and others (1918). A detailed account of the geologic and hydrologic framework is given in a report by Rasmussen and others (1957). Much of the effort in the current study was directed toward supplementing, reexamining, and generally updating and enlarging the work of Rasmussen and others.

Methods of Investigation

Considerable geologic and hydrologic information has become available in recent years as a result of the drilling of wells for small water supplies throughout the two counties and the drilling of large production wells for the cities of Cambridge and Easton. The recent data and the comprehensive report on the water resources of the area by Rasmussen and others (1957) form the basis for the present investigation.

Included in the present effort were the compilation of drilling, water-level, and pumpage data that have accumulated since termination of the last study; test drilling to obtain new data from depths previously unexplored in this area; collection of samples of water from ground-water and surface-water sources for chemical analysis; streamflow studies, preparation of potentiometric maps to show the effect of pumping on water levels, and quantitative studies to determine the long-term yield of aquifers.

Data used in this report were obtained by: (1) collection of information on location, depth, diameter, yield, and other pertinent features of approximately 1,370 wells and test holes, (2) drilling and electric logging of three test holes to depths of about 1,500 feet, (3) field examination of outcrops of surficial deposits, (4) collection and analysis of 92 water samples from aquifers and streams, (5) measurement of water levels in 13 observation wells to determine the magnitude of fluctuations caused by both natural causes and pumping, (6) collection and laboratory examination of drill cuttings and well logs of geologic formations, (7) aquifer testing at 20 sites to determine coefficients of transmissibility and storage, (8) continuous measuring of streamflow at two gaging stations and miscellaneous measuring at seven sites, (9) gamma-ray logging of 33 wells, and (10) electric logging of 19 wells. The locations of the principal data-collection sites are shown in figure 1. The lithologic logs and well records are in the appendix.

Temperatures presented in the report are given in both degrees Fahrenheit and degrees Celsius.

Acknowledgments

The authors wish to express their appreciation for the cooperation received from many well drillers and well owners, as well as Federal, State, County, and city agencies during the course of this investigation. Because of space limitations it is impossible to list by name all those who helped the project. However, special thanks are given the Heikes Well Co., the Leon Jarrett Well Co., Sydnor Hydrodynamics, Inc., the Shannahan Artesian Well Co., and the Layne-Atlantic Well Co., who provided well-construction data and other information and assistance. Richard H. Johnston of the U.S. Geological Survey contributed substantially to the preparation of the report.

Location and Extent of The Area

Dorchester and Talbot Counties are located on the Delmarva Peninsula along the eastern shore of Chesapeake Bay. The area is a low-lying plain, of which about half is water. Dorchester County has an area of 944 square miles, of which 581 square miles is land and 363 square miles is water. The county is bounded on the north by the Choptank River and Caroline County, on the east by the State of Delaware and the Nanticoke River, and on the south and west by Chesapeake Bay. Talbot County has an area of 462 square miles, of which 272 is land and 190 is water. The county is bounded on the north by Queen Annes County, on the east and south by Tuckahoe Creek and the Choptank River, and on the west by Chesapeake Bay.

Physical Features [1]

Dorchester and Talbot Counties form a gently rolling, terraced plain, which ranges in altitude from sea level along the many tidal rivers to 78 feet near Easton. The area is bounded on three sides by tidewater and is deeply indented by tidal rivers. Much of the southernmost two-thirds of Dorchester County is marshland, having altitudes of 2 feet or less. The land gradually rises from the marshland to a maximum of 53 feet in northern Dorchester County. The western half of Talbot County is an area of necks and drowned valleys where the land is 20 feet or less above sea level. The eastern half of Talbot County is a plain which ranges in general from 40 to 70 feet above sea level and reaches 78 feet above sea level at the highest point near Easton.

[1] Adapted from the description of physical features of Caroline, Dorchester, and Talbot Counties by Rasmussen and Slaughter (1957).

The drainage of the two-county area is controlled by two large tidal rivers, the Choptank and the Nanticoke, and by many small rivers and creeks directly tributary to Chesapeake Bay. The Nanticoke River has a prominent tributary, Marshyhope Creek, which is tidal as far upstream as Federalsburg in Caroline County. The Choptank River is tidal to Greensboro, 14 miles upstream from the project area. It has a prominent tributary, Tuckahoe Creek, which is tidal to Hillsboro. Along the bay side of Talbot County, the Wye East River, Miles River, and Tred Avon River are tidal. In Dorchester County, the Little Choptank River and the Honga River are embayed estuaries. The Blackwater River, Transquaking River, and Chicamacomico River are meandering swampy bayous. The specific type names—creek, river, bay, sound, gut—are dictated more by local custom than by exact definition.

Population

The population of Talbot and Dorchester Counties has remained relatively stable at about 46,000 to 50,000 since 1900. A small decline in population occurred between 1910 and 1920, and the population then remained virtually unchanged from 1920 to 1950. Between 1950 and 1960, the population increased by 4,000 or about 8 percent. Predictions by the Maryland Department of Planning (1963) indicate the population may reach 63,000 by the year 2000.

From 1960 to 2000 the population of Cambridge is expected to double from 12,500 to 25,000, and the population of Easton may increase from 6,200 to 20,000 during the same period.

These data indicate that by the year 2000 the combined population of the two cities may increase by 25,000 persons, but the total population of the counties will increase by only 12,000. If the prediction proves to be accurate, the rural population will be reduced by 13,000 persons.

Climate [1]

The climate of an area is one of many controls affecting the availability of surface and gound water. The excess of precipitation over evapotranspiration in the northeastern part of the United States favors the replenishment of surface-water reservoirs and the recharge of water-bearing for-

[1] Modified from text prepared by State Climatologist, Maryland-Delaware, Environmental Science Service Administration, Weather Bureau.

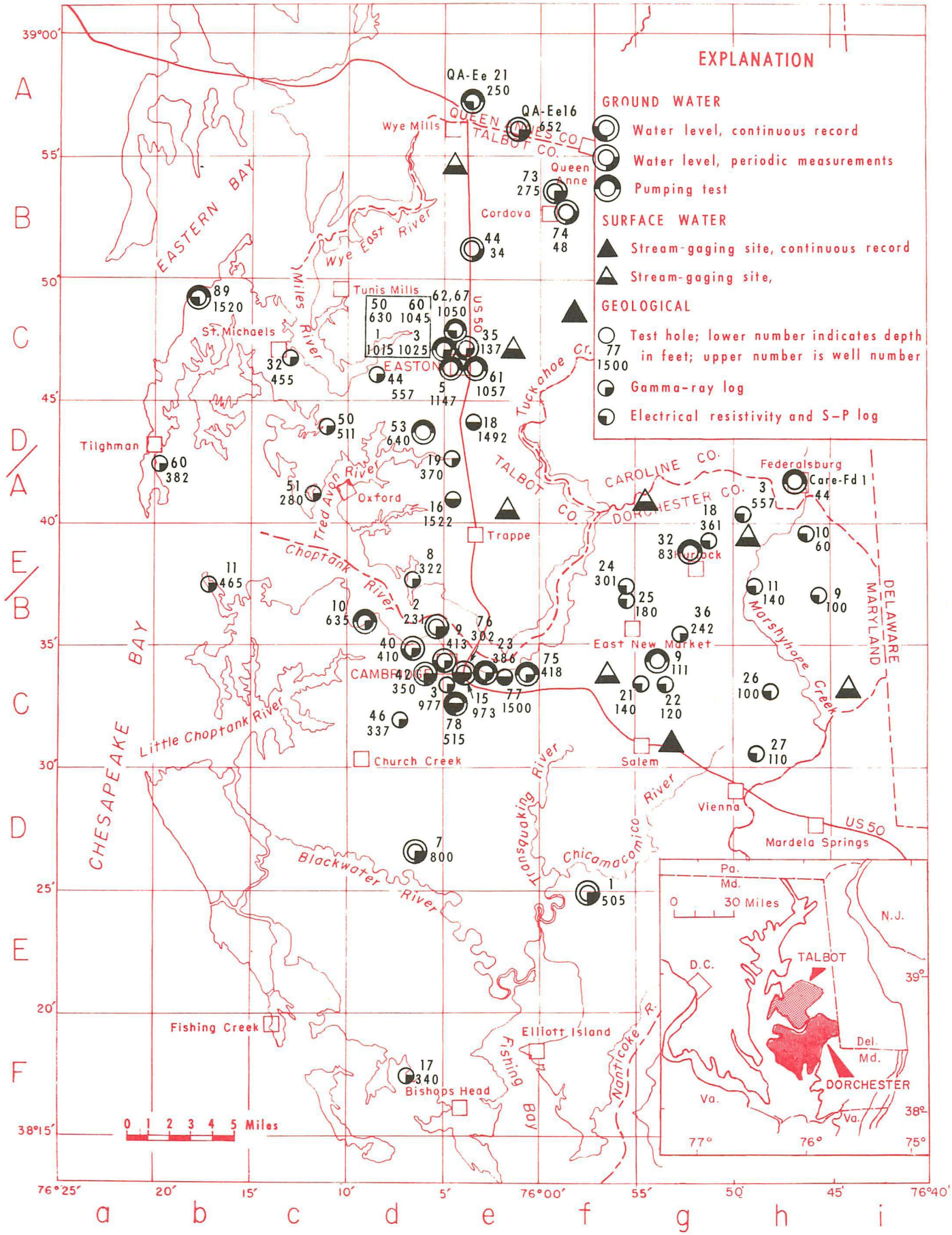


Figure 1—Index map showing location of Dorchester and Talbot Counties and principal data collection sites.

mations. Precipitation occurs throughout the year, but the precipitation during the nongrowing season is most effective in replenishing the shallow ground-water reservoirs. A large proportion of water from summer rains (during the growing season) is returned to the atmosphere almost immediately by evaporation and transpiration.

Dorchester and Talbot Counties have a humid, semicontinental climate. The winters are mild and the summers are rather hot. Spring and fall are the most pleasant seasons.

In this area the prevailing winds are from the west during most of the year, and, therefore, the warming influence of the Atlantic Ocean does not have full effect. Nevertheless, the winds that blow frequently from the east, normally associated with winter storms to the south, bring warmer, moist air off the ocean and tend to make the temperature higher in the winter than for inland areas. The Appalachian Mountains and the waters of Chesapeake Bay also have a moderating effect on the cold air from the northwest. In summer, the temperature of near-shore localities is lowered slightly by cool air from the water.

Average and extreme temperatures are given in figure 2. The hottest month is July. During that month, the average temperature in the shade is in the upper eighties (Fahrenheit) in the afternoon. It can be expected that temperatures will reach about 100°F or 38°Celsius sometime during the summer. A record high of 106°F (41°C) was reported in July 1930. The coldest months are January and February, when the temperature in the early morning averages about 28°F (—2°C). During an average winter, however, the temperature falls to about 7°F (—14°C) on at least one morning. The lowest temperature reported at Cambridge was 6°F below zero (—21°C) in February 1934 and in January 1961.

Cloud cover, wind, and topography affect night temperatures. For example, the difference in elevation may be only 10 to 25 feet from the bottom of a topographic basin to the top of its rim, but, on a clear night, the temperature may be slightly lower in the basin. Also, frost may occur later in spring and earlier in fall in low areas.

Cold air from the northwest and tropical air from the south or southwest account for marked changes in temperature even within a few days. For example, the highest temperature during March 1, 1961, was 41°F (5°C); on March 5 it was 80°F (27°C), and on March 10, 40°F (4°C). Sudden temperature changes are much less

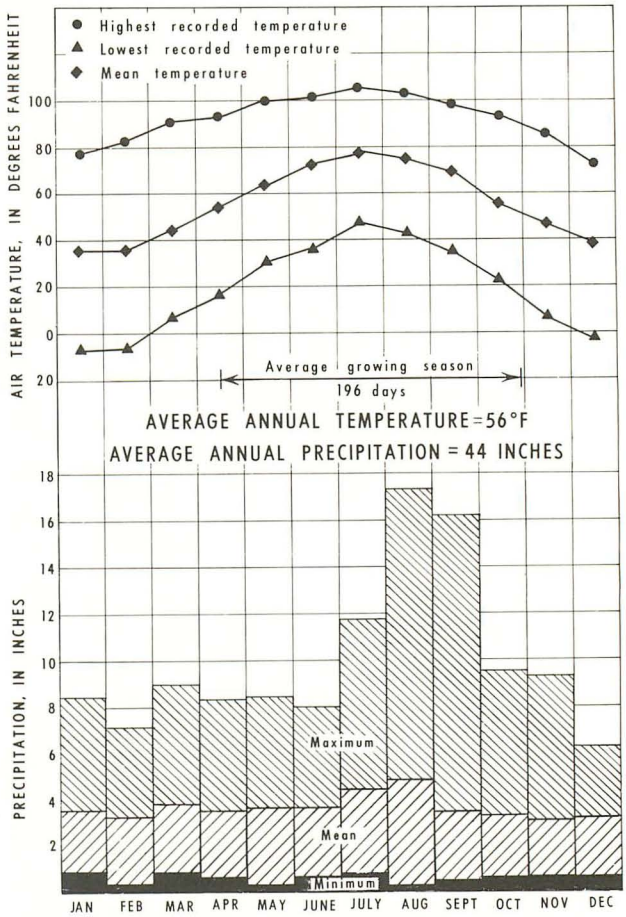


Figure 2—Graphs showing monthly air temperatures and precipitation at Cambridge.

extreme in summer than during other seasons of the year because unmodified polar air seldom reaches the area.

Precipitation is fairly evenly distributed throughout the year. Records of precipitation have been kept for about 65 years at Cambridge. Figure 2 shows the average, maximum, and minimum temperatures and precipitation during that period. Only July and August have an average of more than 4 inches of rainfall. To some extent, this additional rainfall compensates for the greater amount of evaporation during these months.

Rainfall in summer is more variable and less dependable than in winter; as little as 0.25 inch and as much as 17.34 inches have fallen in August. In summer, local thunderstorms are common. Within 2 hours, as much as 2 inches of rain may fall in one area, but a few miles away, only a few drops of rain may fall. General storms cover large areas in winter.

Droughts may occur in any month or season but serious drought is most likely in summer. Although rainfall is generally adequate for good yields of crops, the unequal distribution of the showers in summer and the occasional dry periods make irrigation necessary for maximum yields.

The average annual snowfall is only about 15 inches in Dorchester and Talbot Counties. The amount of snowfall varies greatly from year to year; the range is from only a trace during the winter of 1918–19 to 43 inches in 1904–5. The heaviest snowfall recorded at Cambridge was in January 1922, when 24 inches of snow fell within a 24-hour period and 27½ inches fell within about 36 hours. Snowfall is likely to be heavier in those areas more distant from the bay.

Thunderstorms occur on an average of 30 to 35 days a year; three-fourths of these are in June, July, and August. Once or twice a year, hail may accompany these storms.

Tornadoes seldom occur and in the past have caused little damage. Hurricanes appear about once a year, generally in August or September. Most of them cause only minor damage, but occasionally, the high winds, heavy rains, and high tides from a storm moving up the coast cause widespread damage.

The average velocity of the wind is estimated to be between 8 and 10 miles per hour, but may reach 50 to 60 miles per hour or even higher during severe summer thunderstorms, hurricanes, or common winter storms.

The relative humidity is generally highest in August and September and lowest in winter and early spring. Normally, the relative humidity is highest at sunrise; it is nearly 90 percent in August and September and ranges from 70 percent to 75 percent in winter and in spring. The humidity in the afternoon is about 60 percent in August and September, and it ranges from 50 percent to 55 percent in winter and spring.

Well-Numbering System

The Maryland well-numbering system, which was used in the preparation of this report, groups all wells outside of Baltimore City by counties. A three-letter symbol, derived from the county name, is used as a prefix for each well number. Thus, in this report, Dor- is the prefix for wells in Dorchester County and Tal- is for wells in Talbot County. Each county is divided into 5-minute quadrangles. Each quadrangle, from north to south, is designated by uppercase letters and from west to east by lowercase letters. (See margins of figure 1.) The wells are numbered in each 5-minute quadrangle in the order in which they were inventoried. For example: Tal-Da 1 indicates the first well numbered in the westernmost 5-minute quadrangle in Talbot County.

WATER USE

About 85 mgd of water was used for all purposes in Dorchester and Talbot Counties during 1960. By far the greatest user is the electric power plant at Vienna, which utilized 74 mgd (during 1960) of the water in the tidal Nanticoke River for generating power. However, for all public water supplies and industrial supplies, ground water is used. Pumpage of ground water averaged 10 mgd during 1960. In addition, about 1 mgd of surface water is used for agricultural purposes, mainly irrigation.

The locations of the largest users (public water supplies and canneries) are shown in figure 3. Areas under irrigation in 1966 are also shown in figure 3. A breakdown of water use according to source, type of use, and supplier is given in table 1. Table 1a shows pumpage of ground water by each aquifer in the two counties. For the cities of Cambridge and Easton, graphs of ground-water pumpage are shown in figures 11 and 22, respectively.

The figures given in table 1 were estimated by assuming a per capita usage of 150 gpd (gallons per day) for all areas except Cambridge. An additional 0.7 mgd, which is pumped for industrial purposes, was added to the Cambridge use figure. The per capita usage of 150 gpd includes 100 gpd for domestic purposes and 50 gpd for either industrial or agricultural purposes. The amounts pumped from the individual formations (table 1a)

were computed by dividing the two-county area into districts, multiplying the estimated population of the district by 150 gpd, and assuming values for percentage of water pumped from each formation in the district. The resulting figures were totaled to give the quantity of water pumped from each formation. These figures are approximate and provide only an estimate of water usage.

Water obtained from farm ponds is commonly a mixture of surface water and ground water. Many ponds in the area are commonly dug several feet below the water table and in the strictest sense could be classified as uncased wells of very large diameter.

Table 1. Estimated water use in Dorchester and Talbot Counties in 1960
(in million gallons per day)

Type of use	Type of supply	Dorchester County		Talbot County		Total for project area (mgd)
		Surface water	Ground water	Surface water	Ground water	
Domestic						
	Municipal	0 [1]	1.8	0 [1]	0.8	2.6
	Private	0	1.3	0	1.1	2.4
Total		0	3.1	0	1.9	5.0
Industrial						
	Municipal	0 [1]	.5	0 [1]	.2	.7
	Self-supplied	74.0 [2]	1.5	0	1.6	77.1
Total		74.0	2.0	0	1.8	77.8
Agricultural (some irrigation)	Self-supplied	1.0	1.1	.1	.3	2.5
TOTAL		75	6.2	0.1	4.0	85.3

[1] Water in streams used for transport and dilution of waste is not included.
[2] About 74 mgd taken from the Nanticoke River for cooling at the electric power plant at Vienna.

Table 1a. Summary of average ground-water use by aquifer source, 1960.
(in million gallons per day)

County	Geologic unit [1]					Total
	Pleistocene	St. Marys, Choptank, Calvert	Piney Point	Aquia	Cretaceous	
Dorchester County	1.1	0.6	3.7	0.2	0.6	6.2
Talbot County	.4	.6	1.2	1.0	.8	4.0
Total	1.5	1.2	4.9	1.2	1.4	10.2

[1] Aquifers mentioned here are described in subsequent sections of this report.

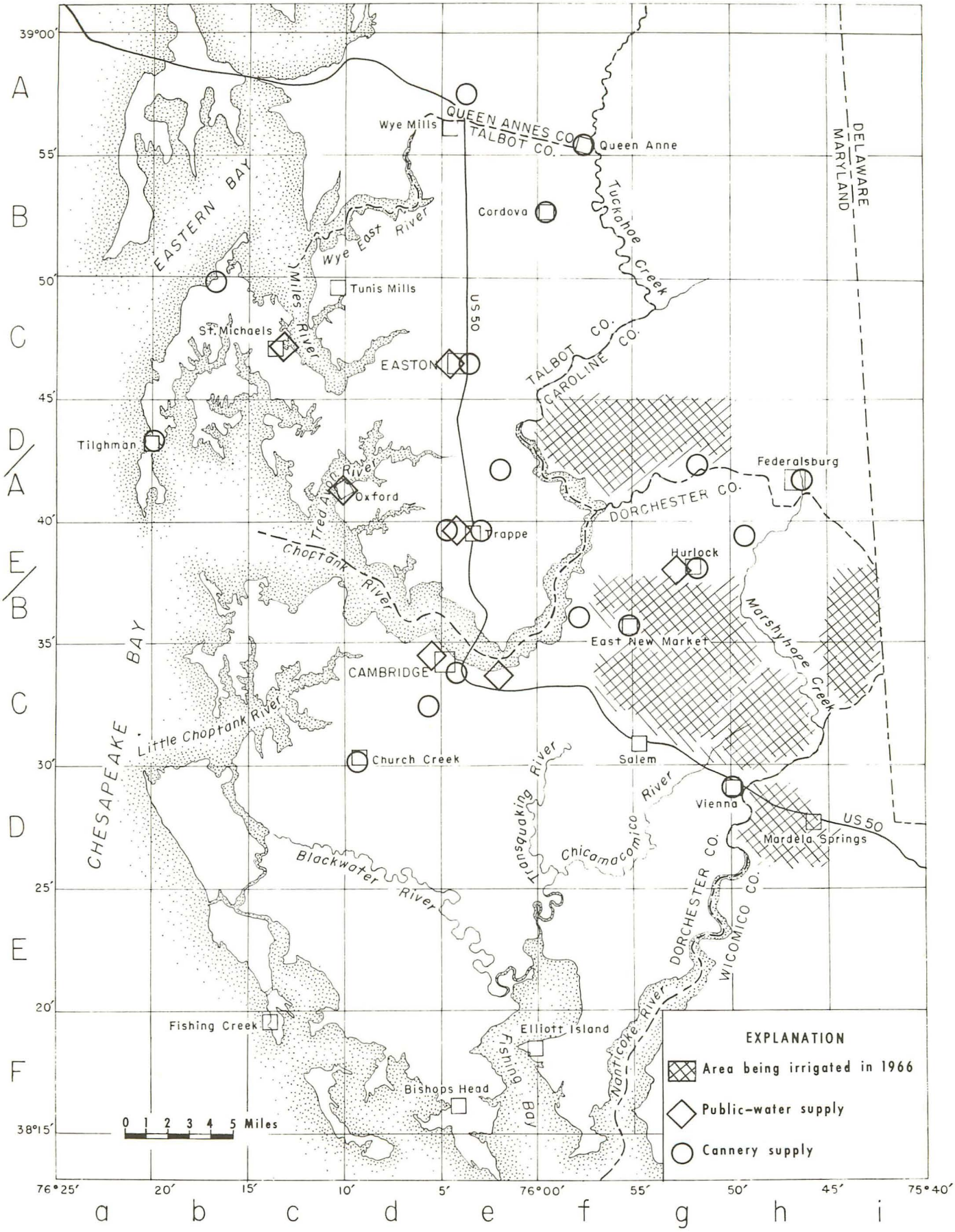


Figure 3—Map showing locations of large water users and type of usage in 1966.

GEOLOGY

Dorchester and Talbot Counties are part of the Atlantic Coastal Plain, a wedge-shaped mass of unconsolidated sedimentary deposits which overlie older hard crystalline rocks. The crystalline rocks, sometimes referred to as the "basement," are igneous and metamorphic rocks of Precambrian or early Paleozoic age. The unconsolidated deposits consist of nearly flat-lying layers of sand, gravel, silt, and clay of Cretaceous to Holocene age. The sand and gravel strata comprise the only important water-bearing sediments.

The crystalline rocks crop out to the northwest of the Fall Line, a line through the major eastern cities of Philadelphia, Wilmington, Baltimore, and Washington. The surface of the crystalline-rock basement slopes below the Coastal Plain sediments from the Fall Line to the southeast at a rate of about 60 to 110 feet per mile (figure 4). At Annapolis, the basement rocks are probably about 1,500 feet below sea level, at Easton they are about 2,700 feet below sea level, and at Cambridge about 3,300 feet. Because adequate supplies of fresh water have been obtained at depths less than 1,000 feet and because the crystalline rocks lie at great depth, crystalline rocks have not been penetrated by drilling in either of the two counties.

The unconsolidated deposits are usually easy to drill and, where exposed, are generally soft enough to be worked with a shovel. The deposits are thinnest in northwestern Talbot County (2,200 feet) and thickest in the southeastern part of Dorchester County (4,200 feet). Most of the layers of clay, silt, sand, and gravel of these deposits crop out in a more or less regular banded sequence trending northeast to southwest. The age of the deposits ranges from Cretaceous, just above the crystalline basement, to Pleistocene or Holocene at land surface. The Cretaceous units make up more than half the section of Coastal Plain sediments underlying the two-county area.

A generalized geologic section southeastward across the Coastal Plain from the Fall Line to Cambridge is shown in figure 4. The section shows that: (1) the depth to crystalline rock increases progressively toward the southeast; (2) the

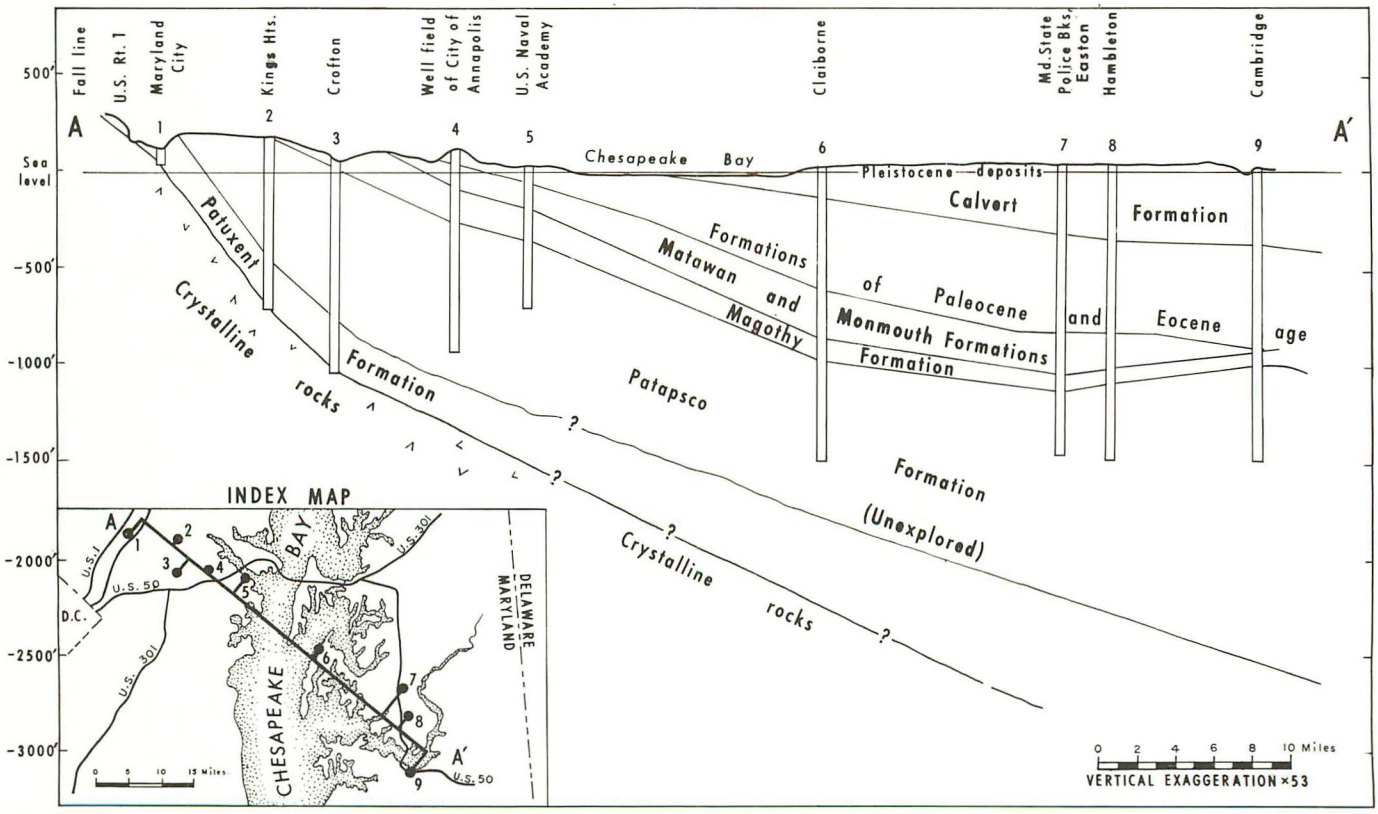


Figure 4—Generalized geologic section from the Fall Line near Laurel to Cambridge, Maryland.

Table 2. Geologic formations and their water-bearing properties in Dorchester and Talbot Counties.[1, 2]

System	Series or Group	Formation (range in depth to top of formation, in feet)		Approximate thickness (feet)	Lithologic character	Water-bearing properties
Quaternary	Holocene	0		0–10	Loam soil, alluvial sand and silt, dune sand and peat.	Provides water to a few shallow wells of small yield.
	Pleistocene [3]	Salisbury Formation	Beaverdam facies	0–100+	Unconsolidated, stratified, lenticular deposits of buff sand and silt, gravel and clay. The deposits contain a few erratic boulders; stabilized dunes; thinly stratified crossbedded channel fill; massive, well-sorted beach sands; and possibly marine sands.	An important aquifer which locally contains the most permeable sands in the area. Highly variable yields ranging up to 1,500 gpm. Transmissibility varies from 95,000 to 175,000 gpd per oot where tested.
			Red gravelly facies	0–45+	Slightly cemented, red, orange, and brown gravelly sand. Locally contains hard ledges, a few inches to 2 feet thick, usually at the base. Occurs chiefly as channel fill.	
Tertiary	Upper and middle Miocene (Chesapeake Group)	Manokin aquifer		0–50	Gray sands with gray or blue clayey silt. Occurs only in the southern end of the area beneath Elliott Island and Bishops Head.	Not known to yield water in this area. The sands lie under a marsh cover, and the water may be of undesirable quality.
		St. Marys Formation		0–110+	Predominantly clayey silt and silty clay with some very fine sand and shells.	An aquiclude. A few wells derive water locally from stringer sands in eastern Dorchester county.
		Choptank Formation		0–130	Gray and brown sand and clay, containing shells.	Yields small to moderate quantities of water to wells in eastern Dorchester County. The water is moderately hard and may be irony.
		Calvert Formation		20–300	Gray diatomaceous silts and clays, containing lenses and thin sheets of gray sand and shell beds.	Largely an aquiclude, but contains two or three aquifers which locally yield large quantities of water at Easton, Federalsburg, Hurlock, and Vienna. The quality ranges from usable for some purposes to usable only for limited purposes.
	Eocene	Piney Point Formation (70–620)		2–191	Olive-green to black quartz sand, slightly to moderately glauconitic, predominantly medium to coarse grained, with some lenses of fine sand, silt, and clay, containing foraminifera.	The most important artesian aquifer in the area, yielding over 3 mgd of ground water in Dorchester County and lower Talbot County. Has yielded 1,200 gpm to an individual well at Cambridge. Transmissibility is 15,000 to 45,000 gpd per foot. The quality of water is suitable for most purposes. The water level has been lowered over 90 feet below sea level at Cambridge in a widespread cone of depression which has extended out into Dorchester County and into Talbot County.
		Nanjemoy Formation (75–510)		0–294	Blackish-green, highly glauconitic sand, silt and clay.	A leaky aquiclude in the northwest: probably a tighter confining formation in the southeast.
	Paleocene	Aquia Formation (250–600)		0–231+	Green glauconitic quartz sand, with a few lenses of clay, containing shell fragments, foraminifera, and hardbeds. Limited to western Talbot County and northwestern Dorchester County with an impermeable boundary passing northeastward through Trappe.	An important aquifer, capable of providing moderate quantities of water to many wells. Transmissibility is from 2,000 to 5,000 gpd per foot at sites tested. Yields of wells vary from about 5 to 250 gpm.

Table 2. Geologic formations and their water-bearing properties in Dorchester and Talbot Counties.[1,2]

System	Series or Group	Formation (range in depth to top of formation, in feet)	Approximate thickness (feet)	Lithologic character	Water-bearing properties
Cretaceous	Upper Cretaceous	Monmouth Formation (450–1,100)	34–230	Dark-green glauconitic sand and lead-gray clay containing shells and foraminifera.	An aquiclude. A small quantity of water is obtained from a few wells at Easton.
		Matawan Formation (650–1,200)	98–176	Black micaceous glauconitic clay and brown glauconitic sand.	An aquifer in Talbot County but an aquiclude in Dorchester County.
		Magothy Formation (650–1,400)	43–139	White, yellow, and gray sand interlaminated with gray and brown shale, containing lignite and carbonaceous matter, but no animal fossils.	An aquifer at Cambridge and Easton. Transmissibility ranges from 6,500 to 15,000 gpd per foot. Yields up to 600 gpm to individual wells.
	Potomac Group	Raritan and Patapsco Formations, undifferentiated (900–1,600)	600–1,700	Intercalated thin sands and shales. The sands are generally gray, fine-grained, micaceous, and lignitic. The shales are mottled pale gray, brown, and red in the upper section and gray-brown in the lower.	An aquifer with transmissibility greater than 16,000 gpd/ft. at Cambridge. Sand beds from 1,100 to 1,500 feet deep in four other test holes are probably aquifers.
		Patuxent Formation (1,600–3,300)	600–800	Not explored in this area, but presumed to be extensively present because of its occurrence in deep oil tests in Wicomico and Worcester Counties, and in the outcrop in Cecil County and on the Western Shore.	A potential aquifer. Water quality is unknown but water temperatures may exceed 100° F and water may be mineralized.
Paleozoic and Precambrian		Crystalline complex (2,200–4,200)	unknown	Not penetrated in Dorchester and Talbot Counties, but presumed to be igneous and metamorphic rocks.	Hard crystalline rocks that contain and transmit very little ground water.

[1] Modified from table 10 (Rasmussen and others, 1957).
[2] Geologic nomenclature used in this report is that of the Maryland Geological Survey and differs somewhat from that of the U.S. Geological Survey.
[3] This term includes those deposits termed Pleistocene and Pliocene (?) by Rasmussen and others, (1957). There may be some deposits of Pliocene age included in this category in some areas.

Coastal Plain sediments lie upon one another in "layer cake fashion," with the youngest formations cropping out progressively to the southeast; and (3) the formations generally thicken to the southeast. Table 2 summarizes the ages, thicknesses, lithologic character, and water-bearing properties of geologic units in the two counties. This table may be used together with the hydrogeologic map in the following section to gain a general idea of the geology and water-bearing properties of the various geologic formations in the area.

Additional geological knowledge of the Coastal Plain sediments was obtained during the study by drilling three exploratory holes to depths of about 1,500 feet. These holes (Tal-De 16, Tal-De 18, and Dor-Ce 77) were drilled to identify and correlate geologic units in the upper 1,000 feet of the section between Cambridge and Easton and to obtain geologic information in the previously unexplored section from 1,000 to 1,500 feet. The lithologic logs are given in the appendix.

Geophysical logs, including resistivity, spontaneous potential, and gamma-ray logs, of the three exploratory holes are shown in figure 5. The figure shows a good correlation between the geophysical logs in the different holes. The lithologic and geophysical logs from the three exploratory holes were used with logs from several other key wells to prepare detailed geologic sections across Dorchester and Talbot Counties.

Figure 6 presents three geologic sections across Dorchester and Talbot Counties showing the general lithologic character of the upper 1,500 feet of Coastal Plain sediments. Section C–C′ is based on geophysical and drillers' logs for holes drilled in

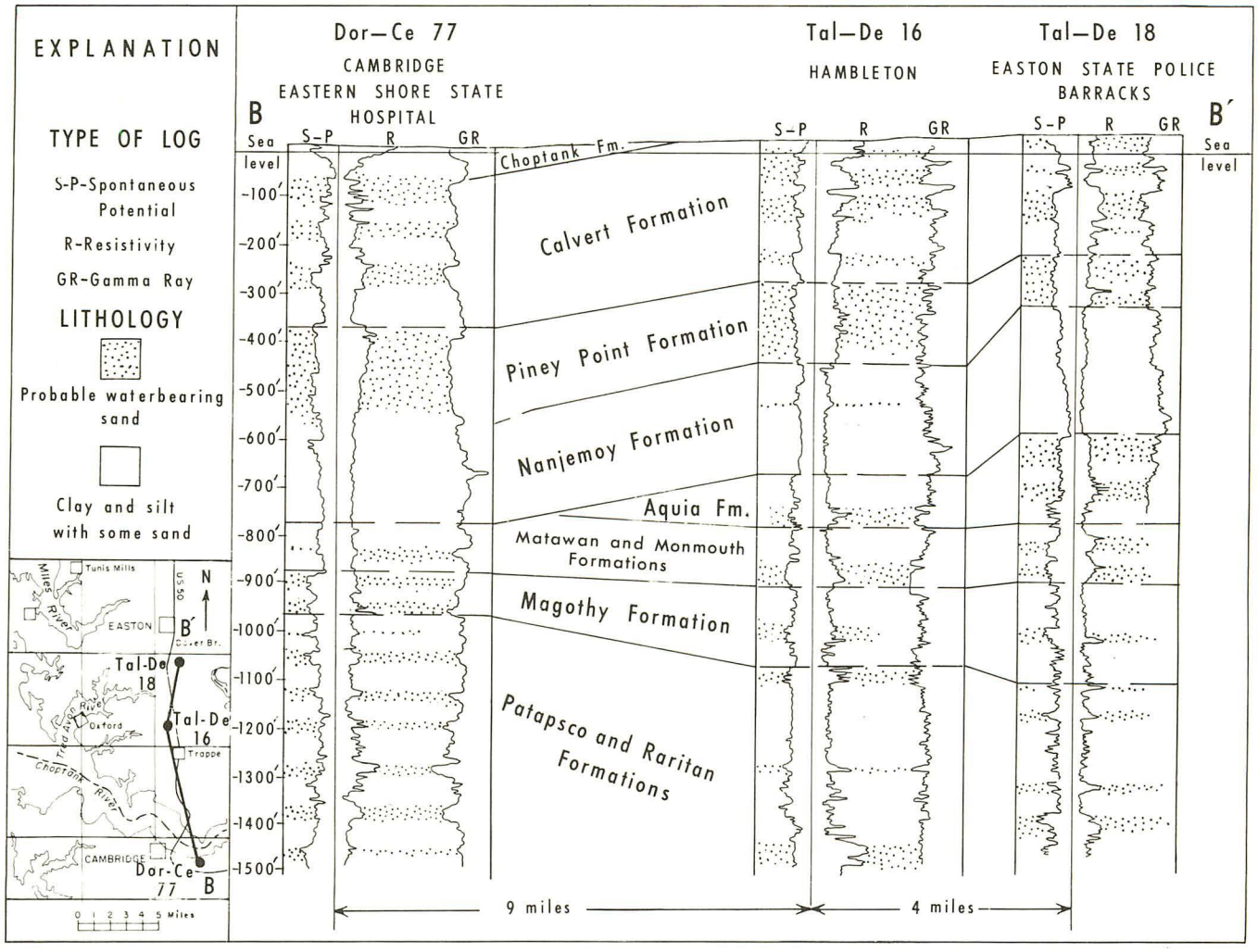


Figure 5—Geophysical and lithologic logs of three 1,500-foot exploratory holes in the Cambridge-Easton area.

part along the line of strike from Queen Anne through Easton, Cambridge, and Church Creek. Sections D–D′ and E–E′, based on logs from holes located along the general direction of dip through Easton and Cambridge, respectively, show the gradual southeast slope of the formations. As may be seen in these sections, sands that are the aquifers comprise only about one-quarter of the section in the upper 1,500 feet of Coastal Plain sediments.

Section C–C′ of figure 6 shows that:

(1) sands occur in the Cretaceous sediments between 1,000 and 1,500 feet. Individual sands have not been correlated between different holes because experience in other parts of the Maryland Coastal Plain has shown that such sands are commonly limited in lateral extent.

(2) sands in the Magothy through the Monmouth Formations occur across the full length of the section.

(3) sands in the Aquia Formation occur in lenticular beds, particularly in the Easton and Queen Anne areas but are completely missing at Cambridge.

(4) sands in the Piney Point Formation are present across the section but are relatively thin in the Easton area.

(5) sands in the Calvert Formation are thickest and probably yield the most water in the vicinity of Easton.

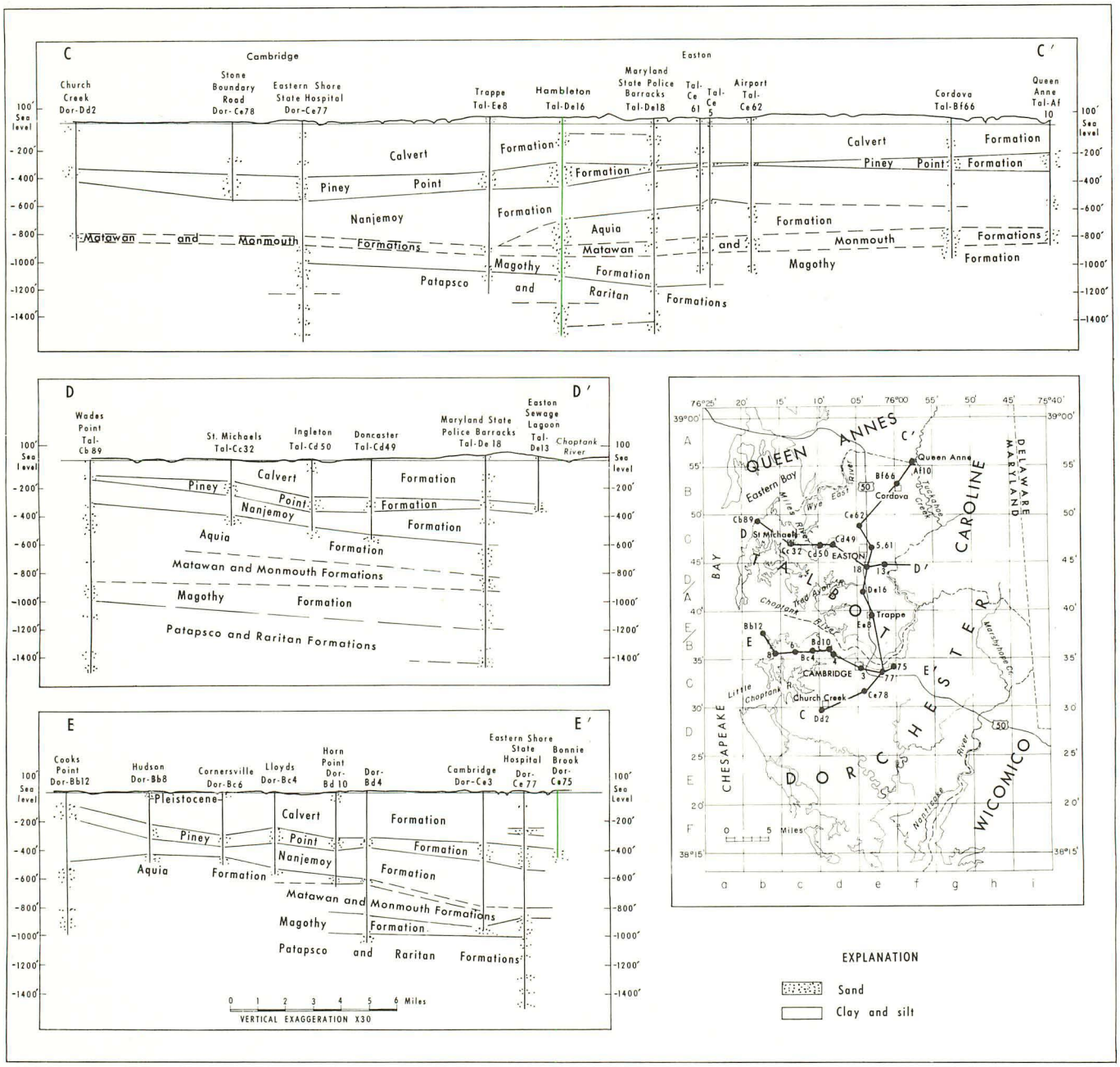


Figure 6—Geologic sections C-C′, D-D′, and E-E′ across Dorchester and Talbot Counties.

Section D–D′ shows that:

(1) several sands occur in the deeper part of the section at the Wades Point well (Tal-Cb 89) and in the deep wells at Easton (Tal-Ce 62 and -De 18).

(2) the Aquia Formation occurs consistently across the section at depths ranging from 300 to 600 feet below sea level.

(3) sands in the Piney Point Formation occur as a thin bed at the Wades Point well in the western part of the section, thicken to more than 100 feet between St. Michaels and Doncaster, and become very thin in Easton. They again thicken to the east of Easton.

(4) sands in the Calvert Formation are too thin and occur at too shallow depths for development of water supplies in the western part of the section but are deep and thick enough to be good aquifers near Easton.

Section E–E′ shows that:

(1) sands occur in the section below 1,100 feet in well Dor-Ce 77, but the lack of additional deep holes precludes any statement regarding their lateral extent.

(2) sands in the Magothy Formation occur in the area between the State Hospital and well Dor-Bd 4, about 4 miles west of Cambridge.

(3) sands in the Aquia Formation occur from the western end of section E–E′ eastward to Horn Point, but pinch out before reaching Cambridge.

(4) sands in the Piney Point Formation occur across the entire length of the section.

(5) sands of the Calvert Formation are limited in lateral extent and hole to hole correlation is difficult.

(6) some sands in the deposits of Pleistocene age extend below sea level and may be subject to intrusion by saline water from adjacent Chesapeake Bay.

The three sections shown in figure 6 represent less than half of the total thickness of the Coastal Plain deposits in the area. The occurrence and extent of water-bearing sands in the lower half of the Coastal Plain sediments remains unknown.

GROUND-WATER RESOURCES

Ground-water supplies nearly all the water presently used (1966) in the area, exclusive of water used for cooling electric power generators, and is expected to continue to do so. This section discusses the availability of ground water from the various geologic units with emphasis on a determination of the quantity of water that can be obtained on a long-term basis. The present and future anticipated water needs are greatest in and around the cities of Cambridge and Easton. Separate sections are included that evaluate the ground-water potentials of each of these cities. A section also describes ground-water availability in northeastern Dorchester County, an area that apparently has the greatest potential for development of large ground-water supplies.

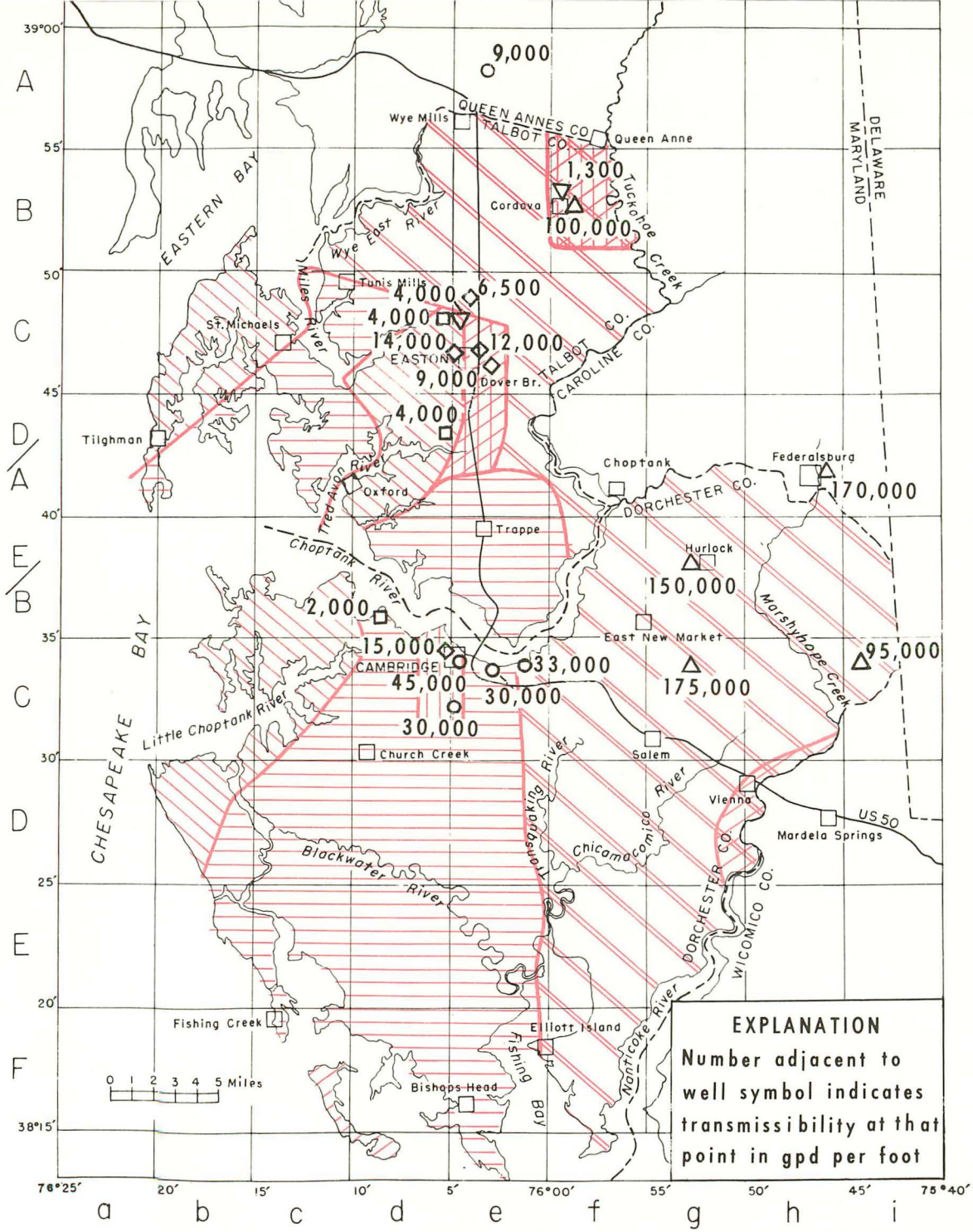
Availability of Ground Water From Geologic Units

The major aquifers in Dorchester and Talbot Counties are sands in the Patapsco, Raritan, Magothy, Matawan, Aquia, Piney Point, and Calvert Formations and in the deposits of Pleistocene age. Some of the water-bearing sands pinch out locally, whereas others are widely distributed and their occurrence is generally predictable. Although each of the major aquifers has its own distinctive water-bearing characteristics, the sands themselves often vary considerably from one place to another in thickness, grain size, mineral content, and permeability.

The geologic character and water-bearing properties of these formations have been described in detail by Rasmussen and Slaughter (1957, p. 33–85). The reader is referred to their work for more detailed information about individual aquifers. This report presents a general description of the principal aquifers, with emphasis on recent findings.

In some places, the aquifers are separated by impermeable confining beds (or aquicludes). In other places, the sands are separated by leaky confining beds (aquitards) and are, therefore, hydraulically connected to some degree. When differences in hydrostatic pressures exist between aquifers, water will leak from one aquifer to another through a leaky confining bed. Thus, the geology of the counties is such that some aquifers function as separate, distinct hydrologic systems, whereas others are interconnected and form more complex systems.

Figure 7 is a hydrogeologic map of Dorchester and Talbot Counties. It shows the principal aquifer being pumped in each area at present (1966). In general, the aquifer used is the shallowest water-bearing formation producing sufficient water of usable quality. However, in some areas more than one aquifer is used. For example, at Easton, the city wells pump water from the Calvert Formation, the Aquia Formation, and the Magothy Formation. Figure 7 also provides a brief description of the water-bearing properties of each



EXPLANATION

PRINCIPAL AQUIFERS

Pleistocene deposits: aquifer consists of blanket of shallow sands and gravel from 40 to 100 feet thick. Yields up to 1500 gpm of water to several wells in northeastern Dorchester County. Transmissibility ranges from 95,000 to 175,000 gpd per foot where tested.

Calvert Formation: aquifer consists of lenses and thin (15 to 20 feet) sheets of gray medium sand containing shell beds within thick beds of silt and clay. Yields up to 200 gpm in one well in Easton. Transmissibility is 4000 gpd per foot at Easton.

Piney Point Formation: aquifer consists of up to 150 feet of medium to coarse olive-green to black, glauconitic sand. Has yielded 1200 gpm to an individual well at Cambridge. Specific capacities range up to 13 gpm per foot of drawdown and transmissibility is 30,000 to 45,000 gpd per foot in the Cambridge area. Water level was 20 feet above sea level when first tapped in 1888. Pumpage to date has created an extensive cone of depression 80 to 90 feet below sea level in the Cambridge area.

Aquia Formation: aquifer consists of layers 5 to 20 feet thick of glauconitic green sand with shell fragments. Transmissibility is from 2000 to 5000 gpd per foot at sites tested. Yields 250 gpm to wells.

Magothy and Matawan Formations: aquifer consists of light gray, fine to coarse sand, 30 to 40 feet thick, at depths of 950 to 1100 feet. Transmissibility ranges from 6500 to 15,000 gpd per foot. Yields of wells range up to 440 gpm.

Figure 7—Hydrogeologic map of Dorchester and Talbot Counties, Maryland.

aquifer, listing such data as transmissibility and the yields of wells. The map may be used as a general guide to the availability of ground water, considering that some of the the deeper aquifers have not been explored or tested to date.

Patapsco and Raritan Formations: The Patapsco and Raritan Formations are not used as sources of water because they occur at depths of 1,000 to 1,500 feet, and adequate supplies have been developed from shallower formations. However, elsewhere in the Maryland Coastal Plain, as at Annapolis and Glen Burnie, the two formations are excellent aquifers.

The Patapsco and Raritan Formations were penetrated by four test holes (Dor-Ce 77, Tal-De 16, Tal-De 18, and Tal-Cb 89 (figure 6)). The logs of these holes disclose the presence of many sands worthy of testing to determine the quantity and quality of water available from them. The individual sands, though relatively limited in extent, may be sufficiently interconnected to form aquifers of local importance. Some individual sands cannot be correlated from one deep test hole to another because the spacing between holes is several miles. The clays in the Patapsco and Raritan are generally red or variegated in color and very tough.

At Easton, test hole Tal-De 18 (figure 5) penetrated three sands that may be aquifers in the previously unexplored interval from 1,100 to 1,500 feet. The thickest sand occurred at a depth of 1,420 to 1,464 feet below land surface, and thinner sands were found at depths of 1,352 to 1,368 feet and 1,210 to 1,219 feet. Geophysical logging indicated that the two thickest sands are probably good aquifers.

Near Cambridge, test hole Dor-Ce 77 (figure 5) penetrated more than 100 feet of sand in the previously unexplored interval in the Patapsco and Raritan Formations, between 1,000 and 1,500 feet. The sand occurs in four beds ranging from 15 to 40 feet in thickness. The upper two beds between 1,010 and 1,215 feet are the thinnest. Electric logging of this interval indicates that these sands contain fresh water. Testing of a well drilled by the city of Cambridge in 1971 showed that sands between 1,270 and 1,350 feet have a transmissibility of over 16,000 gpd/ft. and contain fresh water.

Magothy Formation: For the purpose of this report, the Magothy Formation is grouped with the overlying Matawan and Monmouth Formations, as it is difficult to differentiate the three formations in most drill holes, especially in the northern part of the area.

The Magothy occurs throughout an extensive area, but its sands differ greatly in permeability. In most drill holes, the sands are medium- to-coarse-grained and occur in beds from 20 to 50 feet thick. The top of the formation is found at about 900 feet below sea level in the Cambridge area and at about 1,000 feet below sea level at Easton. A contour map showing the approximate depth to the top of the uppermost water-bearing sand in the Magothy Formation is presented in the report by Rasmussen and Slaughter (1957).

The Magothy is the deepest formation currently (1966) yielding water in Dorchester and Talbot Counties. Sands of the Magothy Formation constitute one of the most productive aquifers in Maryland, especially in the Annapolis area. The water-bearing properties of the formation may be summarized as follows:

(1) The Magothy yields water from permeable water-bearing sands that are lenticular and that may be either isolated or interconnected.

(2) Transmissibility ranges from 6,500 to 15,000 gpd per foot.

(3) Wells completed in the Magothy generally have a large available drawdown because of the relatively shallow static water levels and great depth to the top of the formation (900 to 1,150 feet).

Thus, large additional quantities of water are available from the Magothy Formation by lowering water levels. The limit of this development will probably be at the top of the formation, since lowering water levels below this level will decrease the yield. Pumping water from depths of 800 to 1,000 feet will demand more power, longer pump columns, and will result in greater cost per gallon than the present pumping from shallow levels.

Pumping tests indicate the transmissibility of the sands in the Magothy at Easton and the Cambridge is about 8,000 gpd per foot. In Dorchester County the Magothy is the source of water for some domestic supplies in the vicinity of Church Creek and for one well at Horn Point. Attempts were made to develop a second well in the Magothy Formation about half a mile east of the well at Horn Point, but they were unsuccessful, indicating that the sand in the formation is absent there. A well, Tal-Bf 66, drilled for Esskay Poultry Plant at Cordova in 1947, yielded 210 gpm from the Magothy Formation for 24 hours with 185 feet of drawdown during its acceptance test. Evidence that the sands in the Magothy are interconnected lies in the fact that water levels in these wells, where measured, are at similar depths below sea level. However, some sands may be

lens-shaped, small in areal extent, and enclosed by clay beds. Such beds would receive little or no recharge and, during long periods of heavy pumping, might be pumped to the limit of recovery. Well Tal-Ce 5 at Easton taps a sand that is probably an isolated lens. It has been reported that water levels in this well declined more rapidly and recovered more slowly than would be expected if the sand were hydraulically connected to other sands.

As of 1966, six wells and one test hole have been completed in the Magothy and the overlying Matawan and Monmouth Formations in the Easton area. Each test hole penetrated usable thicknesses of water-bearing sands in the zone between 1,000 and 1,150 feet below sea level. Aquifer tests show that the sands have coefficients of transmissibility ranging from 6,500 to 14,000 gpd per foot and averaging about 10,000 gpd per foot. The sands in these formations are probably the best sources of water in the Easton area.

Two wells, Tal-Ce 61 and -67, are multiple-screened and yield water from a sand at 1,000 feet and from a sand between 800 and 900 feet. The upper sand may be in the Monmouth Formation. Another well, Tal-Ce 60, taps the 1,000-foot sand in the Magothy.

Three wells, Dor-Ce 1, -Ce 3, and -Ce 15 have been completed in the Magothy Formation at Cambridge. Data for these and other wells are listed in table 6. An aquifer test of the Magothy was made in 1958 by E. G. Otton of the U.S. Geological Survey. The test consisted of pumping Dor-Ce 3 at 290 gpm for 12 hours and observing the effect of the pumping on water levels, both in Dor-Ce 3 and in observation well Dor-Ce 15 located 2,250 feet to the northwest. The water level in Dor-Ce 15 was lowered 4.24 feet by this pumping. Computations of the test results indicated the transmissibility of the Magothy Formation at Dor-Ce 3 is about 8,000 gpd per foot and at Dor-Ce 15 is about 15,000 gpd per foot.

The initial well tapping the Magothy at Cambridge, Dor-Ce 1, was drilled in 1945 by the Crystal Ice and Storage Co. At the time it was completed, the static water level was 11 feet above land surface or 29 feet above sea level. This well and Dor-Ce 3, have been pumped almost continuously since they were completed. At present (1966) the water level in the Magothy Formation at Cambridge, as measured in observation well Dor-Ce 15, is 25 to 30 feet below sea level. This represents a total drawdown of 50 to 60 feet, which is caused by the combined pumpage of about 400 gpm from wells Dor-Ce 1 and -Ce 3.

Aquia Formation: The Aquia Formation is a green, glauconitic quartz sand. It also contains a few clay layers, shell fragments, Foraminifera, and hard crusty (cemented) beds. Fossils in the formation attest to its marine origin. The water-bearing sands are about 40 to 65 feet thick.

Within the area, the Aquia is an aquifer only in western Talbot County and northwestern Dorchester County. Because an impermeable boundary passes northeastward through Trappe the Aquia contains no water-bearing sands at Cambridge. (See plate 8 in Rasmussen and Slaughter, 1957.) Most of the recharge to the Aquia occurs in the outcrop area on the western shore of Chesapeake Bay along a narrow band, which strikes northeastward through Annapolis, about 27 miles from Easton.

The Aquia Formation is the primary source of water in: (1) the northwestern part of Dorchester County; (2) an area southwest of Easton (including the Bailey's Neck and Oxford Neck areas), and (3) parts of the St. Michaels-Tilghman Neck area (figure 7). The aquifer is used extensively in the northwestern part of Dorchester County because its water levels are still relatively high as compared with water levels in the overlying Piney Point Formation. Many homeowners, when given a choice of drilling either a relatively shallow and less expensive Piney Point well with a rather deep water level or a deeper, more expensive Aquia well with a shallower water level, choose the deeper Aquia well in order to obtain the shallow water levels. The Aquia Formation is used more as a source of water in the area southwest of Easton because the Piney Point Formation is not as productive in that area as is the Aquia.

Water pumped from the Aquia Formation is used mainly for domestic purposes, much of it being pumped from small-capacity wells at rural homes. However, well Tal-Ce 50, an important producer for the city of Easton, pumps at 250 gpm and averages about 60,000 gpd.

Aquifer characteristics of the Aquia Formation were determined by pumping tests at three locations (table 3). The transmissibility is relatively low, ranging from 2,000 gpd per foot in northern Dorchester County to about 5,000 gpd per foot at Easton. The permeability is also low, ranging from 45 to 79 gpd per square foot. The storage coefficient of 0.0002, determined at one site, is typical of artesian aquifers.

Table 3. Transmissibility, permeability, and storage coefficients of sands in the Aquia Formation.

Location and owner	Coefficient of transmissibility (gpd/ft) T	Effective sand thickness (feet) M	Field coefficient of permeability (gpd/ft ^{2}) P_f	Coefficient of storage S	Length of drawdown phase of test (minutes)	Screen position referred to sea level (feet)	U.S.G.S. well number
Horn Point Allen Evans	2,000	43	45	--	300	−618 to −638	Dor-Bd 10
Easton Easton Utilities Commission	5,000	63	79	--	375	−545 to −578	Tal-Ce 50
Bailey's Neck Talbot Country Club	4,000	54	74	0.0002	572	−571 to −621	Tal-Dd 53

At Easton the Aquia lies 550 to 620 feet below sea level. The original static water level was at least a few feet above sea level, and thus about 550 feet of drawdown was available to the first wells completed in the formation. The Aquia is capable of supplying moderately large quantities of water in the Easton area in spite of its low transmissibility.

Piney Point Formation: The Piney Point Formation, the most important artesian aquifer in the area, provides most of the ground water used in the vicinity of Cambridge and much of the water used in Talbot County. The formation was deposited in a marine environment similar to that in which the Aquia Formation was deposited. The two formations are similar and are distinguished from one another in the field more by position in the geologic column than by lithologic characteristics. The Piney Point is generally an olive-green to black slightly glauconitic quartz sand and is predominantly medium- to coarse-grained. It contains some lenses of fine sand, silt, and clay, and Foraminifera. Earlier studies indicate that the Piney Point Formation pinches out toward the northwest before reaching the land surface. Because the Piney Point does not crop out, it cannot be recharged directly by precipitation, and all fresh water in it must be derived from leakage through adjacent beds. The source of water in the Piney Point is not definitely known, but it is probably derived from both lateral and vertical leakage. In its updip direction, the Piney Point becomes hydrologically connected with the underlying Nanjemoy Formation, which is an aquifer on the western shore of Chesapeake Bay. Thus, some water may move laterally into the Piney Point from the Nanjemoy. The thickness of water-bearing sands in the Piney Point is variable, ranging from a few feet to more than 160 feet.

Coefficients of transmissibility, permeability, and storage, as computed from eight aquifer tests, are listed in table 4. The transmissibility is moderately high, ranging from 9,000 to 45,000 gpd per foot. The permeability ranges from about 170 to 500 gpd per foot, which is typical of aquifers containing fine to coarse sands. The low values for coefficient of storage, 0.0002 to 0.0004, indicate artesian conditions.

Sands in the Piney Point at a depth of 300 to 375 feet below sea level produce much of the water used for domestic and agricultural purposes in rural areas surrounding Easton. These sands appear to be correlative with sands identified as the Piney Point Formation in southern Talbot County and in the Cambridge area.

Currently, no wells at Easton are producing water from the Piney Point because of the desire of the city to leave the aquifer available for users in the surrounding area, and because the formation appears to be incapable of furnishing large supplies of water. Drillers' logs show that in the Easton area, and as far south as Oxford Neck, the formation contains mostly silt and clay and few permeable water-bearing sands.

The Piney Point Formation is the main source of water for Cambridge. The formation occurs

Table 4. Transmissibility, permeability, and storage coefficients of the Piney Point Formation.

Location	Coefficient of transmissibility (gpd/ft) T	Effective sand thickness (feet) M	Field coefficient of permeability (gpd/ft [2]) P_f	Coefficient of storage S	Length of drawdown phase of test (minutes)	Screen position referred to sea level (feet)	U.S.G.S. well number
Cambridge Glasgow St.	30,000	100	300	--	138	−320 to −390 --	Dor-Cd 43 [3] Dor-Cd 44 [4]
Cambridge Washington St.	45,000	150 [1]	300 [1]	--	525	−347 to −397 −348 to −354 [2]	Dor-Ce 2 [3] Dor-Ce 4 [4]
Cambridge Eastern Shore State Hospital	30,000	160	185	--	240	Open hole do.	Dor-Ce 21 [4] Dor-Ce 22 [3]
Cambridge Bonnie Brook	35,000	100 [1]	350	--	240	−388 to −409	Dor-Ce 75 [3]
Cambridge Stone Boundary Rd.	25,000 30,000	147 150	170 200	.00037	2,895 2,895	−344 to −484	Dor-Ce 78 [3] Dor-Ce 79 [4]
Wye Station Queen Annes Co. Friel Cannery	9,000	52	173	.00016	300	−142 to −194	QA-Ee 21 [4]
Dover Air Base Delaware	39,000 [5]	--	--	.00027 [5]	1,420	−337 to −367	Je 32-4 [2] Je 32-5 [3]

[1] Estimated
[2] Open hole
[3] Pumped well
[4] Observation well
[5] Sundstrom and Pickett, 1968

from about 350 to 500 feet below sea level (figure 13). Geophysical logs indicate that it grades upward from a relatively impermeable silty clay at the base to a permeable sand near the top (figure 5).

Most wells owned by the city of Cambridge are pumped from 350 to 600 gpm. The newest well in the system, Dor-Ce 78, was pumped at 1,200 gpm for 48 hours with 106 feet of drawdown during its acceptance test.

Water levels in the Piney Point Formation have been lowered extensively in the study area. A large cone of depression, centered at Cambridge where pumpage from the formation is greatest, extends over a large part of the two-county area. This cone was mapped by Rasmussen and Slaughter (1957), and an updated map for the Cambridge area (figure 16) was prepared for this report. The effects of pumpage from the Piney Point are discussed in detail in the later section on the availability of ground water in the Cambridge area.

Calvert Formation: The Calvert Formation consists of gray diatomaceous silts and clays with interspersed thin lenticular sands. The sands are fine- to medium-grained, silty, and commonly contain associated shell fragments. The formation crops out in Calvert County on the western side of Chesapeake Bay and dips southeastward beneath the Bay. At Easton the top of the Calvert is 50 feet below sea level, and in southeastern Dorchester County it is 250 feet below sea level. The average thickness of the formation beneath Dorchester and Talbot Counties is about 200 feet.

In general the Calvert may be considered as a confining bed, but locally the sands are aquifers. Much of the water pumped from wells in eastern

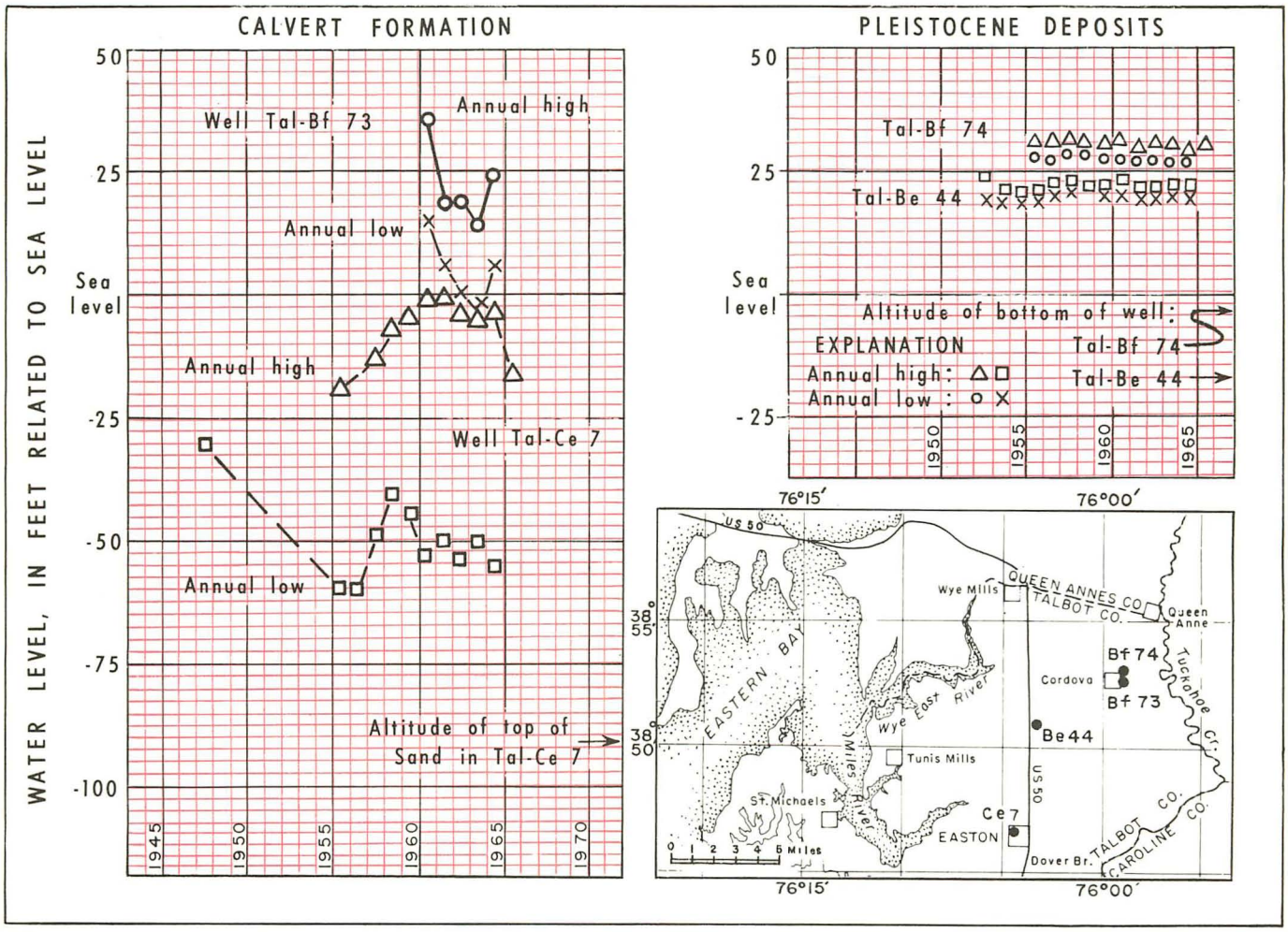


Figure 8—Graphs showing water-levels in the Calvert Formation and Pleistocene deposits in northern Talbot County.

Talbot and Dorchester Counties is from these sands. The yields of wells are moderate and their depths are shallow (less than 200 feet deep). The transmissibility is moderately low (3,500 gpd per foot) and the storage coefficient of 0.0001 at the one site tested at Easton is typical of an artesian aquifer. The combination of moderately low transmissibility and small available drawdown limits the water-yielding capacity of the Calvert.

At Easton, the earliest ground-water supplies were developed from shallow (100-foot) wells tapping sands in the Calvert Formation. Six public-supply wells yielded 75 gpm in 1896, according to Darton (1896, p. 133). At present (1966), one city well, Tal-Ce 2, is being pumped at an average of 82,000 gpd. However, some of the water pumped from well Tal-Ce 2 may be coming from sands of Cretaceous age. Two other wells in the Calvert, Tal-Ce 9 and -Ce 10, at the Tidewater Inn, pump water for air-conditioning. At the time of their completion in 1946, each of these wells was tested individually at 200 gpm for 6.5 hours, with a drawdown of 48 feet. Because they supply water for cooling purposes, these wells are not used in the winter. Ten to fifteen additional wells were completed in the Calvert Formation on the eastern side of Easton between 1964 and 1967.

It is likely that much of the water pumped from the Calvert Formation in the Easton area is derived by downward leakage through the overlying Choptank Formation.

Water-level fluctuations for two wells in the Calvert Formation, Tal-Bf 73 and Tal-Ce 7, are shown in figure 8. No long-term decline in water levels is evident from the figure. However, the

Table 5. Transmissibility, permeability, and storage coefficients of the deposits of Pleistocene age.

Location and owner	Coefficient of transmissibility (gpd/ft) T	Effective sand thickness (feet) M	Field coefficient of permeability (gpd/ft [2]) P_f	Coefficient of storage S	Length of drawdown phase of test (minutes)	Screen position referred to sea level (feet)	U.S.G.S. well number
Hurlock American Stores	150,000 [3]	96	1,500	0.0005	2,760	−26 to −43 −45 to −50	Dor-Bg 32 [1] Dor-Bg 33 [2]
Galestown William Altvater	95,000	62	1,500	.0001	307	+14 to −42	Dor-Ci 3 [1] Dor-Ci 5 [2]
East New Market Norman Messick	175,000	100	1,750	--	300	+ 6 to −74	Dor-Cg 9 [1]
Cordova Schluderberg-Kurdle Co.	100,000 [3]	38	2,600	.0006	2,502	+11 to −10 − 1 to − 6	Tal-Bf 72 [1] Tal-Bf 74 [2]
Federalsburg Town of Federalsburg	170,000 [3]	46	3,700	.15	720	+15 to − 9	Care-Fd 1 [1] Care-Fd 2 [2]

[1] Pumped well
[2] Observation well
[3] From Rasmussen and Slaughter, 1957, p. 102–105

water level in one well, Tal-Ce 7, has been below sea level for the past 10 years.

In the Cambridge area, a few wells yield water from shell beds in the Calvert Formation. The water is reportedly of poor quality, and for this reason most drillers attempt to seal off the Calvert strata when constructing wells into the deeper Piney Point Formation. One well, several hundred feet from Cambridge Creek, was observed in 1965 to contain water with high chloride content. Probably saline water from the creek reached the Calvert Formation by way of one or more nearby abandoned wells. Steps have been taken to prevent further contamination of the water in the Calvert by grouting the abandoned wells.

In northeastern Dorchester County, water-bearing sands in the Calvert are found at depths of 280 to 330 feet below sea level. A few wells yield water from the Calvert, particularly where the overlying Pleistocene sands are not productive.

Deposits of Pleistocene Age: Large areas in Talbot and Dorchester Counties are underlain by substantial thicknesses of very permeable sands and gravels of probable Pleistocene age, capable of yielding large quantities of water to wells. The deposits consist of two lithologic types: (1) slightly cemented red, orange, and brown gravelly sands, and (2) uncemented, stratified, lenticular buff-colored sands and silts with minor amounts of gravel and clay. The reddish-brown gravelly sands were tentatively designated as being Pliocene in age by Rasmussen and Slaughter (1957, p. 78–80). However, more recent work by Hansen (1966, p. 8–16) suggests that the two lithologic types are closely related in age, and Hansen classifies both units as Pleistocene. This report follows Hansen's terminology and groups the two lithologic types under the general heading of deposits of Pleistocene age.

The thickness of the Pleistocene ranges from a few feet to more than 150 feet.

Aquifer tests indicate that the deposits of Pleistocene age are characterized by high permeability and transmissibility (table 5). The coefficient of permeability ranges from 1,500 to 3,700 gpd per square foot which is in the range for coarse sands. The high values for coefficient of transmissibility (95,000 to 175,000 gpd per foot) indicate that large

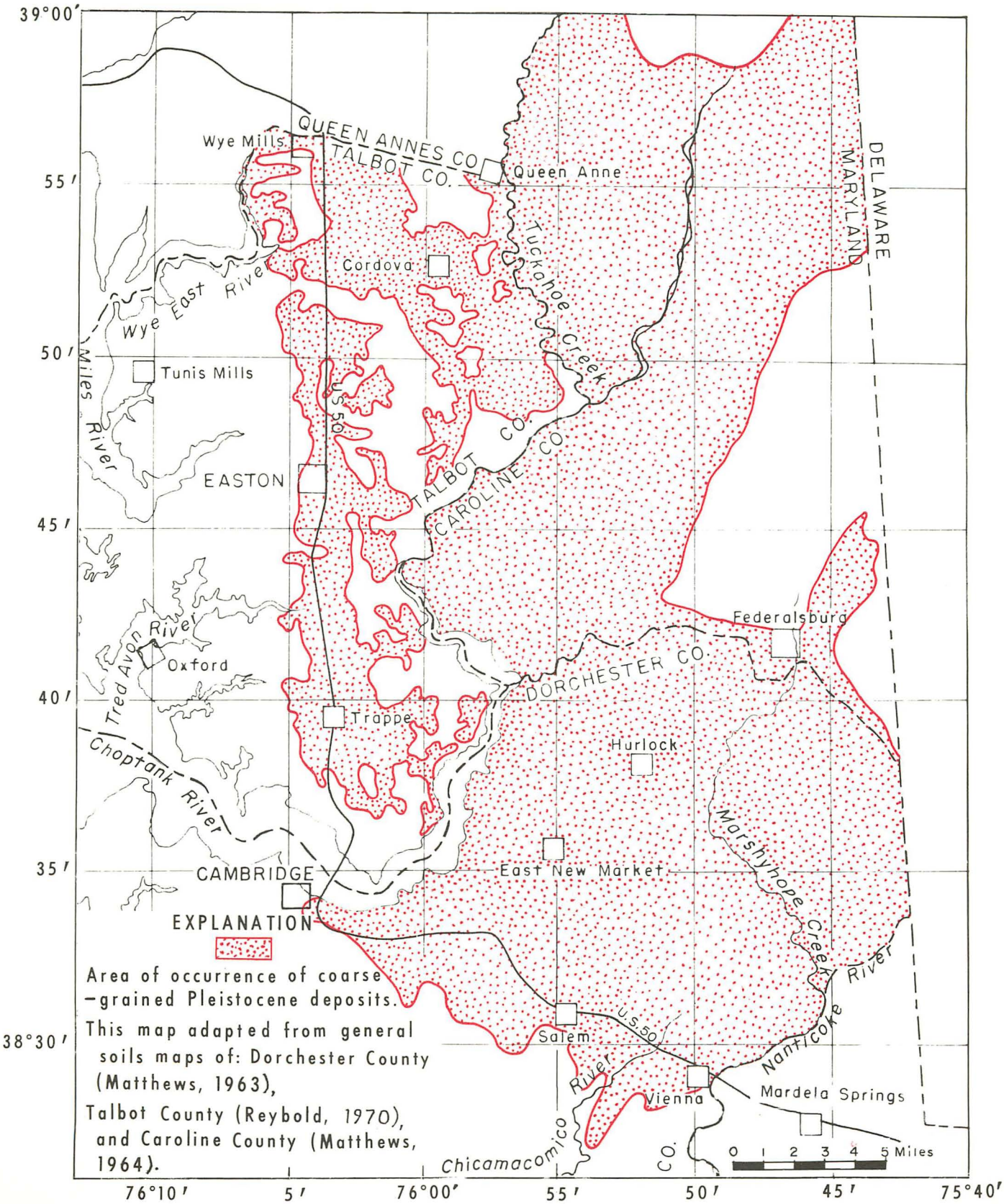


Figure 9—Map showing distribution of coarse-grained Pleistocene deposits.

amounts of water may be obtained from wells where sufficient available drawdown exists. Both artesian and water-table conditions occur in these deposits, as indicated by the artesian storage coefficients (0.0001 to 0.0006) at three sites and the water-table storage coefficient (0.15) at one site.

Figure 9 is a map showing the areal extent of the Pleistocene deposits. It is based on published soil maps prepared by the U.S. Department of Agriculture, Soil Conservation Service (Matthews, 1963 and 1964, and Reybold, 1970), which show the extent of coarse-grained soils in Talbot and Dorchester Counties. The deposits of Pleistocene age are not good aquifers in all the area shown in figure 9. In some places they are too thin, and in other places, where they are thicker, they are capable of yielding little water to wells because they are too well drained and the water table is too deep. However, moderately thick sections of saturated sands blanket much of northeastern Dorchester County and form the most productive aquifer there. These coarse-grained sands fill a rather deep trough in older fine-grained sediments, their base being about 80 feet below sea level. (See figure 26.) Because the water table is generally about 30 feet above sea level, drawdown available to some wells completed in these deposits is as much as 110 feet.

At Cordova in Talbot County an aquifer test indicated a high transmissibility (100,000 gpd per foot) for the deposits of Pleistocene age. However, the deposits near Cordova are of irregular distribution and have not been traced laterally any great distance (figure 9). In addition, the deposits are thin and thus have limited available drawdown in wells. (See bottom of wells Tal-Bf 74 and -Be 44 in figure 8.)

Figure 9 shows that there is a north-south strip of these deposits across Talbot County, straddling the right-of-way of U.S. Highway 50. However, no high-yielding wells have been developed along this strip to date (1966).

Water-level fluctuations have been observed for several years in two wells tapping these aquifers in northern Talbot County. Figure 8 is a graph showing annual highest and lowest measured levels in these wells. Water levels in these wells fluctuate less than 5 feet in any year and change little from year to year. Water levels in the deposits of Pleistocene age are not affected by pumping from nearby wells in the deeper Calvert Formation. For example, the water level in well Tal-Bf 74 showed no change while the pumping level in well Tal-Bf 73 (in the Calvert about 13 feet away) fluctuated from 35 feet above sea level to 5 feet below.

Availability of Ground Water from Selected Areas

Future demands for water are expected to be greatest in and around the cities of Cambridge and Easton. Thus, special efforts have been made to evaluate the potential for developing ground-water supplies in and near the two cities. However, the area with greatest ground-water potential may be northeastern Dorchester County, where large supplies of good quality water are available from the deposits of Pleistocene age at shallow depth.

This section describes the current utilization of water and presents a quantitative appraisal of the ground-water potential for Cambridge, Easton, and northeastern Dorchester County.

Cambridge Area

The city of Cambridge, the county seat of Dorchester County, is on the south bank of the Choptank River (figure 1). It is an inland port city, serving as a harbor for many small craft on Cambridge Creek and for ocean vessels at newly constructed pier facilities on the Choptank River. Cambridge has served as a food processing center for many years, both for canning produce and poultry grown locally and for canning frozen sea food shipped in from other parts of the world. The population of Cambridge in 1960 was 12,239.

Current Use of Ground Water and Estimated Future Requirements: Cambridge is dependent on ground water as a source of industrial, private, and municipal water supplies. The few streams in the vicinity occupy broad drainage basins of low relief, affording little opportunity for the construction of suitable surface impoundments. Furthermore, some of the streams contain brackish water in their lower and middle reaches. (See section on surface-water resources.)

As of 1966, wells tapping the Piney Point and Magothy Formations have supplied the water used in Cambridge. The Piney Point has been the main source of water, and the deeper Magothy wells have been used only in recent years.

The first wells were drilled into the Piney Point Formation at Cambridge in 1888. The quantity of water pumped from the aquifer from 1888 to 1932 is not known, but from 1932 through 1965 the pumpage gradually increased from a reported average of 1.1 mgd to about 2.8 mgd. Beginning in 1945, additional water was obtained from the Magothy Formation. By 1965 the total pumpage was 3.5 mgd, of which about 0.7 mgd (20 percent) was from the Magothy Formation, and the remaining 2.8 mgd (80 percent) was from the Piney Point Formation. The average daily pumpage from the two formations from 1932 to 1966 is shown in figure 10. As can be seen in the bar graph, the proportion of water being pumped from the Magothy has increased slightly in recent years.

The pattern of water use at Cambridge has changed recently, as shown in figure 11, in which the average daily pumpage for each month from 1954 to 1966 is given. During the first 4 years shown on the graph, total water pumped by both the municipal and industrial users ranged from 6 mgd to 2 mgd. These wide seasonal ranges reflect the large quantities of water pumped by canneries during summer months and periods of inactivity during winter months. During some periods, the canneries pumped about half as much water as was pumped by the city. In 1959, pumpage by the canneries was reduced, and by 1960 the total water pumped was lower than it had been in the preceding 10 years. Since 1960, pumpage has been increasing gradually with the city pumping a larger proportion of the total water used. The more evenly distributed pattern of pumping since 1960 results from the transition in the city's economy from seasonal industries to year-round industries.

Extrapolation of population projections by Werner and Dyer (1963) suggests that the population of Cambridge will be about 23,000 by the year 2000. Anticipated ground-water pumpage is difficult to predict because there is no distinct trend of increasing pumpage in recent years. In fact, pumpage rates have not changed significantly in the past 15 years, as shown in figures 10 and 11. However, it seems likely that if the population doubles by the year 2000, the rate of pumping will at least double the 1966 rate of 3.5 mgd to about 7 mgd in 2000. Increases or decreases in the amount of water used by canneries or new industries would, of course, modify this figure.

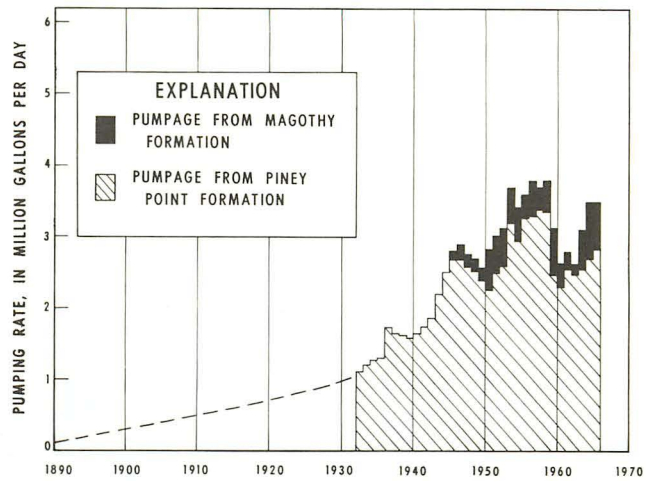


Figure 10—Average daily pumpage from the Piney Point and Magothy Formations at Cambridge.

The high-capacity wells in Dorchester County, including the municipal supply wells at Cambridge and wells used by food-processing industries in the Cambridge area are listed in table 6. The table summarizes pertinent details such as well construction, depth, aquifer, yield, water levels, and pumping test data. The locations of these wells are shown in figure 12.

Quantitative Appraisal of Aquifers: The Coastal Plain sediments are about 3,300 feet thick at Cambridge. However, only the upper 1,500 feet of the sediments have been penetrated by test drilling. Little is known about the geologic or water-bearing characteristics of the sediments between 1,500 feet and the crystalline basement rocks believed to occur at about 3,300 feet. A geologic section of the upper 1,500 feet of the Coastal Plain deposits at Cambridge is shown in figure 13. The section is based on lithologic and geophysical logs of test hole Dor-Ce 77. Also shown in the figure are the hydraulic characteristics of the aquifers and the chemical character of the ground water. The stratigraphic relationship of the sediments underlying Cambridge to those elsewhere in Dorchester and Talbot Counties is shown in figure 6, discussed previously.

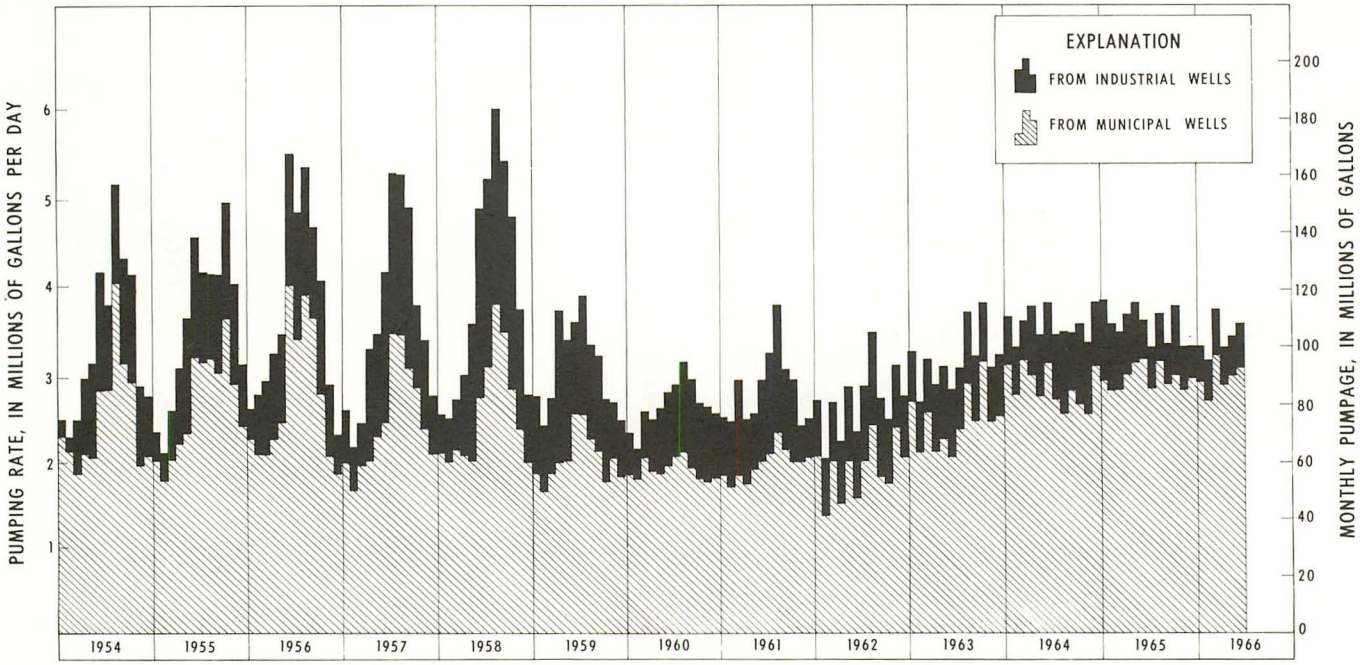


Figure 11—Graph showing ground-water pumpage from municipal wells and industrial wells at Cambridge by months, 1954-1966.

Potential aquifers are believed to occur in the Raritan and Patapsco Formations in the depth interval from 1,025 to 1,500 feet. The geophysical and lithologic logs of test hole Dor-Ce 77 show the existence of at least four water-bearing sands in this interval that are probably worthy of future testing (figure 5).

As the Piney Point and Magothy Formations are the principal sources of water for Cambridge, a quantitative evaluation of the long-term yields of these aquifers follows. The calculations of long-term yields are based on the nonequilibrium equation developed by Theis (1935). A discussion of the Theis equation may be found in any standard text on ground-water hydrology. The Theis equation relates the drawdown at any point from a pumping well to the pumping rate, coefficients of transmissibility and storage of the aquifer, and time. Thus, it is possible to predict drawdown at variable times and pumping rates at any distance from a pumping well, which aids in proper well spacing.

The maximum available drawdown in artesian aquifers such as the Piney Point and Magothy Formations is generally the difference between the static water level and the upper surface of the aquifer. Lowering the water level below the upper surface would dewater the aquifer and the yield would decline.

Available drawdown and the coefficients of transmissibility and storage are reasonably well known for the Piney Point and Magothy Formations in the Cambridge area (figure 13). The long-term yields have been calculated and are presented in the following sections. However, it is emphasized that these are theoretical yields based on assumptions of the Theis equation: (1) the aquifer is horizontal and is of infinite areal extent, (2) the pumped well fully penetrates the aquifer, (3) the transmissibility is constant within the cone of depression, and (4) the aquifer receives no recharge. In practice these assumptions are never fully met. However, in such widespread artesian aquifers as the Magothy and Piney Point, the assumptions are approached, and the calculated long-term yields are reasonably accurate.

As large drawdowns are required for maximum yield, the effects of extensive lowering of water levels should be considered. One effect, of course, is to increase the cost of pumping water. Another

Table 6. Data for high-capacity wells in Dorchester County.

Well number		Owner's name and designation	Date drilled	Altitude of land surface (feet)	Depth of well (feet)	Altitude of screen (feet)	Test data					Specific capacity (gpm/ft drawdown)	Operating data				Aquifer		Remarks
							Altitude of water level						Altitude of water level						
U.S.G.S. Dor-	Permit						Static (feet)	Pumping (feet)	Yield (gpm)	Date	Length of test (hours)		Static (feet)	Pumping (feet)	Yield (gpm)	Date	Name	Trans-missibility (gpd/ft)	
Cd 40	10964	Riverside Apartments	1953	5	400	-363 to -384	-64	- 96	41	5/-/53	6	1.3	-	-	-	-	Piney Point	-	Observation well.
Cd 43	32096	Municipal Utilities Commission, Glasgow St.	1959	16	406	-320 to -390	-	- 98	300	1/15/59	24	-	-	-	-	-	do.	30,000	
Ce 1	-	Crystal Ice Co.	1945	18	966	-938 to -948	+29	-	20 2/	5/ -/45	-	-	-	-	-	-	Magothy	-	
Ce 2	-	Municipal Utilities Commission, Dorchester Ave.	1945	15	412	-347 to -397	-87	-166	625	6/28/51	½	8	-	-	500	1965	Piney Point	-	"Shallow" well.
Ce 3	174	do.	1946	15	977	-926 to -955	+15	- 92	436	4/- /46	24	4	-14 10/27/65	-	300	1966	Magothy	8,000	"Deep" well.
Ce 4	-	Municipal Utilities Commission, Washington St. No. 1	1931	18	372	-348 to -354 1/	-82	-	-	7/23/51	-	-	-106	-	-	11/1/65	Piney Point	45,000	
Ce 5	-	do. No. 2	1931	18	405	- 1/	-82	-	600	7/ -/51	-	-	-	-	-	-	do.	45,000	
Ce 6	-	Municipal Utilities Commission, Fletcher Ave.	1936	16	463	-350 to -447 1/	-	-	-	-	-	-	-95	-	500	5/6/65	do.	-	
Ce 9	-	Municipal Utilities Commission, High St.	1936	25	413	-	-77	-	700	7/3/51	-	-	-	3/	-	-	do.	-	Used only as an observation well in 1967.
Ce 10	-	Municipal Utilities Commission, Mill St.	1910	6	375	-329 to -369 1/	-	-	-	-	-	-	-87	-	585	8/25/65	do.	-	
Ce 12	1427	Municipal Utilities Commission, Nathans Ave. No.1	1947	18	432	-361 to -412	-65	- 93	350	7/-/47	24	12	-	-	-	-	do.	-	
Ce 13	1645	do. No.2	1947	18	430	-357 to -408	-70	-127	350	10/-/47	24	6	-	-	-	-	do.	-	
Ce 15	1220	Carroll W. Thomas Inc., Trenton St.	1947	6	974	-944 to -964	-74	-122	200	1947	24	4	-27	3/	-	8/10/64	Magothy	15,000	Do.
Ce 21	-	Eastern Shore State Hospital	1914	12	370	-	-27	- 40	180	8/-/14	-	14	-62	-	-	2/14/52	Piney Point	30,000	Do.
Ce 22	-	do.	1921	12	411	-	-84	-102	185	6/2/65	-	10	-	-	-	-	do.	30,000	Do.
Ce 61	9474	Coastal Foods Co.	1952	15	442	-377 to -427	-83	-	580	3/-/52	24	12	-120	-163	540	5/6/66	do.	40,000	
Ce 62	9902	Maryland Tuna Corp. No. 1	1952	15	446	-377 to -431	-94	-179	513	6/25/52	24	6	-	-	-	-	do.	-	
Ce 72	24574	do. No. 2	1956	25	450	-376 to -425	-129	-206	510	8/29/56	24	7	-	-	-	-	do.	-	
Ce 73	26604	Catalyst Research Corp.	1957	20	446	-384 to -426	-76	- 80	56	6/-/57	24	14	-	3/	-	-	do.	-	Not operated in 1966.
Ce 74	56055	Bonnie Brook Development 4-inch	1964	15	422	-386 to -407	-67	-105	100	6/-/64	72	3	-	-	-	-	do.	-	
Ce 75	56056	do. 6-inch	1964	15	454	-388 to -409	-68	- 90	60	5/21/65	4	3	-	-	-	-	do.	30,000	
Ce 78	D66W26	Municipal Utilities Commission, Stone Boundary Rd.	1965	16	503	-344 to -483	-84	-190	1200	11/1/65-11/3/65	48	11	-	-	-	-	do.	30,000	Observation well until permanent pump was installed. Not operated in 1966.

1/ Open hole.

2/ Free flow at land surface.

3/ Well out of service.

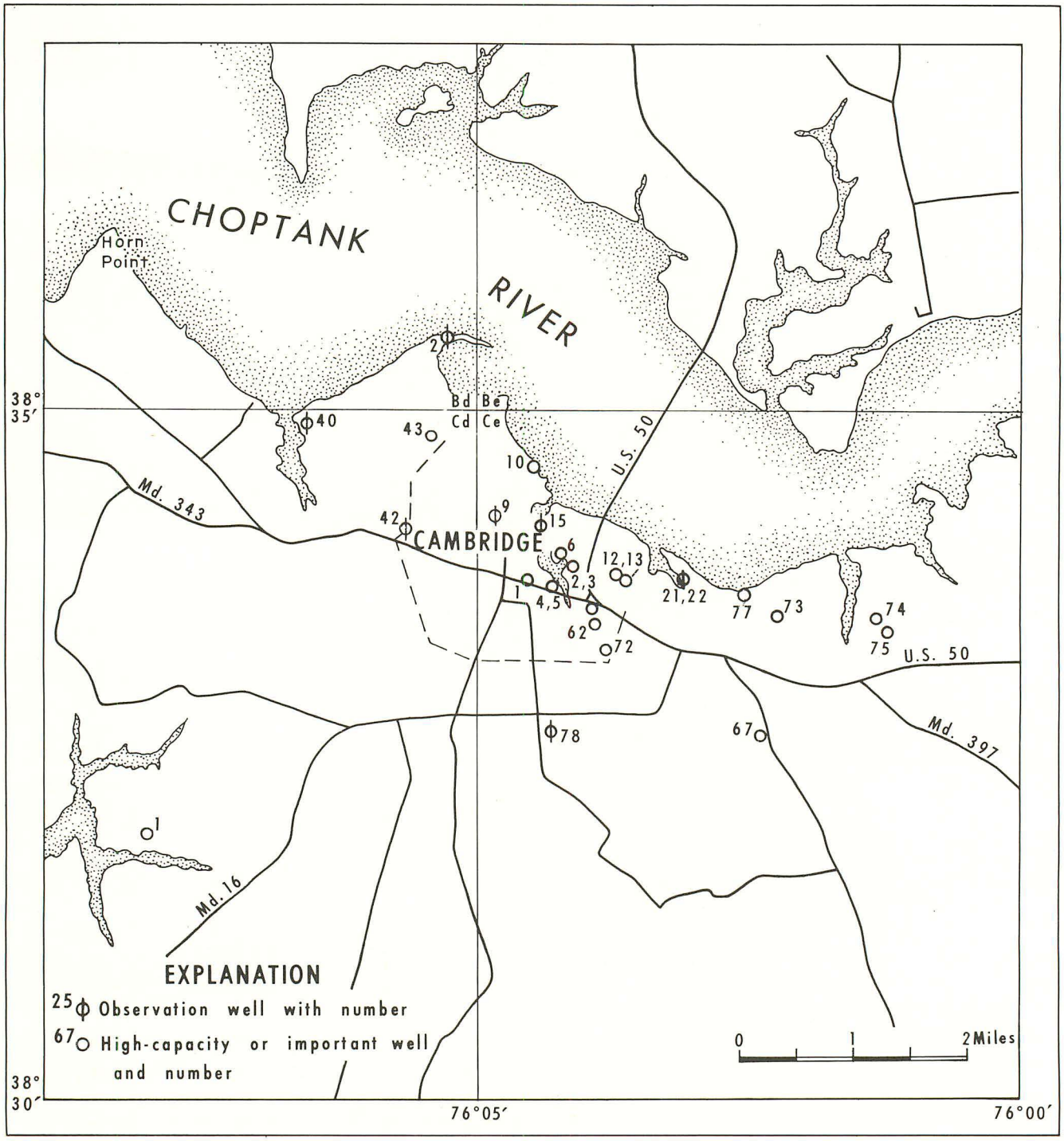
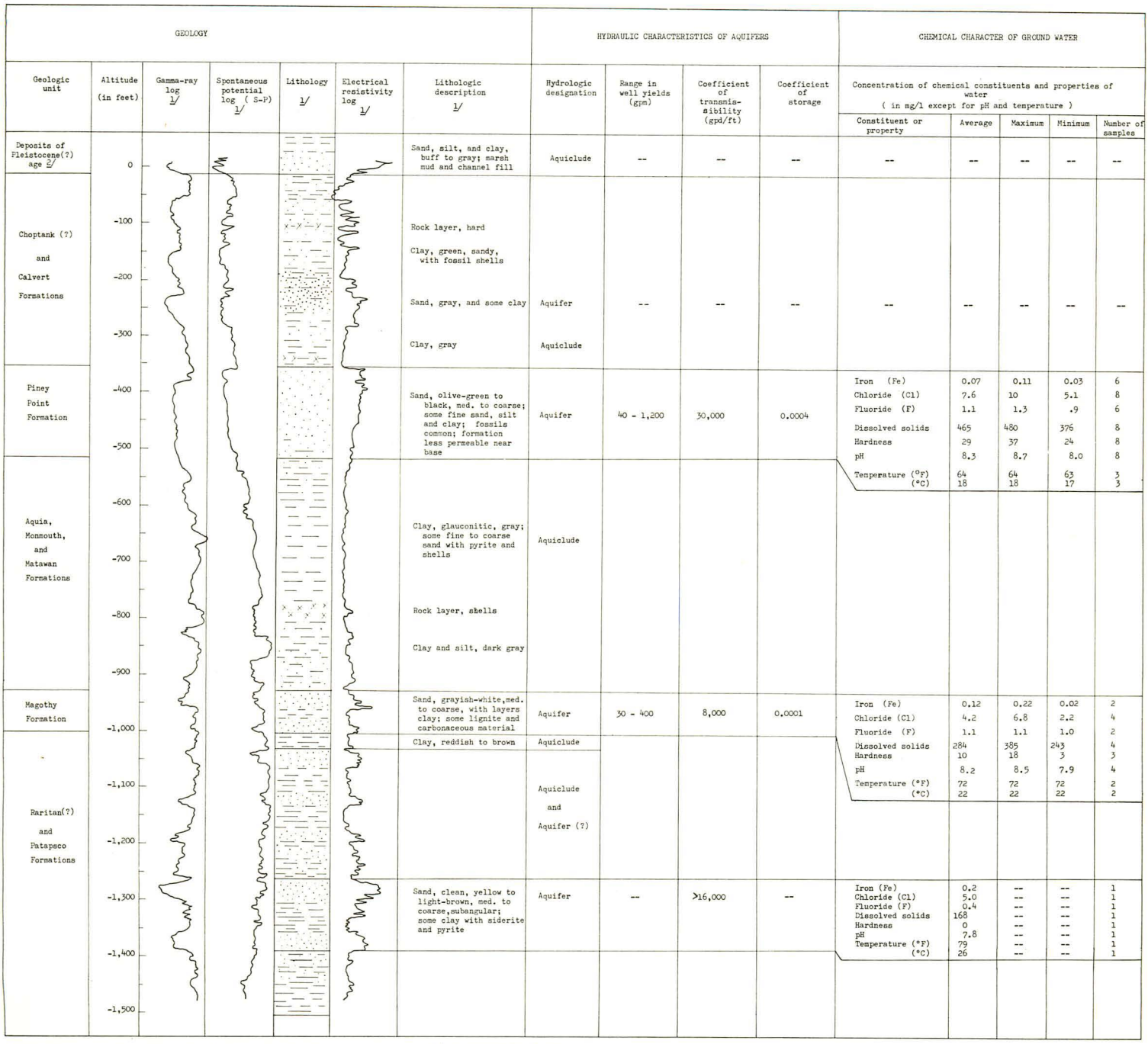


Figure 12—Map showing locations of important wells in the Cambridge area.



1/ Based on data from test hole Dor-Ce 77 at Eastern Shore State Hospital. 2/ Not an aquifer at Cambridge.

Figure 13—Geologic section at Cambridge to a depth of 1,500 feet showing lithologic and geophysical logs, hydraulic characteristics of aquifers, and chemical character of the ground water.

effect may be the more serious one of land subsidence. The reduction of artesian pressure in the water-bearing sand and particularly in the adjacent clay and silt may induce compaction. This results in subsidence of the land surface. Such subsidence has been more than 10 feet over a large area in California (Lohman, 1961; Miller, 1961; and Poland, 1961). However, in other localities, extensive decline of artesian heads has caused no measurable land subsidence. Needless to say, subsidence of the land surface in the Cambridge area should be avoided because of the low elevation of the land surface. If greatly increased pumpage is begun at Cambridge, land subsidence should be monitored. (See section on Future Monitoring.)

A. *Magothy Formation*

The Magothy Formation is capable of yielding considerably more water than is presently being pumped from it. One well (Dor-Ce 3) yields 300 gpm, and it is believed that additional wells capable of yielding as much as 400 gpm (with drawdowns ranging from 100 to 200 feet) can be completed in the aquifer.

The coefficients of transmissibility (8,000 gpd per foot) and storage (0.0001) of the Magothy Formation have been used to calculate theoretical drawdowns at various distances from a pumping well. Figure 14 shows the calculated drawdown at

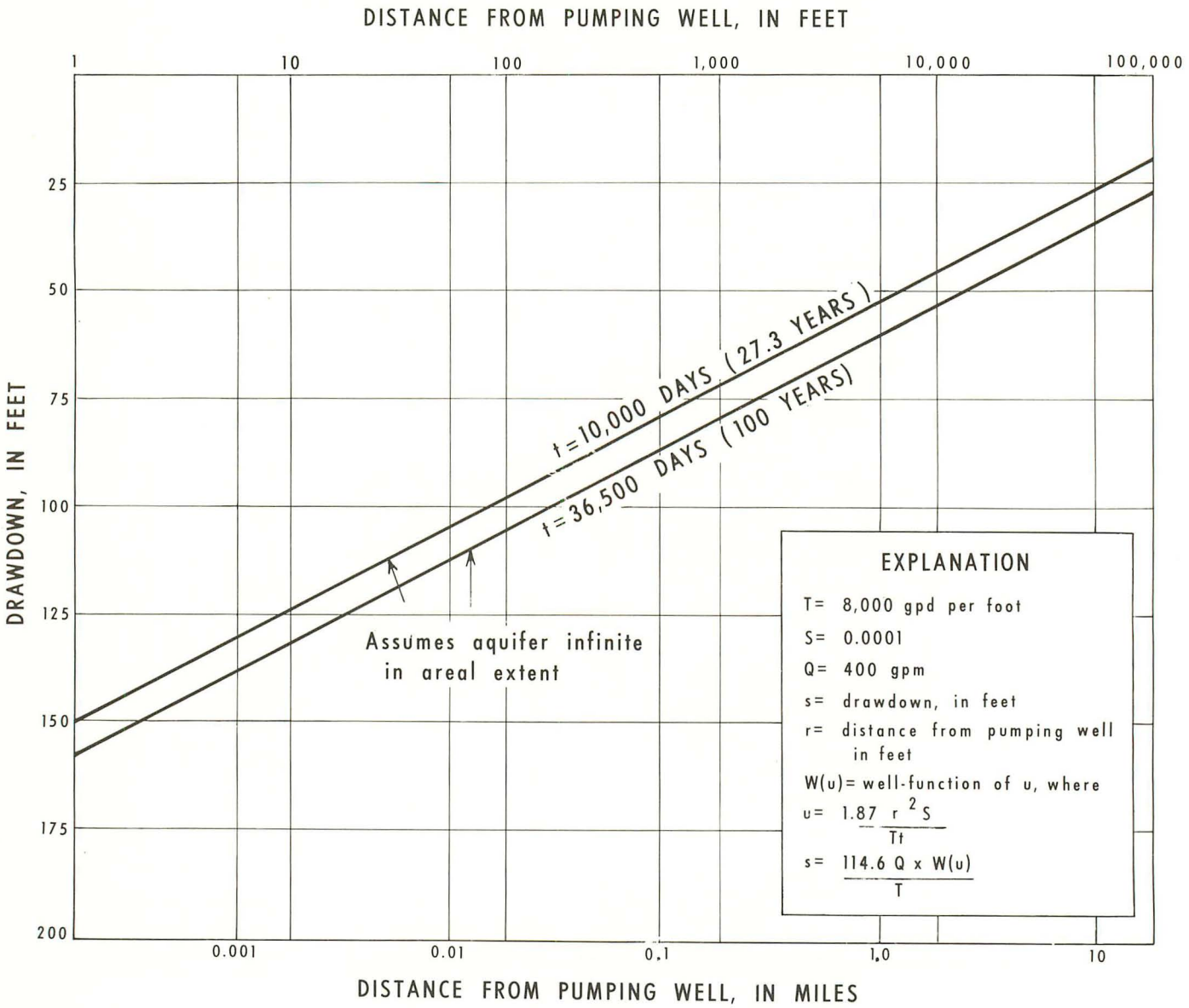


Figure 14—Distance-drawdown graph for the Magothy Formation at Cambridge showing theoretical drawdown after 27 years and 100 years of pumping at 400 gpm.

distances of 1 to 100,000 feet from a Magothy well discharging 400 gpm after 27 years and 100 years of continuous pumping. It should be noted that the drawdown after 27 years is more than 90 percent of the drawdown after 100 years. Thus, for the estimate of long-term yield, the 27-year drawdowns have been used. The figure shows that a well pumping 400 gpm for 27 years will cause a drawdown of 72 feet at a distance of 1,000 feet. The drawdown in the aquifer just outside the pumping well (12-inch effective radius) would be about 150 feet. Thus, if two wells 1,000 feet apart were pumped 400 gpm each, the drawdown in each well would be 222 feet in 27 years. The

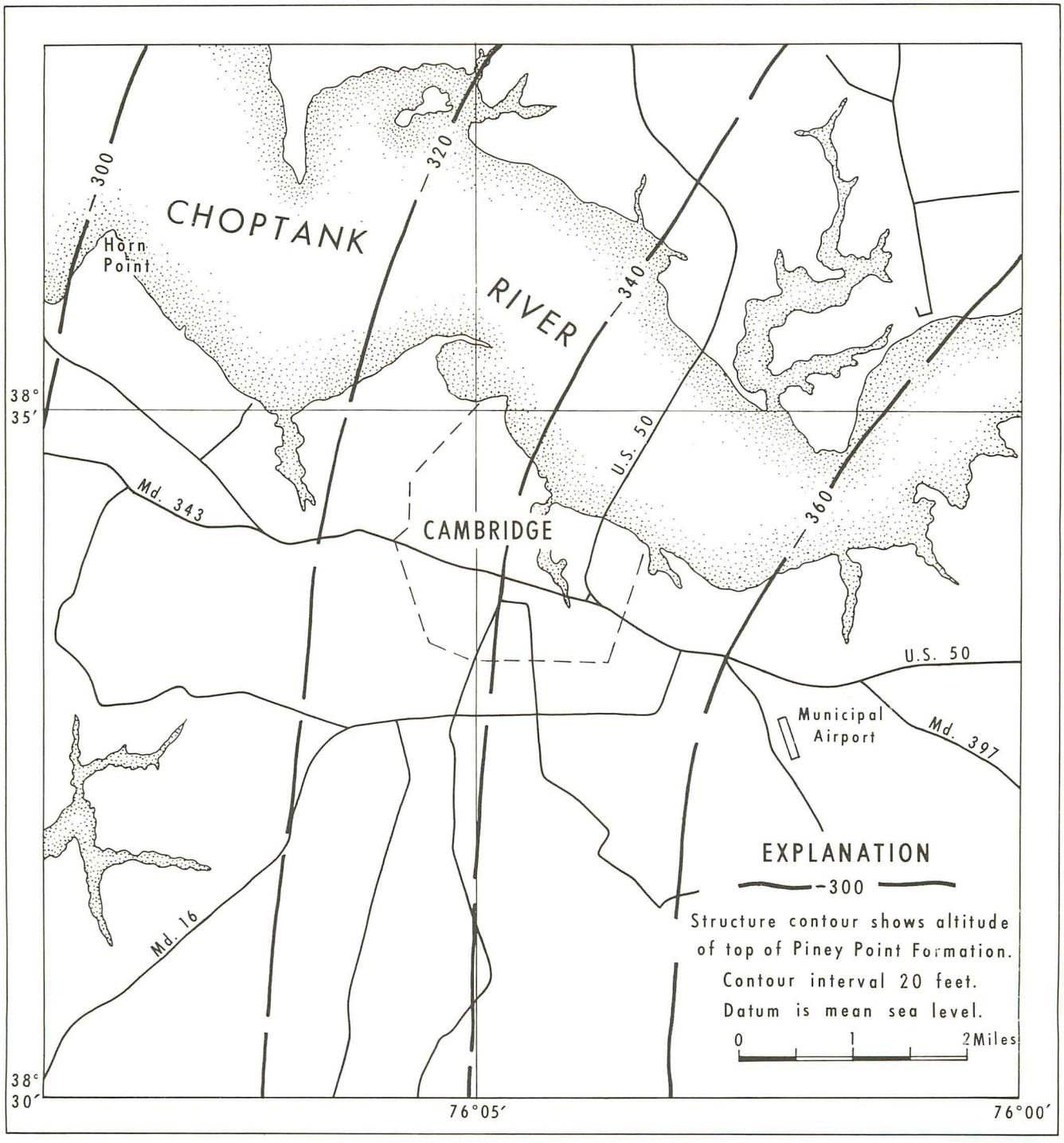


Figure 15—Map showing the altitude of the top of the Piney Point Formation at Cambridge.

drawdowns in additional wells can be similarly computed for any number of wells.

In estimating the amount of water available from the Magothy Formation, two hypothetical well-field configurations were considered—each with wells of 12-inch effective radius located along a line 4 miles in length. In the first field, having 5 wells spaced at 1-mile intervals, the drawdown in the center well at the end of 10,000 days is 444[1] feet, and the quantity of water obtained is 2.9 mgd. In the second hypothetical field, having 9 wells spaced at 0.5-mile intervals, the drawdown in the center well at the end of 10,000 days is 660[1] feet and the quantity of water obtained is 5.2 mgd. The wells would preferably be oriented parallel to the distant recharge boundary, but the hydraulic gain from the parallel orientation is not large.

In the Cambridge area, the approximate limit of drawdown in the Magothy (upper surface of the sand) is at an altitude of about —900 feet. In 1965 when all major pumping from the Magothy Formation at Cambridge was temporarily stopped, water levels in wells recovered to about 15 feet below sea level. Therefore, a total drawdown of 885 feet is theoretically available. Thus, the 444-foot drawdown predicted for the 5-well configuration has a safety factor of 441 feet (50 percent) and the 660-foot drawdown for the 9-well configuration has a safety factor of 225 feet (25 percent) to allow for possible localized decreases in aquifer transmissibility, lower than anticipated well efficiencies, and the general regional decline in the artesian head in the aquifer caused by withdrawals from it at other localities. Because the value for the coefficient of transmissibility used in this computation was derived from a relatively short (12-hour) pumping test, and because drillers' records indicate that barrier boundaries may be within a few miles of the Cambridge area, the use of the well configuration providing the larger safety factor is suggested. Thus, in this report the value of about 2.9 mgd is the estimate of the quantity available from the Magothy Formation. However, hydrogeologic data gathered during future drilling and testing of wells in the formation may reveal that larger or smaller quantities can be obtained from the Magothy.

[1] As no wells are 100 percent efficient, for purposes of computation, an additional 100 feet of drawdown is added to the theoretical drawdown to allow for estimated losses through the well screen.

B. *Piney Point Formation*

Although continuous pumping in the Piney Point Formation for many years has caused a widespread lowering of water levels, an estimate of long-term yield shows that the formation is capable of yielding additional quantities of water.

As shown in figure 15, the uppermost sands in the Piney Point occur at a depth of about 340 feet below sea level at Cambridge. The top of the formation dips to the southeast at about 10 feet per mile and ranges from 300 feet below sea level 5 miles northwest of the city to 365 feet below sea level at the airport 3 miles southeast of the city.

1. *Effects of Pumping*

The earliest withdrawal of water from the Piney Point Formation at Cambridge dates back to 1888. The initial wells flowed at an altitude of about 20 feet. Pumping from the Piney Point since 1888 has created a widespread cone of depression. The cone extended about 25 miles to the northeast as far as the town of Denton and at least 20 miles to the southwest near the town of Fishing Creek on Chesapeake Bay (Rasmussen and Slaughter, 1957, pl. 9). The cone of depression during 1966 is shown in figure 16, which is a map of the potentiometric surface in the Piney Point in the vicinity of Cambridge. The exact configuration of the potentiometric contours, of course, changes slightly as patterns of well use shift from day to day. As may be seen in figure 16, water levels have been lowered to more than 90 feet below sea level at Cambridge. At two centers of pumping, on the northwest and southeast margins of the city, water levels were 120 feet below sea level.

Figure 17 is a graph showing water-level fluctuations from late 1965 through 1966 in two wells tapping the Piney Point Formation at Cambridge and the pumpage that caused the fluctuations. The graph indicates both weekly high and low water levels for the period. One well (-Ce 9) is in the center of the city well field, whereas the other well (-Ce 78) is about 1 mile from the nearest pumping well. Total weekly pumpage by the city is

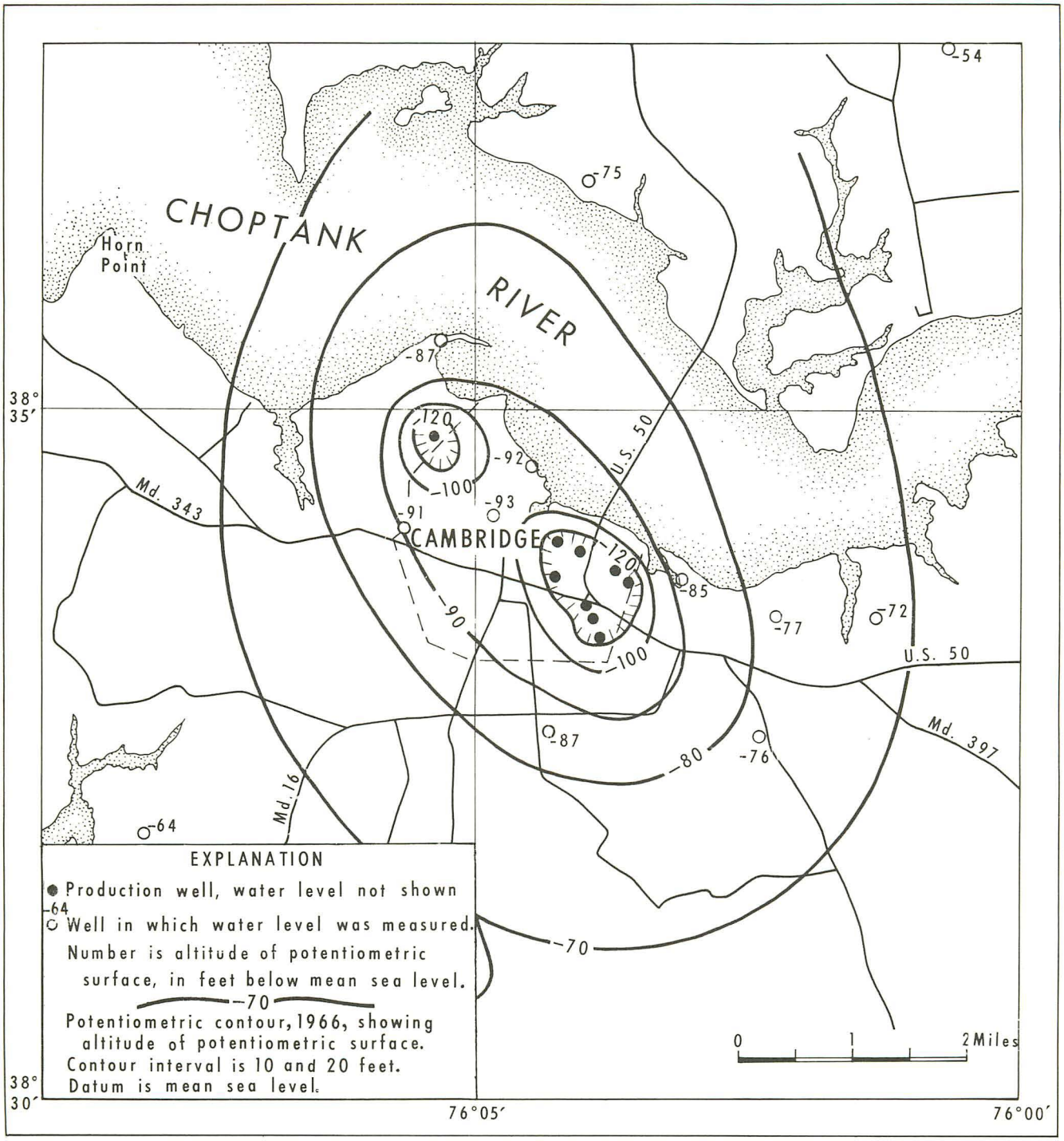


Figure 16—Map of the potentiometric surface in the Piney Point Formation in the vicinity of Cambridge, 1966.

shown on the graph, which shows also the weekly totals of the other large users—Coastal Foods Corp. and Maryland Tuna Co. The graph shows that the water level in well Dor-Ce 9, an unpumped well, ranged from about 85 feet bsl (below sea level) in April 1966 to about 114 feet bsl at the height of the canning season in September 1966—a fluctuation of about 30 feet. Water levels in Dor-Ce 78, at least 1 mile from the center of pumpage, were consistently 7 feet higher than water levels in Dor-Ce 9. The levels ranged from about 78 feet bsl in April 1966 to about 97 feet bsl in September 1966. Pumpage shown in the figure indicates that water levels remained fairly steady

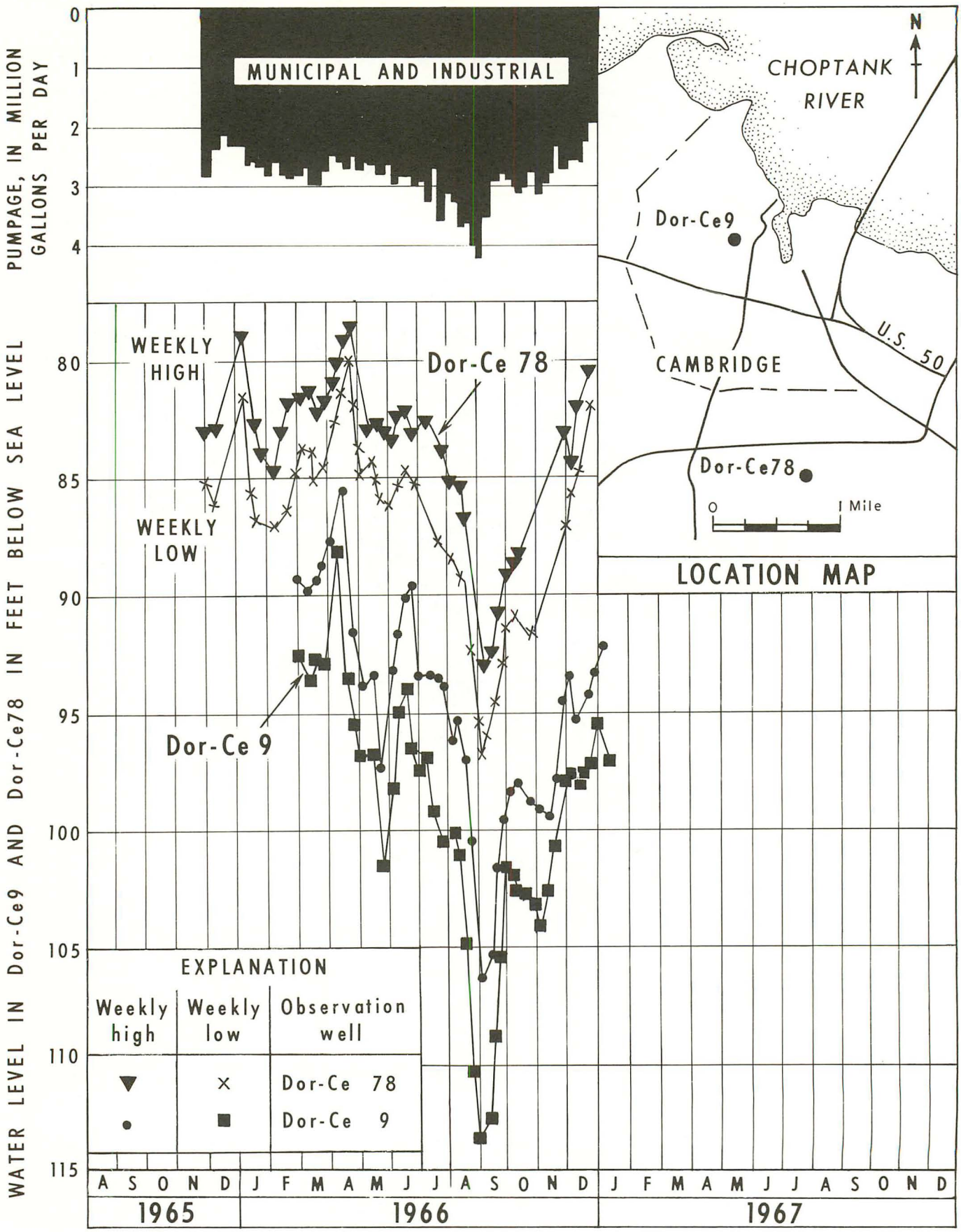


Figure 17—Hydrographs showing response of water-levels in wells Dor-Ce 9 and Ce 78 to various pumping rates during 1965-66.

at about 85 feet bsl in -Ce 78 when pumping rates were held at an average of 2.8 mgd during May and June 1966. The graph shows also that by increasing the pumping rate to 4.2 mgd during the first week of September 1966 the water level declined to 97 feet in the same well. Continued pumping at that rate would have caused a slight additional decline in the water level.

The response of water levels to changes in pumping from the Piney Point Formation is typical of that expected from an artesian aquifer with moderately high transmissibility. The response occurs immediately in a well within the center of pumping and shortly thereafter in a well a mile away. The relatively small difference of 7 feet between the water levels near the center of pumping and at a distance of 1 mile indicates that the cone of depression has a gentle gradient. Thus, the cone of depression produced by pumping from the Piney Point at Cambridge can be described as being widespread, having a relatively gentle slope toward the center of pumping, and reacting quickly to changes in pumping rates.

2. *Long-term Yield*

The coefficients of transmissibility (30,000 gpd per foot) and storage (0.0004) of the Piney Point have been used to calculate theoretical drawdowns at various distances from a pumping well in the same manner as discussed in the previous section on the Magothy Formation

Figure 18 shows the calculated drawdowns at distances of 1 to 100,000 feet from a Piney Point well discharging at 700 gpm continuously for 27 years (or 10,000 days) and 100 years (or 36,500 days). This graph shows that the drawdown after 27 years is more than 90 percent of the drawdown after 100 years.

The range in altitude of the top of the well screens in 12 Piney Point wells at Cambridge is from —320 feet to —377 feet. The uppermost well screen at —320 feet is in the western part of the area and this altitude is selected as the limiting altitude below which water levels should not decline if the well is to continue to be usable.

As the altitude of the water level in the aquifer prior to the start of pumping was about 20 feet above sea level, the total available drawdown is assumed to be 340 feet.

Two well arrays have been prepared using the distance-drawdown graph shown in figure 18. Figure 19 shows a plan view of the two well arrays, which have the following configuration: (A) eight wells in a single line and (B) eight wells in two parallel rows. The drawdown shown for each well is the sum of the drawdown caused by its own pumping plus the interference caused by pumping from the seven other wells. The theoretical drawdown in each well caused by its own pumping is 73 feet after pumping continuously for 100 years (based on a well diameter of 12 inches). However, a value of 100 feet has been used in preparing figure 19 to provide an additional drawdown of 27 feet to allow for local decreases in the transmissibility of the aquifer and for head losses caused by well construction, particularly head losses through the well screen.

Part A of figure 19 shows that wells 4 and 5 of a line of eight wells, spaced 0.5 mile apart, would have drawdowns of 292 feet after pumping at 700 gpm for 100 years. Thus, the drawdown in the two middle wells in this array would be 48 feet less than the available drawdown of 340 feet. A safety factor of about 14 percent is provided by this arrangement. The combined yield of the eight wells would be 5,600 gpm, or 8 mgd.

Part B of figure 19 shows the theoretical drawdowns if eight wells were to be placed along two parallel lines of four wells each, with the lines spaced 0.5 mile apart. In this array, the four middle wells, numbers 2, 3, 6, and 7 would have drawdowns of 306 feet. The drawdown in these wells after 100 years of pumping at 700 gpm each would be 34 feet less than the available drawdown of 340 feet. A safety factor of 10 percent is provided in this arrangement. The combined yield of the eight wells would be the same as for the array shown in Part A of figure 19.

The difference in drawdowns in the middle, or critical, wells of the two suggested well configurations is not large, amounting to only 14 feet (the difference between 306 and 292 feet). The selection of well configurations will undoubtedly be governed chiefly by factors such as cost and availability of land for well sites and cost of pipelines and other transmission facilities, but should also provide for hydraulic interference between wells.

A point to be clarified in the preceding analysis is that the 1966 pattern of pumping, as illustrated by figure 16, is hydraulically inefficient, and the approximate 1966 pumpage of 2.8 mgd would be transferred to the more efficiently spaced 8 hypothetical wells. Thus, the present pumpage of 2.8 mgd would be included in the 8.0 mgd sustained yield predicted to be available.

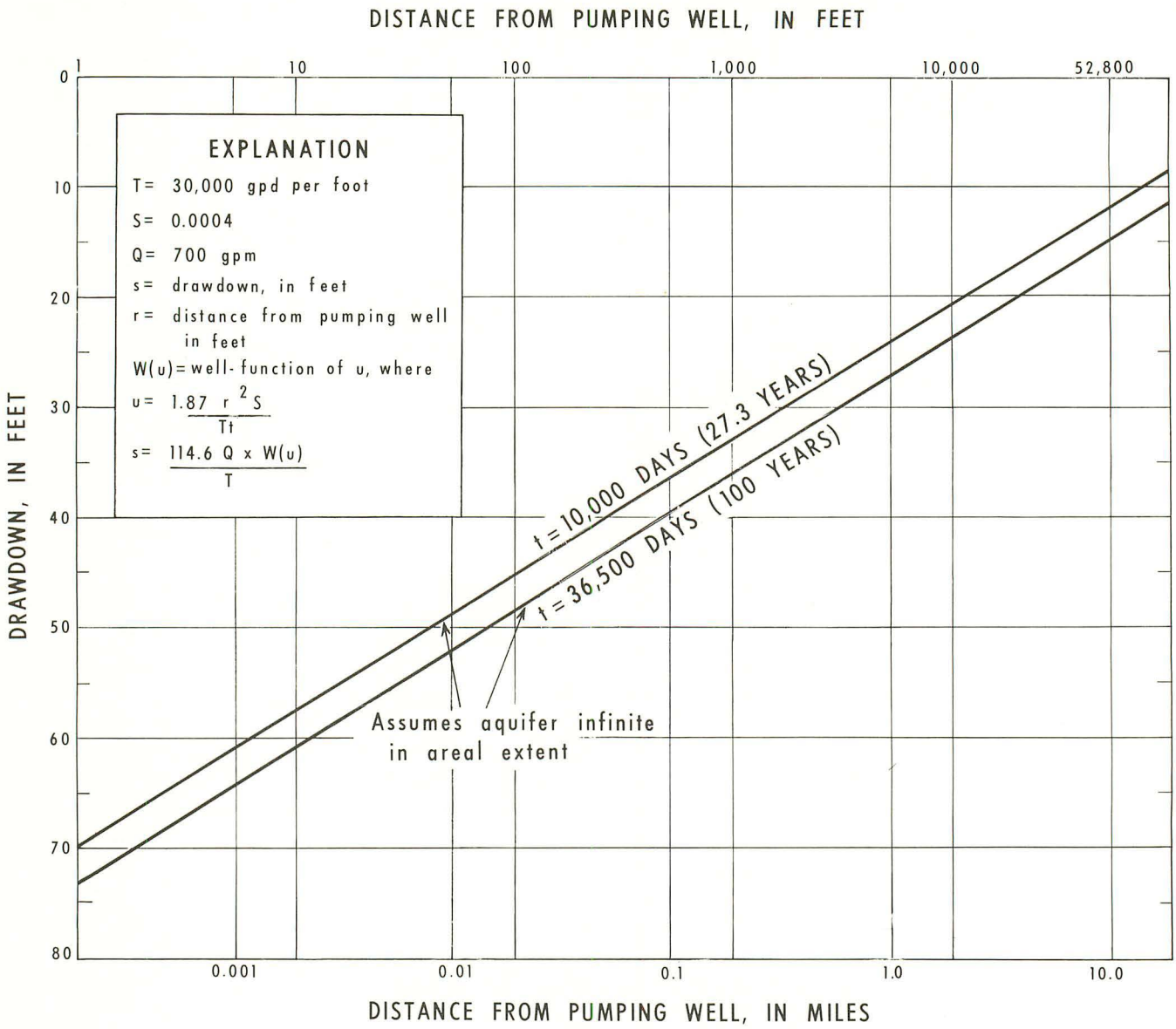


Figure 18—Distance-drawdown graph for the Piney Point Formation at Cambridge showing the theoretical drawdown after 27 years of pumping at 700 gpm.

The preceding analysis is based on the assumption that the Piney Point Formation is infinite in areal extent and also that there is no vertical leakage into it. The Piney Point does not crop out and thus cannot be directly recharged. However, the outcrop belt of the underlying Nanjemoy Formation, which is in hydraulic continuity with the Piney Point, lies about 35 miles northwest of Cambridge. As precipitation along the outcrop belt is adequate to replenish the aquifer continuously, the outcrop belt is considered to function as a recharging boundary. The hydraulic effect of a recharging boundary 35 miles distant would be to decrease the drawdown in wells at Cambridge by about 7 feet. However, the Piney Point Formation is also believed to pinch out or become less permeable southeastward 20 to 30 miles from Cambridge. The hydraulic effect of this would be to nullify effects of the recharging boundary. The infinite-aquifer assumption is, therefore, considered to be justified.

The possibility also exists that the confining layers above and below the Piney Point Formation are sufficiently permeable to permit some vertical leakage of water into it. This leakage would increase as heads decline in the Piney Point. However, the amount of leakage, if it exists, is not known, and this factor could not be

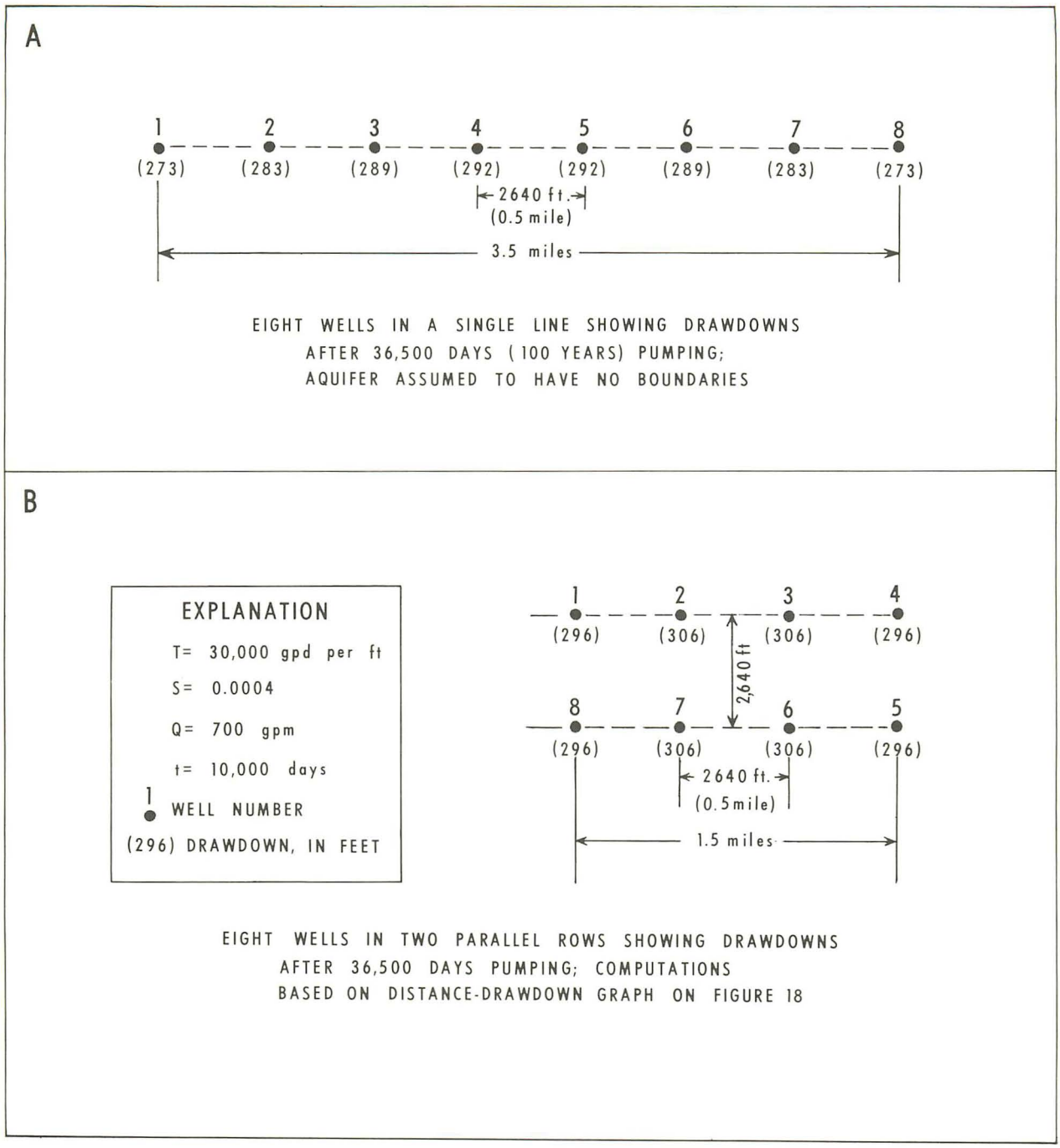


Figure 19—Plan view of two well arrays showing the theoretical drawdowns caused by pumping 8 mgd (about 700 gpm from each of 8 wells) from the Piney Formation.

included in the analysis. The effect of vertical leakage would be to increase the long-term yield of the aquifer.

The preceding analysis indicates that the sustained yield of the Piney Point Formation is about 8 mgd in the vicinity of Cambridge. The safety factor provided in the analysis allows for a general regional decline of water levels, which might result from some pumping from the aquifer in areas distant from Cambridge.

C. *Summary*

In summary, the combined long-term yield of the Magothy and the Piney Point Formations is about 11 mgd. Thus, the present withdrawal of about 3 mgd at Cambridge is considerably less than maximum potential yield. It should be recognized that the long-term yield of 11 mgd is only an approximation subject to those assumptions mentioned in the previous discussions.

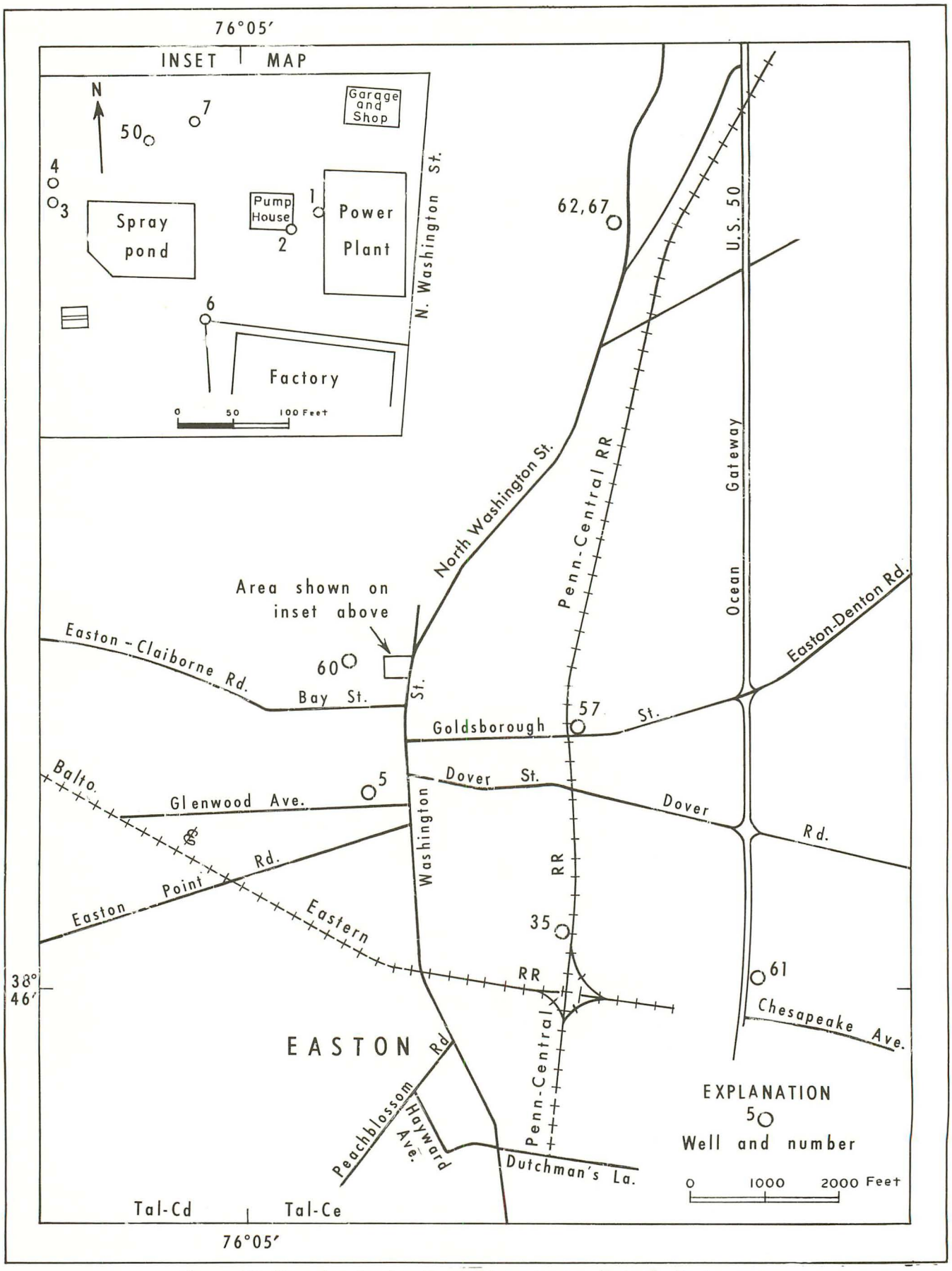


Figure 20—Map showing locations of important wells in the Easton area.

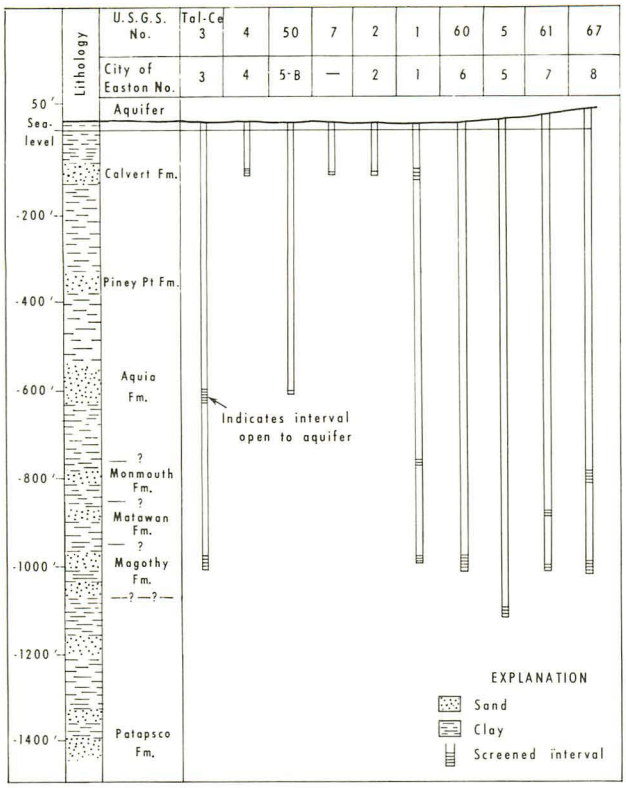


Figure 21—Sketch showing screened intervals in wells of the City of Easton.

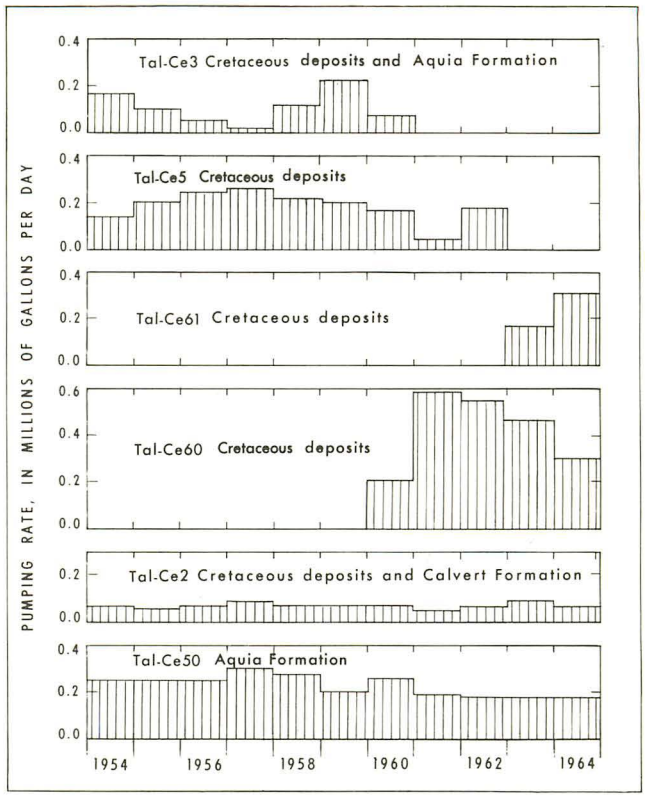


Figure 22—Graphs showing pumpage from municipal supply wells of the City of Easton from 1954 through 1964.

Easton Area

The city of Easton, the County seat of Talbot County, had a population of 7,400 in 1964. It is centrally located in the County and is on U.S. 50 at the junction of Maryland Route 33 leading to the Tilghman Island-St. Michaels neck area. The Easton area, as discussed here, is arbitrarily considered to include about 6 square miles in a rectangular shape about 4 miles long in a north-south direction and 1½ miles wide in an east-west direction. It is centered near the Pennsylvania Railroad crossing with Maryland Route 331. Tidal parts of the Tred Avon River, a tributary of Chesapeake Bay, reach almost into the city limits. Inland extensions of the Miles River, another estuary of Chesapeake Bay, reach to within 2 miles of the city. A reach of the Choptank River is less than 4 miles east of Easton.

Current Use of Ground Water and Estimated Future Requirements: The city of Easton depends on ground water for its municipal supplies as do several small industries in the area. No fresh-water streams in the area flow sufficiently for reservoirs.

Approximately 7,500 people were provided an average of 0.93 mgd of water by the Easton Utilities Commission in 1964. The water was used primarily for domestic or commercial purposes with a minor amount used by small industries.

The number of people served by the Easton municipal water supply will be about 12,000 by 1975 and possibly 20,000 by the year 2000, based on predicted population trends since 1950. The ground-water pumpage will probably be about 1.5 mgd by 1975 and 3 mgd by the year 2000.

In 1964, all the water pumped by the city of Easton was obtained from four wells, Tal-Ce 50, which taps the Aquia Formation; Tal-Ce 60 and -Ce 61, which tap sands of Cretaceous age; and Tal-Ce 2, which taps the Calvert Formation. The depth, screened interval, water levels, aquifer, yield, and pumping-test data for these and other

Table 7. Data for high-capacity wells in Talbot County.

Well number		Owner's name and designation	Date drilled	Altitude of land surface (feet)	Depth of well (feet)	Altitude of screen (feet)	Test data					Specific capacity (gpm/ft) (drawdown)	Operating data				Aquifer		Remarks
							Altitude of water level						Altitude of water level						
U.S.G.S. Tal-	Permit						Static (feet)	Pumping (feet)	Yield (gpm)	Date	Length of test (hours)		Static (feet)	Pumping (feet)	Yield (gpm)	Date	Name	Trans-missibility (gpd/ft)	
Af 10	41413	Fox Canning Co.	1961	10	845	-600 to -635 -760 to -830	4	-197	325	7/12/61	24	1.6	-	-	-	-	Aquia Matawan	-	
Bf 72	16235	Schluderberg-Kurdle Co.	1954	42	52	11 to -10	31	17	175	9/22/54	4	12	-	-	-	-	Pleistocene	100,000 5/	
Cc 32	T65W50	Commissioners of St. Michaels	1965	15	458	-393 to -443	0 6/	-37	265	2/15/65	10	7	-	-	-	-	Aquia	-	
Ce 1	-	Easton Utilities Commission No. 1	1901	15	1,015	-85 to -95 -767 to -773 -985 to -1,000	15	-10 -	60 -	1901	- -	- 2.4	- -31 6/ -58 6/	- - -	- 280 1/	- 10/7/48 6/11/64	Calvert and Cretaceous	- -	Used as an observation well in 1966. Affected by pumping of Ce 2.
Ce 2	-	do. No. 2	1910	20	110	- to -90	-13	-	193	1/16/56	19	-	-25 6/	-	200	8/27/64	Calvert	3,500	
Ce 3	-	do. No. 3	1929	15	1,025	-625 to -980 to -1,010	- 7 6/	-80 6/	616	8/19/50	24	8	-53 6/	1/	-	8/27/64	Aquia Matawan	20,000 2/	
Ce 5	2261	do. West St.	1947	30	1,148	-1,096 to -1,117	22 6/	-37 6/	415	1/18/49	2	7	15 6/	1/	-	8/22/64	Magothy	12,000 4/	
Ce 7	-	do. Well G	-	13	104	-82± to -89	-	-	-	-	-	-	-30 6/ -42 6/	1/ 1/	- -	10/7/48 4/9/66	Calvert	-	Used as an observation well in 1966. Affected by pumping of Ce 2.
Ce 50	8836	do. No. 1B	1952	20	623	-550 to -603	- 9	-176	362	1/24/52	24	2	-21 6/	-	200	9/21/65	Aquia	4,000	
Ce 60	37628	do. No. 6	1960	21	1,045	-989 to -1,024	-22	-104	463	4/22/60	24	5.6	-79 6/	3/	555	9/28/65	Matawan	15,000	
Ce 61	46762	do. No. 7 Clifton	1962	35.5	1,057	-883 to -892 -1,006 to -1,022	-59	-217	494	7/10/62	24	3	-94 6/	-238 6/	600	9/22/65	Matawan	10,000	
Ce 67	T66W12	do. No. 8 Airport	1965	56	1,092	-794 to -821 -1,004 to -1,036	-13	-215	500	9/10/65	48	2.4	-51 6/	-215 6/ -	610 -	8/22/66 3/29/66	Cretaceous	6,500	
Dd 53	53609	Talbot Country Club, Inc.	1963	10	640	-580 to -630	-22	-173	200	9/20/63	8	1.3	-15 6/	-147 6/	180	12/13/66	Aquia	4,000	
Ee 8	895	Trappe Frozen Food Corp.	1946	55	940	-352 to -372 -858 to -870	-13	-191	240	6/12/46	1½	1.9	-	-	-	-	Piney Point and Cretaceous	-	

1/ Well out of service.

2/ Value for Cretaceous and Aquia aquifers combined (see Rasmussen and Slaughter, 1957, p. 53).

3/ Water level cannot be measured.

4/ Period of recovery to static level was exceptionally long, suggesting that aquifer is of limited lateral extent.

5/ Value obtained during pumping test of March 24, 1956 (see Rasmussen and Slaughter, 1957, p. 102).

6/ Measured.

high-capacity wells in Talbot County are given in table 7. The locations of important wells in the Easton area are shown in figure 20. The aquifer and screened interval of the supply wells of the city of Easton are shown graphically in figure 21. As can be seen in the illustration, four of the wells are screened in more than one aquifer.

The sands of Cretaceous age are the principal source of Easton's water, supplying 72 percent of the ground water pumped in 1964. The Aquia and Calvert Formations, respectively, supplied 19 percent and 9 percent of the water pumped in 1964. Figure 22 shows the pumpage from Easton's municipal supply wells and the aquifers supplying this water during 1954–64. Figure 22 shows that pumpage from wells in the Cretaceous sands has increased in recent years. However, pumpage from the Aquia and Calvert Formations (Tertiary age) has remained relatively constant. Currently (1966) no city wells produce from the Piney Point Formation, in part because of the desire of the city to leave the formation available for users in the surrounding area and in part because the formation appears to be relatively impermeable locally.

Quantitative Appraisal of Aquifers: The Coastal Plain sediments are estimated to be 2,700 feet thick at Easton, although only the upper 1,500 feet of strata have been explored. Figure 23 is a geologic section of the upper 1,500 feet of Coastal Plain sediments showing the position of the various water-bearing sands, the chemical quality of ground water, and the hydraulic characteristics, and estimated long-term yield of the principal aquifers underlying Easton.

The long-term yields of the Calvert, Aquia, and Magothy Formations have been calculated from the estimates of available drawdown and the coefficients of transmissibility and storage shown on figure 23. The calculations were made by the use of the Theis nonequilibrium method in the same manner as discussed in the section on the Cambridge area. The long-term yields presented here are only approximate, intended as guidelines for future planning.

A. *Long-term Yield of the Sands of the Cretaceous System*

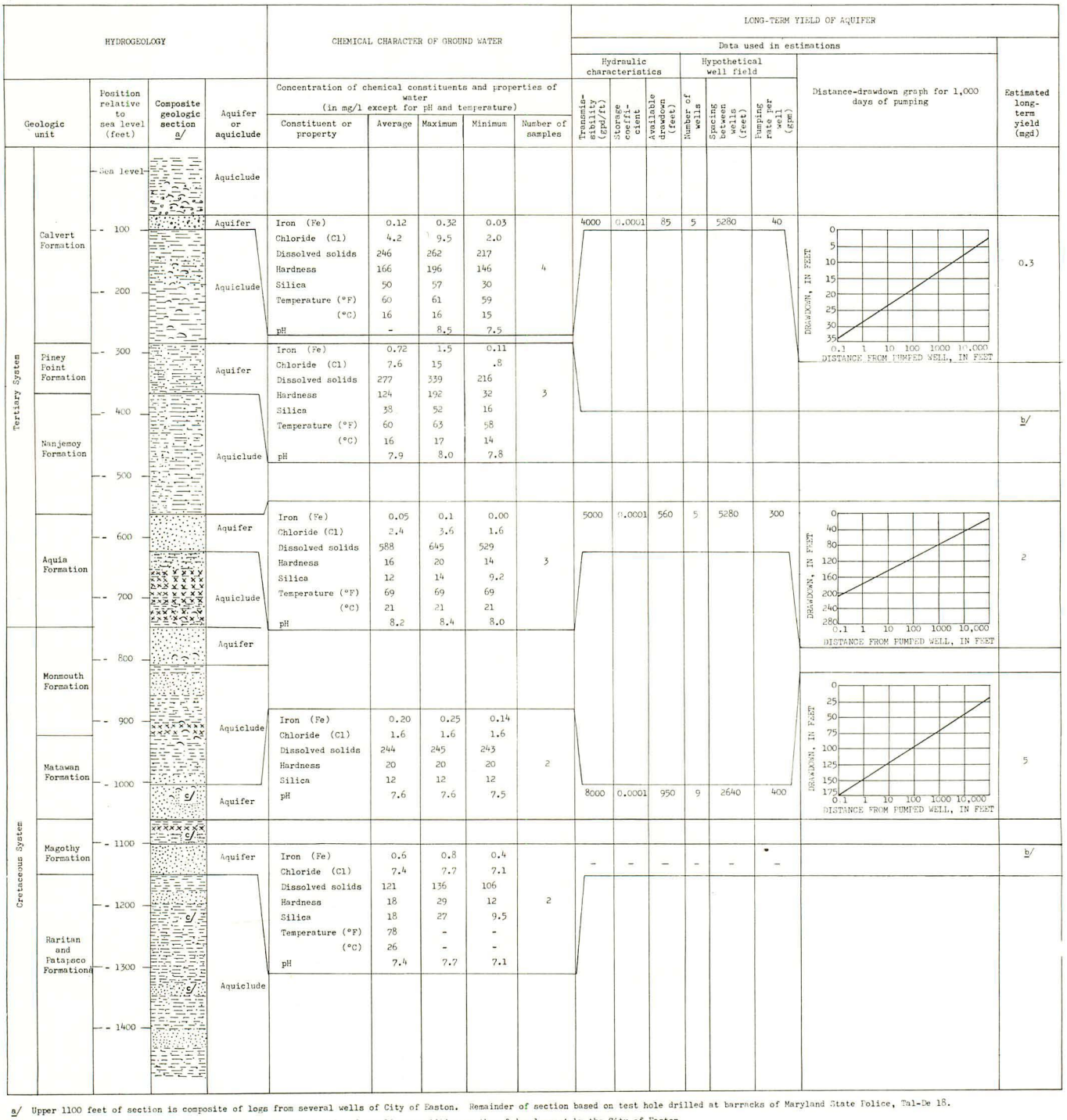
Although the sands of Late Cretaceous age are the primary source of ground water for Easton, these aquifers seem capable of substantially greater development. Additional wells capable of yielding 400 gpm with drawdowns of 180 to 250 feet can probably be developed.

Coefficients of transmissibility, 8,000 gpd per foot, and of storage, 0.0001, have been used to calculate the theoretical drawdown at various distances from a pumping well in the Magothy Formation after 27 years. The available drawdown in the aquifer is about 950 feet, based on a current (1965) static water level in the aquifer of about 50 feet below sea level. Because the hydraulic coefficients and the amount of available drawdown are about the same for this aquifer as they are for the Magothy Formation at Cambridge, the same analysis used in that section of this report is applied here to show that 3 mgd could be obtained from Cretaceous sands in the Easton area.

B. *Long-term Yield of the Aquia Formation*

Sands of the Aquia Formation are presently tapped by only one well in the city of Easton. Using the same method as described for the sands of Cretaceous age and based on hydraulic coefficients determined for the Aquia Formation, the hydraulic interference in the aquifer caused by a line of 5 wells spaced 1 mile apart with each well pumping 300 gpm for 10,000 days (27 years) may be computed. The theoretical drawdown at each well, caused by its own pumping, would be about 186 feet. The computations show that the line of 5 wells pumping at 300 gpm will yield 2.1 mgd. The available drawdown is about 560 feet below sea level. The total predicted drawdown in the middle well of the 5-well field is 450 feet. An additional 45 feet of drawdown was added to the theoretical drawdown to allow for estimated well losses.

Prior to the drilling of any wells to the aquifer in the area, the hydraulic head was about 5 feet above sea level. Therefore, based on the initial head, a total drawdown of 565 feet is theoretically available. The 450-foot predicted drawdown in-



a/ Upper 1100 feet of section is composite of logs from several wells of City of Easton. Remainder of section based on test hole drilled at barracks of Maryland State Police, Tal-De 18.

b/ Information available indicates these sands may not be capable of suppling quantities worthy of development by the City of Easton.

c/ Lignite

Figure 23—Geologic section of the upper 1,500 feet of sediments at Easton showing the quality of water, hydraulic characteristics, and estimated long-term yield of the principal aquifers.

cludes a safety factor of 110 feet (25 percent) to allow for possible localized decreases in aquifer transmissibility, lower-than-anticipated well efficiencies, and general regional decline in the artesian head in the aquifer caused by withdrawals from it at other localities.

C. *Long-term Yield of the Calvert Formation*

Sands in the Calvert Formation are capable of yielding only small quantities of water because they have a low coefficient of transmissibility and are so thin that little drawdown is available. One well in the Calvert Formation, Tal-Ce 2, is currently (1966) pumped at about 250 gpm for relatively short periods. However, some of the water from this well probably reaches the Calvert Formation from deeper sands of Cretaceous age by movement through well Tal-Ce 1, which is 25 feet away and taps both aquifers.

The coefficients of transmissibility (4,000 gpd per foot) and storage (0.0001) of the Calvert Formation have been used to calculate the theoretical drawdown at various distances from a pumping well. Based on drawdown calculations using these coefficients, the hydraulic interference was determined among five 12-inch diameter wells spaced 1 mile apart and pumping 40 gpm each for 27 years. The wide spacing of wells, assumed to pump at moderate rates, is necessary to take full advantage of the small available drawdown. The total available drawdown is only about 85 feet, based on an initial static water level of 5 feet above sea level. The drawdown at each well in the five-well array caused by its own pumping would be about 31 feet. The total drawdown in the middle well would be about 82 feet (including an additional 15 feet to allow for well losses). The five-well array allows very little margin to provide for lower-than average well efficiencies or local decreases in transmissibility. However, the shallow depth of the Calvert and the absence of a thick confining stratum above it suggests probable recharge to the aquifer. The effect of the recharge would, of course, be to decrease the drawdown.

The long-term yield of the Calvert Formation, with five wells pumping at 40 gpm, as described above, would be 200 gpm or slightly less than 0.3 mgd.

D. *Summary*

In summary, the estimated long-term yields of the three principal aquifers in the Easton area are as follows:

Aquifer	Estimated long-term yield (mgd)
Calvert Formation	0.3
Aquia Formation	2.0
Upper Cretaceous sands, chiefly the Magothy Formation.	3.0
Total	5.3

The 1964 pumpage of 0.9 mgd was about 17 percent of the estimated 5.3 mgd available on a long-term basis. The long-term yields are conservative estimates subject to the assumptions discussed previously and allow a considerable margin of safety for adjustment as additional data are acquired.

Interformational Movement of Ground Water: The static water level is different in the various aquifers underlying Easton and thus a potential exists for water movement between the aquifers. Normally, such movement is very slow because of intervening clay beds. However, where there is a direct hydraulic connection, such as an unused well screened or otherwise open to two or more aquifers, water movement is appreciable and may be measured.

A survey to detect vertical movement of water between two aquifers was made in well Tal-Ce 3 (in the Easton well field) by E. G. Otton and T. H. Slaughter in 1958. The survey was made under nonpumping conditions using a current meter and Whitney (thermistor-type) thermometer. The results of the survey are shown in figure 24.

Part A shows construction features of the well, Part B shows the current-meter measurements (large dots indicate the location of individual measurements made at 4-foot intervals), and Part D shows the authors' interpretation of water movement. The current-meter survey (Part B) indicated movement from a depth of 820 feet to 474 feet and no movement above 474 feet. The graph

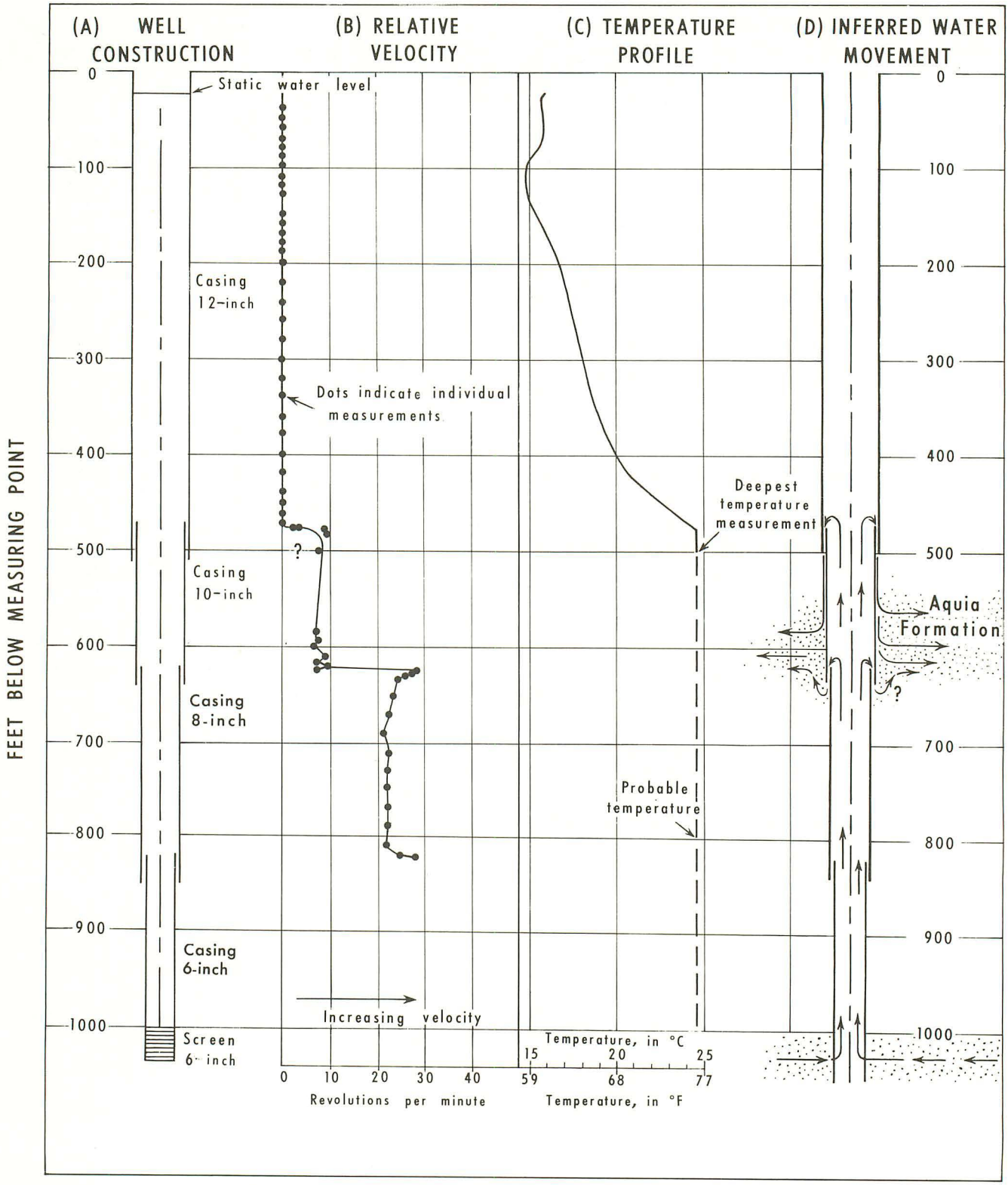


Figure 24—Diagrams showing interformational movement of water in an unpumped well, Tal-Ce 3, located in the City of Easton well field.

is only a relative indication of upward velocity because the current meter was not calibrated for conversion from revolutions per minute to gallons per minute. The decrease in apparent upward velocity was in part caused by the increase in the casing diameter—from 6 to 8 to 10 inches. The temperature survey (Part C) showed a constant temperature from a depth of 500 feet to about 475 feet and a gradual decrease from 475 to 104 feet. No measurements were made below 500 feet because of the depth limitation of the thermometer. However, because the velocity of the water moving from the bottom of the well up to 500 feet was relatively high, it is probable that the temperature of water in that zone was representative of temperatures at the bottom of the hole—ranging between 76° and 77°F.

The best interpretation of the flowmeter and temperature data is that warm water moves through the screen into the well from the sands of the Cretaceous system at the bottom, upward through the casing to a depth of 474 feet, and then out into the Aquia Formation at the overlap between the 10- and 12-inch casings. Such upward movement explains the constant temperature of water, 76.4°F between depths of 476 and 500 feet. Above 476 feet, where there is little water movement, the temperature decreases gradually to that of the shallow ground water. Some of the water probably left the casing and entered the Aquia Formation at the 640-foot level, where the 8-inch pipe is overlapped by the 10-inch pipe. This is suggested because the sudden drop in velocity at 640 feet cannot be completely explained by the increase in casing diameter.

In summary, figure 24 shows that water moves between the two aquifers in this well. The direction of movement depends on the relative hydrostatic heads in the aquifers. At the time the temperature and flow data were obtained, the hydrostatic head in the Aquia Formation was lower than that in the sand of the Cretaceous System because of pumping from well Tal-Ce 50 (in the Aquia Formation) about 100 feet east of Tal-Ce 3. At other times, when water is being pumped from the sands of Cretaceous age and well Tal-Ce 50 is idle, it is quite probable that the direction of flow in Tal-Ce 3 is reversed. Under these conditions, the water from the Aquia Formation would move down the well into the deeper sand. Currently (1966), water levels are much lower in the 1,000-foot sand than they were in 1958, and it is likely that flow is downward most of the time.

Northeastern Dorchester County

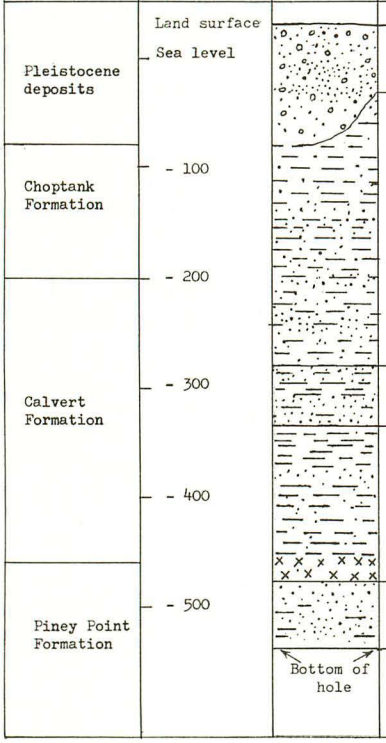
Northeastern Dorchester County, as described in this report, includes the area bounded by the Choptank River on the west, U.S. Highway 50 on the south, the Nanticoke River and the Delaware State line on the east, and Caroline County on the north. The total area is about 160 square miles and is mainly rural, but includes the villages of Hurlock, East New Market, Williamsburg, and Eldorado. Currently, the land is used principally for raising crops. Water is used to supply canneries operated on a seasonal basis, to supply homes, and to irrigate crops during periods of inadequate rainfall.

The streams in the area are characterized by large rates of fair-weather flow (base flow), indicating substantial discharge of ground water from shallow aquifers. A brief discussion of the streamflow is given in a later section of this report describing the surface water resources (area I).

Coastal Plain sediments in northeastern Dorchester County are estimated to be 3,300 to 4,000 feet thick, as shown by Rasmussen and Slaughter (1957, plate 2). Because drilling in the area to date (1966) has reached only to 557 feet, a substantial thickness of potential water-bearing sediments remains to be explored. Figure 25 shows a geologic section of the upper 550 feet of Coastal Plain sediments, the hydraulic characteristics of aquifers, and the chemical quality of the ground water. The geologic section is a composite of the lithologic logs of test holes Dor-Cg 21 (land surface to 80 feet bsl) and Dor-Ah 3 (80 to 557 feet bsl).

The aquifers underlying northeastern Dorchester County include the Piney Point Formation, the Calvert Formation, and the deposits of Pleistocene age. Little is known about the geologic or water-bearing characteristics of the thick section of sediments below the Piney Point Formation. However, it is likely that there are other aquifers in the strata of Cretaceous age, as there are elsewhere in Dorchester and Talbot Counties. Estimates were not made of the long term yield of the three aquifers shown in figure 25 because the hydraulic characteristics of the Piney Point and Calvert Formations are not well enough known in this area.

The Piney Point Formation contains water-bearing sands from 475 to 510 feet below sea



GEOLOGY			HYDRAULIC CHARACTERISTICS OF AQUIFERS				CHEMICAL QUALITY OF GROUND WATER				
Geologic unit	Position relative to sea level (feet)	Composite geologic section 1/	Aquifer or aquiclude	Transmissibility (gpd/ft)	Storage coefficient	Available drawdown (feet)	Concentration of chemical constituents and properties of water (in mg/l except for pH and temperature)				
							Constituent or property	Average	Maximum	Minimum	Number of samples
Pleistocene deposits			Aquifer	150,000	0.0005	34	Iron (Fe)	0.32	21 2/	0.00	9
							Chloride (Cl)	11	22	2.0	10
							Nitrate (NO_3)	32	95	.1	10
							Dissolved solids	112	257	54	8
							Hardness	33	77	4	10
							pH	5.9	6.9	5.1	10
							Temperature (°F)	57	60	50	7
							(°C)	14	16	10	7
Choptank Formation	- 100										
	- 200		Aquiclude								
Calvert Formation							Iron (Fe)	0.13	7.9 2/	0.01	5
							Chloride (Cl)	7.8	8.4	7.2	5
							Nitrate (NO_3)	0.3	0.8	0.06	5
	- 300		Aquifer	—	—	270	Dissolved solids	240	330	190	5
							Hardness	94	131	52	5
							pH	7.8	8.4	7.2	5
							Temperature (°F)	59	63	55	4
	- 400		Aquiclude				(°C)	15	17	13	4
Piney Point Formation							Iron (Fe)	0.07	–	–	3/
							Chloride (Cl)	8.2	–	–	
	- 500		Aquifer	—	—	450	Dissolved solids	444	–	–	
							Hardness	37	–	–	
		Bottom of hole					pH	7.9	–	–	

1/ Section from land surface to -80 feet based on data from test hole Dor-Cg 21 (test hole 2 ½ miles south of East New Market). Section from -80 feet to bottom of hole based on test hole Dor-Ah 3, (2½ miles southwest of Federalsburg).

2/ Maximum value not included in average.

3/ Data presented is average of 13 analyses for water from Dor-Bf 1 and is probably typical only of the area near the village of Secretary.

Figure 25—Geologic section of the upper 550 feet of sediments underlying northeastern Dorchester County showing the hydraulic characteristics of aquifers and chemical quality of ground water.

level. However, only one public-supply well, Dor-Bf 1 at Secretary is yielding water from the formation in this area.

Water-bearing sands in the Calvert Formation, which lie 280 to 330 feet below sea level, furnish water to several wells in the area. However, the transmissibility of the sands is low, and the Calvert is not used as a source of water except at those places where the overlying Pleistocene sands are not productive.

The Pleistocene sands, collectively, constitute a highly productive aquifer in much of northeastern Dorchester County, where they occur as a blanket of varying thickness deposited on an uneven surface on the Miocene sediments. The configuration of the base of the Pleistocene (or top of the Miocene) which is shown in figure 26, is based on test holes and drillers' logs. The altitudes shown on the map are approximate because parts of the map are based on very sketchy well logs. The main criterion for the contact between the Pleistocene and underlying Miocene deposits, a color change from yellow-brown to gray, was not noted in many of the logs. However, the contours show the approximate configuration of the base of the sands of Pleistocene age, based on the reliability of the well-log interpretation. A striking feature of the map is the trough or depression in the top of the Miocene surface northwest of Vienna. The existence of the trough is based on seven test holes drilled as part of this study and several detailed well logs furnished by the Delmarva Drilling Co. The trough contains thick beds of sand

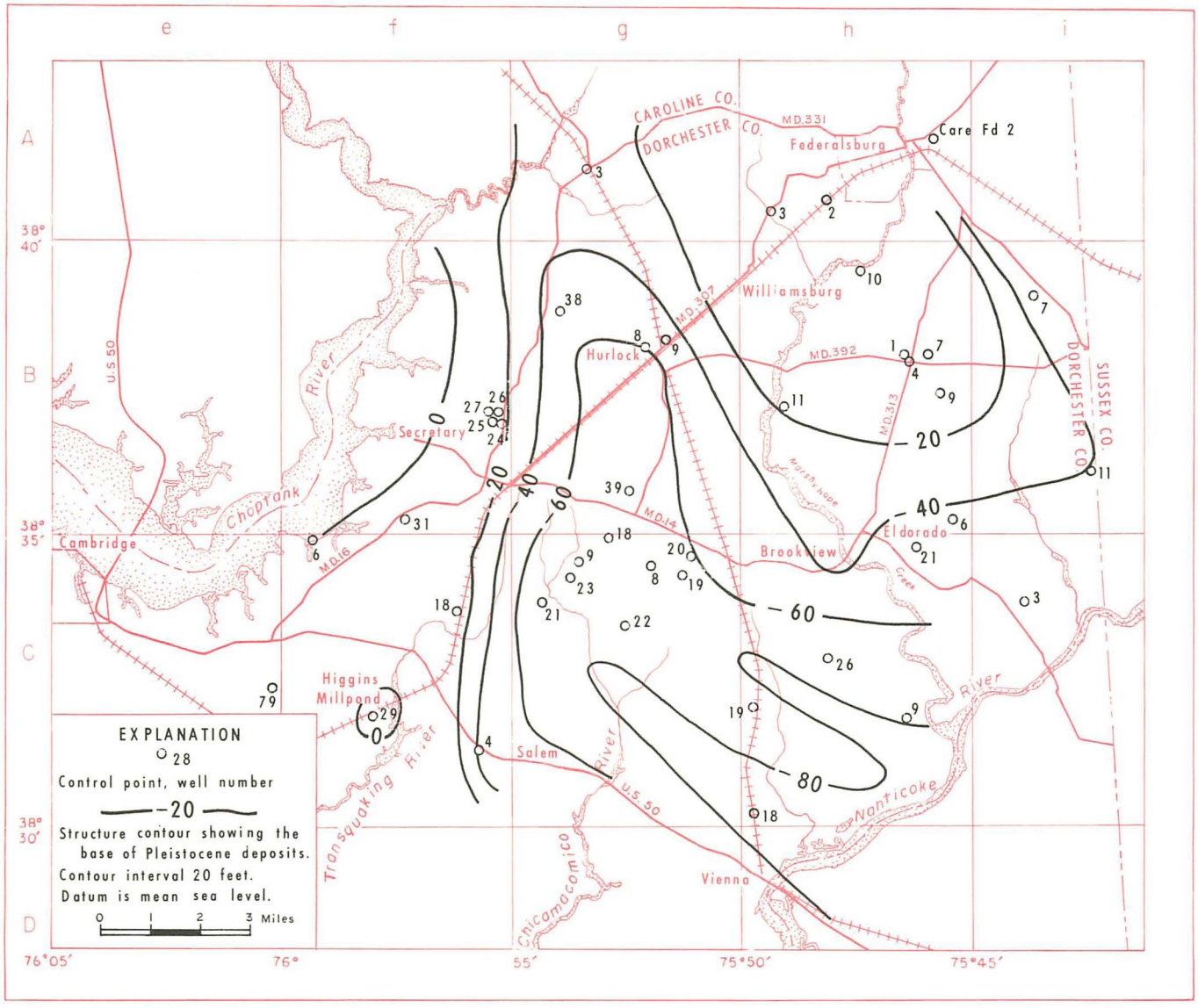


Figure 26—Map showing the altitude of the base of the Pleistocene deposits in northeastern Dorchester County.

and gravel and may be an ancient stream channel. Large quantities of water may be obtained from shallow wells in these beds. The depths, yields, and specific capacities of high-capacity wells tapping the deposits of Pleistocene age in northeastern Dorchester County are presented in table 8. The table shows that well yields as high as 1,500 gpm and specific capacities as much as 87 gpm per foot of drawdown may be obtained.

Aquifer tests were made at the sites of two of these high-yielding wells. One test consisted of pumping well Dor-Cg 9 at 700 gpm for 5 hours. At the end of pumping, the drawdown (from a static level of 5.3 feet below land surface) was only 8.15 feet.

The transmissibility, as calculated from water-level recovery data, is 175,000 gpd per foot. The second test consisted of pumping well Dor-Ci 3 at 475 gpm for 5 hours. Water levels were measured both in the pumping well and in an observation well 143 feet distant. As a result of pumping, the water level in well Dor-Ci 3 declined 13.25 feet from a static water level of 9.73 feet below land surface. The water level in the observation well declined 3.19 feet from a static level of 6.53 feet. Analysis of the drawdown and recovery data indicates that the coefficient of transmissibility is about 100,000 gpd per foot and the storage coefficient is about 0.0001. The low storage coefficient indicates the water in the aquifer is under arte-

Table 8. Data for high-capacity wells in the deposits of Pleistocene age in northeastern Dorchester County and vicinity.

Well number	Depth of well (in feet)	Reported yield (gpm)	Specific capacity (gpm/ft of drawdown)	Well number	Depth of well (in feet)	Reported yield (gpm)	Specific capacity (gpm/ft of drawdown)
Dor-Bg 37	68	533	19	Dor-Cg 19	100	980	----
-Bg 38	90	1,069	26	-Cg 20	111	1,110	----
-Bg 39	85	1,067	50	-Cg 23	104	1,045	80
-Bg 55	106	600	30	-Ch 17	60	919	----
-Bh 6	94	1,110	27	-Ch 21	74	766	85
-Cg 8	112	1,500	71	-Ch 25	78	200-300	24
-Cg 9	115	1,227	87	-Ci 3	73	1.140	30
-Cg 16	117	1,175	----	Care-Fc 28	64	1,300	32
-Cg 18	104	1,120	37	Wi-Bc 52	136	931	15.5

sian conditions. However, under prolonged pumping, water-table conditions would prevail. Cuttings obtained at the time well Dor-Ci 3 was drilled showed that a thin clay layer occurs at a depth of 3 to 11 feet. The clay layer serves as a confining bed until the water level declines below its base; water-table (or unconfined) conditions then prevail.

To summarize, three aquifers, the Piney Point Formation, the Calvert Formation, and the deposits of Pleistocene age are currently being used in northeastern Dorchester County. The Pleistocene deposits are an aquifer of great potential in much of northeastern Dorchester County. Wells probably capable of yielding as much as 1,500 gpm can be completed in these deposits throughout most of the area.

QUALITY OF GROUND WATER

The quality of the ground water in Dorchester and Talbot Counties is generally good, and the water can be used for most purposes without treatment. However, there are a few areas where the water would be satisfactory for domestic use only after extensive treatment. The chemical quality has been discussed in some detail by Rasmussen and others (1957, p. 105). For a discussion of water-quality standards the reader is referred to that report or a report of the U.S. Public Health Service (1962).

Chemical analyses of water from 83 wells in the two-county area are listed in table 9. The chemical character of the water in each of the principal aquifers is summarized in table 10. The locations of the wells that were sampled for chemical analysis, and the aquifer tapped by each well are shown in figure 27. Generally, the chemical quality of ground water does not change with time at a given site, although the chloride content of the water has changed in a few wells at Cambridge.

Chemical Quality of Water by Formations

The chemical analyses in tables 9 and 10 show that the water in the various aquifers differ somewhat in chemical character. Study of the analyses shows that, although individual samples from the same formation have certain characteristics in common, there is generally a predictable areal variation in the character of the water within individual aquifers.

Sands of Cretaceous Age: The quality of water from the Raritan Formation, the deepest aquifer sampled for chemical quality in the two-county area, is known only at two sites. Water from a depth of 1360 feet below sea level from well Tal-Cb 89 at Wades Point is a calcium-sulfate type containing more iron and manganese than any other sample of ground water from the two counties. It is relatively low in dissolved solids, was moderately hard, and had a relatively low pH. Water from 1242 to 1329 feet below sea level in the Raritan well drilled at Cambridge in 1971 (Dor-Ce82) is soft with 184 mg/l of dissolved solids, 0.20 mg/l of iron and a pH of 7.8.

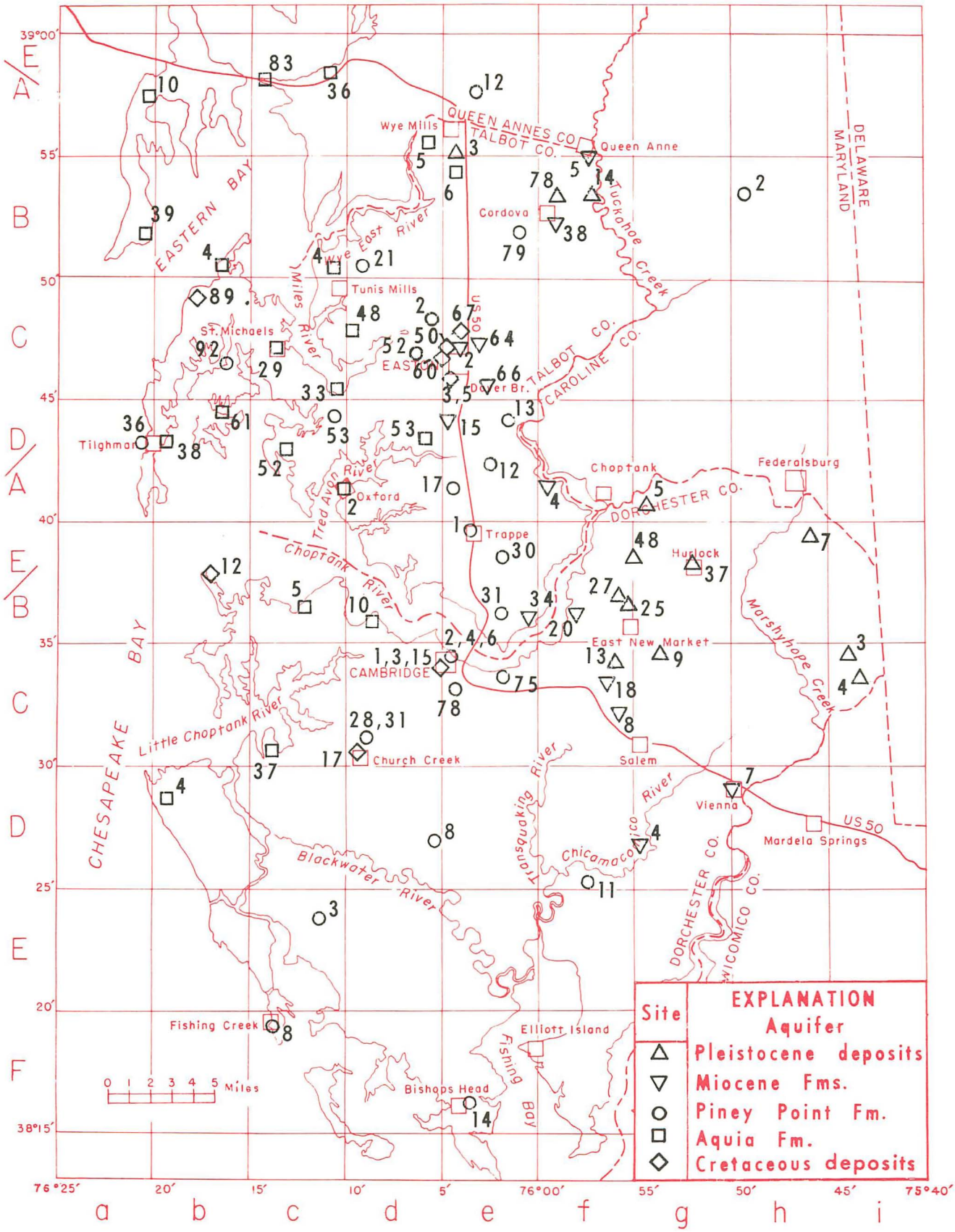


Figure 27—Map of Dorchester and Talbot Counties showing locations of wells sampled for chemical analysis, and the aquifier tapped by each.

Table 9. Chemical analyses of water from wells in or near Dorchester and Talbot Counties. (in mg/l except as indicated)

Well number	Water-bearing formation	Altitude of screen or well opening (feet)	Date of collection	Temperature (°F)	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color
Care-Dd 2	Piney Point	-	11/24/53	64	18	23	0.04	0.00	4.4	3.6	190	8	512	18	7.4	3.5	1.6	0.7	0.09	517	26	0	809	8.5	25
Dor-Ag 5	Pleistocene	-	5/20/65	-	-	19	-	-	6.2	4.7	4.7	3.0	3	0	16	9.3	.1	20	-	96	35	33	123	5.1	-
Dor-Bb 12	Cretaceous	-855 to -875	4/23/65	70	21	10	4.4	.06	9.6	5.8	7.1	9.6	76	0	10	1.5	.3	.0	-	89	48	0	151	7.0	-
Dor-Bc 5	Aquia	-549 to -555	2/18/54	56	13	-	.00	-	-	-	100		224	16	8.4	3.0	-	.4	-	-	6	0	411	8.5	-
Dor-Bd 10	do.	-616 to -636	12/1/65	66	19	12	.13	.00	2.4	2.4	188	9.0	492	0	9.4	6.0	3.2	.2	-	473	16	0	754	8.0	3
Dor-Bf 20	Miocene	-	9/16/65	63	17	58	.05	.00	32	5.6	26	6.1	192	0	5.0	2.3	.4	.1	-	220	103	0	296	7.8	-
Dor-Bf 25	Pleistocene	-	10/8/53	-	-	-	.02	-	-	-	3.9		7	0	1.0	2.0	-	3.6	-	-	4	0	36	5.8	-
Dor-Bf 27	do.	-	10/9/53	-	-	-	.09	-	-	-	17		7	0	11	15	-	95	-	-	77	71	236	5.9	-
Dor-Bg 37	do.	+ 6 to - 26	9/16/65	50	10	18	.00	.04	17	5.7	11	3.4	9	0	28	15	.0	44	-	152	66	59	210	6.2	-
Dor-Bg 48	do.	-	10/7/65	58	14	8.4	.05	.02	5.8	5.7	9.0	84	75	0	30	22	.1	53	-	257	38	0	396	6.9	-
Dor-Bh 7	do.	-	10/7/65	59	15	16	2.4	.01	4.8	1.5	8.0	2.0	5	0	.8	8.5	.0	28	-	80	18	14	92	6.0	-
Dor-Cc 37	Aquia	-493 to -513	10/28/65	62	17	12	.06	.00	5.5	.4	78	8.2	223	0	8.1	1.7	.7	.0	-	230	15	0	349	7.9	-
Dor-Cd 17	Cretaceous	-919 to -929	2/3/55	-	-	13	.09	.02	.9	.1	58	3.4	145	0	9.2	2.0	.4	.5	.3	168	3	0	245	7.9	10
Dor-Cd 28	Piney Point	-330 to -364	2/18/54	53	12	-	.00	-	-	-	167		412	20	4.6	17	-	.2	-	-	36	0	720	8.5	-
Dor-Cd 31	do.	-339 to -369	10/15/65	63	17	38	.03	.00	14	6.8	154	13	460	0	5.8	24	1.3	.0	-	472	63	0	712	7.9	-
Dor-Ce 1	Cretaceous	-938 to -948	4/17/46	72	22	-	-	-	-	-	-	-	234	0	3	4	-	.1	-	-	9	-	388	8.0	-
Dor-Ce 2	Piney Point	-347 to -397	4/2/65	64	18	21	.04	.03	4.0	3.4	177	7.8	489	0	11	5.1	1.1	.0	-	480	24	0	750	8.2	-
Dor-Ce 2	do.	-347 to -397	1/17/52	-	-	21	.09	.00	4.6	3.3	160	7.4	432	-	16	10	1.1	.7	.4	441	25	0	685	8.4	5
Dor-Ce 2	do.	-347 to -397	10/8/48	64	18	20	.11	-	5.1	3.5	172	6.4	455	8	19	7.5	1.2	.4	-	473	27	0	766	8.0	-
Dor-Ce 3	Cretaceous	-926 to -955	4/2/65	-	-	11	.02	.01	.0	1.0	93	4.4	245	0	9.6	2.2	1.1	.0	-	248	4	0	397	7.9	-
Dor-Ce 3	do.	-926 to -955	10/8/48	72	22	18	.22	-	3.2	2.4	139	5.3	358	9	14	6.8	1.0	.2	-	385	18	0	615	8.2	5
Dor-Ce 4	Piney Point	-348 to -354	2/27/58	-	-	21	.03	.01	6.0	2.3	181		434	19	15	7.5	1.3	.8	.0	471	24	0	754	8.7	9

Table 9. Chemical analyses of water from wells in or near Dorchester and Talbot Counties.—Continued (in mg/l except as indicated)

Well number	Water-bearing formation	Altitude of screen or well opening (feet)	Date of collection	Temperature (°F)	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color
Dor-Ce 6	Piney Point	-350 to -447	4/17/46	-	-	-	-	-	-	-	-	-	452	18	5.0	8.0	-	0.2	-	-	33	0	771	8.1	-
Dor-Ce 6	do.	-350 to -447	4/17/46	-	-	-	-	-	-	-	-	-	494	-	10	7.0	-	.3	-	-	30	0	770	8.1	-
Dor-Ce 15	Cretaceous	-944 to -964	2/27/58	-	-	-	-	-	-	-	-	-	219	5	-	4.0	-	-	-	260	-	-	384	8.5	-
Dor-Ce 75	Piney Point	-388 to -409	5/21/65	-	-	20	0.07	0.00	4.1	6.6	130	9.5	370	0	10	5.8	.9	.0	-	376	37	0	577	8.1	2
Dor-Ce 78	do.	-344 to -483	11/3/65	63	17	22	.06	.00	5.4	4.6	168	8.0	408	16	18	10	1.0	.5	-	456	32	0	719	8.6	3
Dor-Cf 8	Miocene	-162 to -182	2/19/54	55	13	-	.05	-	-	-	111		300	14	13	7.0	-	.8	-	-	52	0	530	8.4	-
Dor-Cf 13	Pleistocene	- 5 to - 15	10/14/65	60	16	28	21	.01	3.5	1.6	14	1.5	21	0	7.0	17	.0	.1	-	96	15	0	107	6.0	-
Dor-Cf 18	Miocene	-122 to -229	10/14/65	59	15	42	.01	.00	17	7.7	50	6.4	224	0	4.1	1.9	.3	.1	-	234	74	0	338	7.8	-
Dor-Cg 9	Pleistocene	+ 30 to - 81	11/4/65	59	15	11	.02	.00	4.4	1.4	3.1	2.0	6	0	.0	5.7	.0	15	-	54	17	12	68	6.1	3
Dor-Ci 3	do.	+ 17 to - 56	12/9/65	57	14	15	.13	.00	6.0	3.7	5.5	2.4	6	0	5.6	9.5	.0	28	-	90	30	25	115	5.8	4
Dor-Ci 4	do.	-	4/29/65	55	13	10	.17	.01	2.0	5.6	3.6	3.2	3	0	.0	8.2	.1	30	-	73	28	26	98	5.4	-
Dor-Db 4	Aquia	-535 to -541	10/15/65	65	18	12	.02	.00	4.1	.7	42	8.3	124	0	6.8	2.4	.4	.2	-	136	13	0	207	7.7	-
Dor-Dd 8	Piney Point	-406 to -437	4/20/65	65	18	17	.08	.01	5.1	3.3	186	8.8	471	0	19	24	1.6	.1	-	502	26	0	803	8.1	-
Dor-Df 11	do.	-479 to -531	4/29/65	59	15	24	.00	.00	6.3	4.3	322	12	720	0	74	65	2.3	.1	-	885	33	0	1370	8.0	-
Dor-Dg 4	Miocene	-254 to -287	4/22/65	63	17	62	.04	.01	11	7.2	312	13	672	0	60	102	.8	.1	-	914	57	0	1390	8.2	-
Dor-Dh 7	do.	-	12/9/52	-	-	55	3.0	.00	9.0	6.2	438	14	804	8	163	170	1.0	.5	0.00	1270	48	0	2030	8.5	38
Dor-Ec 3	Piney Point	-336 to -395	2/17/54	-	-	-	-	-	-	-	186		390	22	8.2	59	-	.5	-	-	44	0	837	8.5	-
Dor-Fe 8	do.	-337 to -400	4/28/65	64	18	30	.10	.00	8.6	5.7	178	10	452	0	11	49	1.4	.0	-	527	45	0	834	7.8	-
Dor-Fe 14	do.	-	2/26/54	58	14	25	.06	.00	7.8	5.2	300	16	528	14	22	195	1.4	.9	.0	864	41	0	1450	8.5	8
QA-Ea 10	Aquia	- 80 to -100	12/20/54	54	12	27	.57	.01	43	7.5	4.1	4.6	168	0	.1	3.1	.2	1.5	.0	187	139	0	297	7.5	-
QA-Ec 83	do.	-171 to -195	9/29/54	59	15	15	.06	.01	31	12	41	12	290	0	1.4	4.0	.3	1.3	.1	260	128	0	435	7.8	-
QA-Ed 36	do.	-171 to -305	12/20/54	54	12	16	.39	.00	34	11	11	12	199	0	5.0	1.3	.5	.2	.0	194	131	0	322	7.8	-

Table 9. Chemical analyses of water from wells in or near Dorchester and Talbot Counties.—Continued (in mg/l except as indicated)

Well number	Water-bearing formation	Altitude of screen or well opening (feet)	Date of collection	Temperature (°F)	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color
QA-Ee 12	Piney Point	-160 to -165	6/20/66	58	14	48	0.29	0.00	42	14	13	16	252	0	3.4	1.6	0.3	0.1	0.08	266	163	0	389	7.7	3
QA-Fa 39	Aquia	-206 to -211	12/21/54	-	-	18	.46	.02	23	4.7	85	6.2	289	0	7.0	18	1.1	.2	.1	312	77	0	507	7.8	-
Tal-Ad 5	do.	-375 to -390	9/22/65	63	17	11	.10	.00	13	3.8	56	9.8	213	0	2.5	1.1	1.9	.1	-	212	48	0	332	7.7	-
Tal-Af 5	Miocene	-	12/21/54	53	12	51	.17	.00	22	11	30	9.8	207	0	2.0	2.1	.4	1.0	.0	256	100	0	363	8.1	3
Tal-Bb 4	Aquia	-297 to -351	9/24/65	60	16	19	.42	.00	41	17	48	13	264	0	3.8	53	.2	.0	-	317	172	0	559	7.8	-
Tal-Bc 4	do.	-410 to -418	2/4/55	60	16	15	.26	.01	10	6.8	115	16	351	0	4.5	22	.5	1.4	.1	355	51	0	595	8.1	2
Tal-Bd 21	Piney Point	-178 to -193	2/4/55	57	14	48	.65	.02	26	12	67	10	325	0	6.2	3.2	.6	.6	.1	327	116	0	494	8.0	10
Tal-Be 3	Pleistocene	-	1/14/55	56	13	25	4.1	.02	.9	.8	6.0	1.0	0	0	11	9.1	.7	.2	.0	61	7	7	90	4.1	6
Tal-Be 6	Aquia	-445 to -455	2/4/55	62	17	16	.45	.01	12	5.8	134	16	406	13	4.9	6.0	1.4	2.1	.0	411	54	0	657	8.5	10
Tal-Be 79	Piney Point	-239 to -250	9/17/65	63	17	53	.15	.00	19	16	32	9.2	232	0	4.3	2.2	.3	.4	-	258	115	0	353	7.8	-
Tal-Bf 14	Pleistocene	-	2/4/55	53	12	18	.12	.03	3.0	2.2	6.4	.5	8	0	.4	7.6	.2	16	.0	63	17	10	80	5.6	5
Tal-Bf 38	Miocene	- 60 to - 92	2/26/54	53	12	-	2.4	-	-	-		7.6	208	0	1.6	3.0	-	.2	-	-	160	0	325	8.1	-
Tal-Bf 78	Pleistocene	+ 15 to - 10	9/16/65	56	14	22	.05	.00	14	2.4	3.8	1.9	29	0	2.5	6.4	.2	25	-	107	45	21	126	6.5	-
Tal-Cb 89	Cretaceous	-930 to -960	8/3/53	69	21	7.7	7.7	.15	15	5.8	3.4	4.2	56	0	26	2.0	.2	.2	.0	94	61	15	145	6.7	5
Tal-Cb 89	do.	-1340 to - 1380	8/3/53	69	21	8.2	10	.28	15	8.0	4.5	5.1	36	0	57	2.0	.1	.2	.0	124	70	41	177	6.3	5
Tal-Cb 92	Piney Point	-155 to -160	10/26/65	58	14	29	2.1	.00	32	33	7.2	22	306	0	.0	3.6	.3	.0	-	269	216	0	464	8.0	-
Tal-Cc 29	Aquia	-370 to -394	2/10/54	63	17	12	.15	.00	13	6.7	86	14	224	4	9.6	54	.3	.8	.2	338	60	0	536	8.4	6
Tal-Cc 33	do.	-497 to -507	10/26/65	64	18	14	.01	.00	5.7	3.9	126	11	308	0	11	32	.7	.3	-	347	30	0	569	8.0	-
Tal-Cd 2	Piney Point	-	10/14/65	58	14	46	.56	.02	40	11	6.5	3.4	171	0	15	6.9	.3	.0	-	216	147	7	310	7.9	-
Tal-Cd 48	Aquia	-446 to -466	10/28/65	61	16	13	.05	.00	7.7	7.1	151	12	378	7	12	35	1.4	.0	-	429	48	0	702	8.4	-

Table 9. Chemical analyses of water from wells in or near Dorchester and Talbot Counties.—Continued (in mg/l except as indicated)

Well number	Water-bearing formation	Altitude of screen or well opening (feet)	Date of collection	Temperature (°F)	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_4)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color
Tal-Cd 52	Piney Point	-243 to -336	11/22/65	60	16	16	0.11	0.00	5.8	4.1	114	11	334	0	1.6	15	0.9	1.3	-	339	32	0	540	8.0	3
Tal-Ce 2	Miocene	-	10/7/48	59	15	56	.03	-	36	15	27	5.9	242	0	6.9	2.8	.5	.3	-	260	152	0	394	7.5	2
Tal-Ce 3	Cretaceous	-980 to -1010 open at -625	3/18/49	74	24	14	.06	-	4.8	1.2	81	1.8	210	0	15	2.5	.9	1.8	-	241	17	0	377	8.2	5
Tal-Ce 3	do.	-980 to -1010 open at -625	10/6/48	76	24	13	.13	-	4.1	2.2	72	6.9	211	0	12	2.2	.6	.9	-	221	19	0	362	7.8	3
Tal-Ce 5	do.	-1096 to -1117	3/11/49	78	26	9.5	.38	-	2.4	2.0	30	2.2	80	0	15	2.5	.2	1.6	-	111	14	0	168	7.5	15
Tal-Ce 50	Aquia	-550 to -603	4/1/65	69	21	14	.00	.01	4.0	2.4	196	8.6	550	0	12	2.1	3.7	.0	-	529	20	0	838	8.1	-
Tal-Ce 60	Cretaceous	-990 to -1025	4/1/65	75	24	12	.14	.01	6.0	1.2	81	9.4	234	0	12	1.6	.8	.0	-	243	20	0	379	7.6	-
Tal-Ce 64	Miocene	+ 19 to - 13	9/17/65	59	15	30	.32	.04	72	4.0	4.5	1.1	225	0	8.5	9.5	.2	.0	-	245	196	12	373	7.9	-
Tal-Ce 66	do.	- 82 to - 92	9/14/65	61	16	55	.10	.01	56	7.2	11	6.3	202	11	9.7	2.0	.3	.1	-	262	169	4	347	8.5	-
Tal-Ce 67	Cretaceous	-794 to -821 -1004 to -1036	9/16/65	76	24	12	.25	.01	4.0	2.4	81	7.0	232	0	13	1.6	.2	.0	-	245	20	0	363	7.5	-
Tal-Da 36	Piney Point	- 95 to -200	2/10/54	57	14	-	.82	-	-	-	-	-	260	12	.4	2.0	-	3.0	-	-	106	0	430	8.4	-
Tal-Db 38	Aquia	-407 to -437	4/9/65	62	17	14	.13	.00	24	12	10	14	176	0	3.5	1.5	.2	.2	-	175	111	0	281	7.8	-
Tal-Db 61	do.	-	10/26/65	62	17	12	.16	.00	22	10	16	14	171	0	7.4	1.7	.3	.7	-	165	98	0	281	7.7	-
Tal-Dc 2	do.	-533 to -553	3/3/65	68	20	14	.00	.00	6.6	.9	136	8.4	368	0	12	13	1.6	.0	-	386	20	0	607	8.0	-
Tal-Dc 2	do.	-533 to -553	2/5/54	68	20	-	.17	-	-	-	147		322	22	8.6	6.0	-	.8	-	-	8	0	589	8.5	-
Tal-Dc 52	do.	-477 to -489	10/26/65	61	16	13	.03	.00	10	5.6	70	12	181	0	9.8	36	.4	.0	-	241	48	0	406	7.6	-
Tal-Dc 53	Piney Point	-295 to -305	10/26/65	61	16	15	.40	.01	12	7.8	99	15	311	0	3.4	21	1.0	.3	-	333	62	0	533	7.9	-
Tal-Dd 53	Aquia	-580 to -630	9/24/65	69	21	14	.04	.00	3.2	1.5	245	9.2	572	27	11	1.6	4.2	.3	-	645	14	0	915	8.4	-
Tal-De 12	Piney Point	-336 to -354	9/15/65	65	18	60	.52	.01	45	7.7	3.7	2.8	171	0	8.5	2.6	.2	.1	-	225	144	4	277	7.8	-
Tal-De 13	do.	-325 to -330 -348 to -363	9/17/65	63	17	52	1.5	.00	45	19	9.2	8.6	265	0	5.4	.8	.3	.0	-	277	192	0	395	7.8	-

Table 9. Chemical analyses of water from wells in or near Dorchester and Talbot Counties.—Continued
(in mg/l except as indicated)

Well number	Water-bearing formation	Altitude of screen or well opening (feet)	Date of collection	Temperature (°F)	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color
Tal-De 15	Miocene	- 94 to -106	9/17/65	61	16	57	0.05	0.00	32	16	3.6	2.8	180	0	5.0	2.5	0.2	0.0	-	217	146	0	281	7.5	-
Tal-De 17	Piney Point	-316 to -331	9/17/65	64	18	53	.05	.00	20	9.7	25	8.9	182	0	8.1	.7	.4	.0	-	219	90	0	286	7.9	-
Tal-Df 4	Miocene	-150 to -165	9/23/65	62	17	61	.04	.00	21	10	64	5.7	278	0	6.2	2.1	.7	.1	-	307	94	0	418	7.9	-
Tal-Ee 1	Piney Point	-	2/9/54	65	18	-	.48	-	-	-	58		204	6	12	.2	-	1.2	-	-	64	0	354	8.4	-
Tal-Ee 30	do.	-333 to -363	9/22/65	64	18	40	.13	.00	16	1.0	75	8.2	246	0	12	1.1	.7	.1	-	281	48	0	392	7.8	-
Tal-Ee 31	do.	-359 to -379	9/23/65	64	18	28	.09	.00	7.3	4.4	174	9.2	473	4	7.2	4.6	1.1	.2	-	467	36	0	717	8.3	-
Tal-Ee 34	Miocene	-	9/23/65	61	16	63	.01	.01	33	17	74	12	370	0	4.2	9.1	.2	.5	-	385	152	0	571	8.0	-

Table 10—Summary of important chemical and physical characteristics of ground water from the principal aquifers of Dorchester and Talbot Counties.
(in mg/l except pH and temperature)

Aquifer	Hardness as $CaCO_3$			Iron (Fe)			Chloride (Cl)			Fluoride (F)			Dissolved solids (Residue at 180° C)			Bicarbonate (HCO_3)			pH			Temperature					
																						Min		Avg		Max	
	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	°F	°C	°F	°C	°F	°C
Deposits of Pleistocene age	4	31	77	0.00	0.06[2]	21	2.0	10	22	0.0	0.1	0.7	54	103	257	0.0	6[2]	75	4.1	5.8	6.9	50	10	55	13	59	15
Calvert Formation	48	112	196	.01	.32	3.0	1.9	2.7[2]	170	.2	.4	1.0	217	261[2]	1270	180	325	804	7.5	8.0	8.5	53	12	60	16	63	17
Piney Point Formation	24	75	216	.00	.36	2.1	1	5.0[2]	195	.2	.9	2.3	216	411	885	171	356	720	7.8	8.1	8.6	53	12	62	17	65	18
Aquia Formation	6	59	172	.00	.14	.57	1.1	14	54	.2	1.2	4.2	136	317	645	124	297	572	7.5	8.0	8.5	56	13	63	17	69	21
Magothy Formation	4	21	61	.02	.3[2]	7.7	1.5	2.8	6.8	.2	.6	1.1	89	211	385	56	190	358	6.7	7.7	8.5	69	21	74	23	78	26
Raritan Formation [1]	—	70	—	—	10	—	—	2	—	—	.1	—	—	124	—	—	36	—	—	6.3	—	—	—	69	21	—	—
Desirable concentration for domestic use (in mg/l)		60			<0.3			<250			0.6 to 1.7			<500			—			—		—	—	—	—	—	—

[1] One well only.
[2] Median value

Chemical analyses were made on nine samples from the Magothy Formation. Two of these analyses, from wells Tal-Cb 89 and Dor-Bb 12, indicate that in the western part of the two-county area, water from the Magothy is generally soft, of the calcium bicarbonate type, low in dissolved solids, has a pH of 6.7 to 7.0, and is high in iron. In the central part of the counties, the water can be classified as sodium bicarbonate type, soft, low in iron, and relatively high in dissolved solids. The high proportion of sodium in the total concentration of cations should be considered before use of this water for irrigation. The chemical character of water from public-supply wells at Cambridge and Easton is shown in figures 13 and 23 respectively.

Aquia Formation: Water from the Aquia Formation (table 10) is suitable for domestic use without treatment. Some water from the Aquia has a high ratio of sodium to other cations, which may limit its long-term use for irrigation.

There is a marked areal variation in the chemical quality of water from the Aquia. A gradation exists from hard water in the northwestern part of the area to soft water in the central and southern parts. In addition, there is a gradual increase in the dissolved-solids content from northwest to southeast, along the dip of the formation. Primarily on the basis of hardness, the Aquia Formation has been divided into four areas, each of similar chemical quality. Figure 28 shows the areas and the wells on which the areal classification is based. The chemical character of water in the areas may be summarized as follows:

Area I: water is hard, bicarbonate type, high in iron, and contains about 240 mg/l dissolved solids.

Area II: water is moderately hard, bicarbonate type, low in iron, and has about the same dissolved solids content as area I.

Area III: water is soft, bicarbonate type, low in iron, and contains about 300 mg/l dissolved solids.

Area IV: water is soft, bicarbonate type, low in iron, and relatively high in dissolved solids (about 550 mg/l). The fluoride concentrations in all samples from area IV exceeded 3.2 mg/l and averaged 3.7 mg/l; these concentrations are 2 to 4 times the recommended levels for drinking water (U.S. Public Health Service, 1962). The dissolved-solids content also averaged slightly above the recommended limit.

Chloride and manganese concentrations in water from all areas are substantially below the maximum recommended for drinking water.

Piney Point Formation: Water from the Piney Point Formation in most of the area can be used for domestic and industrial purposes without treatment. In southeastern Dorchester County, however, the dissolved-solids content is higher than the drinking water standards suggested by the U.S. Public Health Service (1962), but the water is usable if a better supply is not available.

Water in the Piney Point shows an areal variation in chemical quality similar to that in the Aquia Formation. On the basis of hardness and dissolved-solids content, the Piney Point has been subdivided into three areas of similar water quality (figure 29). There is a definite gradation in chemical quality from area I to III, as may be seen in the table in figure 29. However, all water from the Piney Point is the mildly alkaline bicarbonate type.

Water from area I is very hard to moderately hard, contains excessive iron, and is high in bicarbonate. Six samples are calcium magnesium and two are sodium types. Dissolved solids in these samples averaged 250 mg/l, and silica averaged 50 mg/l.

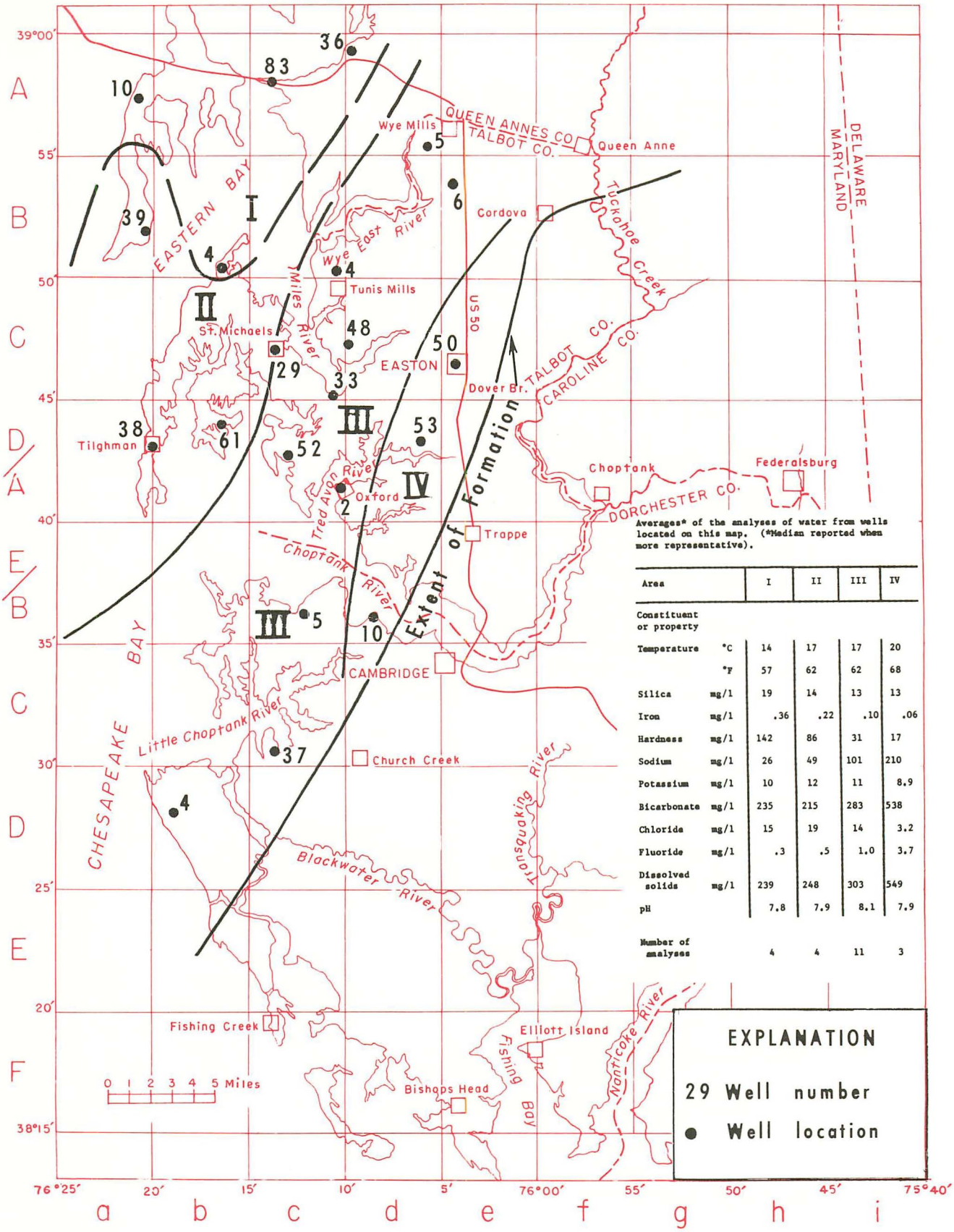
Area II is characterized by moderately hard to soft, bicarbonate type water that is low in iron and contains an average of 400 mg/l dissolved solids.

Water in area III is a soft, sodium bicarbonate type, low in iron, and contains an average of 660 mg/l dissolved solids. This water has an average of 66 mg/l chloride, which is about 10 times as much as in the other areas but well below the recommended 250 mg/l limit.

South of the Choptank River, water from the Piney Point Formation commonly has an odor of hydrogen sulfide. The city of Cambridge aerates its water to remove this gas.

Minor chemical constituents in water from the Piney Point Formation are shown in table 11. The concentrations of zinc, lithium, and boron seem to vary directly with the dissolved-solids content.

Calvert Formation: Water from the Calvert Formation is of the bicarbonate type and is characterized by its rather high silica content, which ranges from 30 to 63 mg/l and averages over 50 mg/l. Water in the formation in areas northwest of Salem differs considerably from the water in areas to the southeast. In the northwest, it meets the drinking water standards suggested by the U.S. Public Health Service. Hardness there ranges from 48 to 196 mg/l; dissolved solids range from 217 to 385 mg/l; iron averages 0.08



Averages* of the analyses of water from wells located on this map. (*Median reported when more representative).

Area		I	II	III	IV
Constituent or property					
Temperature	°C	14	17	17	20
	°F	57	62	62	68
Silica	mg/l	19	14	13	13
Iron	mg/l	.36	.22	.10	.06
Hardness	mg/l	142	86	31	17
Sodium	mg/l	26	49	101	210
Potassium	mg/l	10	12	11	8.9
Bicarbonate	mg/l	235	215	283	538
Chloride	mg/l	15	19	14	3.2
Fluoride	mg/l	.3	.5	1.0	3.7
Dissolved solids	mg/l	239	248	303	549
pH		7.8	7.9	8.1	7.9
Number of analyses		4	4	11	3

Figure 28—Map showing areal variation in chemical quality of water from the Aquia Formation.

Table 11. Minor chemical constituents in water from the Piney Point Formation.

Constituent	Number of samples	Concentration in mg/l		
		Minimum	Average	Maximum
Manganese (Mn)	20	0.00	0.00	0.03
Aluminum (Al)	3	.0	.1	.2
Phosphate (PO_4)	4	.0	.1	.4
Boron (B)	3	.5	.8	1.0
Zinc (Zn)	5	.0	.06	.28
Copper (Cu)	4	.00	.0	.0
Lithium (Li)	3	.6	2.3	5.5
Dissolved solids	----	216	411	885

mg/l; and the chloride content averages 4.1 mg/l. Water in the area southeast of Salem is soft and more mineralized. Here water from two wells in the Calvert Formation, Dor-Dg 4 and Dor-Dh 7, has a hardness of 57 and 48 mg/l, respectively; dissolved solids are 914 and 1,270 mg/l, which is substantially above the Public Health Service recommended limit of 500 mg/l, iron is 0.04 and 3.0 mg/l, respectively and chloride is 102 and 170 mg/l, respectively or about 50 times the chloride content of water in the area to the north.

In summary, the water from the Calvert Formation throughout most of the area is hard but suitable for most purposes, including drinking. The water in the extreme southeastern part of the area is more mineralized and does not meet U.S. Public Health Service standards for drinking water.

Deposits of Pleistocene Age: Water from the deposits of Pleistocene age is soft, low in dissolved solids and silica, and higher in nitrate than water from other formations. Except for excessive iron in water from 3 of the 13 wells tested, and the few rather high values for nitrate, the water meets the drinking water standards of the U.S. Public Health Service. Hardness of the water ranged from 4 to 77 mg/l and averaged 31 mg/l. Dissolved solids content ranged from 54 to 257 and averaged 103 mg/l. Chloride content ranged from 2.0 to 22 and averaged 10 mg/l. Silica ranged from 8.4 to 28 and averaged 17 mg/l. Nitrate ranges from 0.1 to 95 and averages 28 mg/l, the highest concentrations found in any aquifer in the two counties. A high concentration of nitrate in ground water can be caused by repeated use of fertilizers or by contact with wastes of warm-blooded animals, thereby becoming an end product of organic pollution. Water containing a nitrate content greater than 44 mg/l is believed to cause infant cyanosis or "blue-baby" disease.

In general, the concentrations of major constituents in water from the deposits of Pleistocene age do not range widely. No evidence was found of an areal pattern of water quality, as occurs in the Aquia and Piney Point Formations.

Changes in Chemical Quality at Cambridge

There has been no major deterioration in the chemical quality of water from the Piney Point Formation since pumping began at Cambridge around 1890. Comparison of the earliest chemical analyses with recent ones shows no significant change. However, the decline in water levels resulting from long-term pumping could cause water of less desirable quality to move into the pumping wells—downward from the saline Cambridge Creek or the Choptank River through leaking wells or laterally from the Piney Point Formation in southeastern Dorchester County.

Downward movement of saline water from Cambridge Creek or the Choptank River into the Piney Point could occur because the hydraulic head in the aquifer is substantially lower than sea level. It is likely that the water quality in the Piney Point would have changed already if it were not for the ability of clay beds overlying the Piney Point aquifer to retard vertical movement of water. However, construction of wells in the aquifer requires penetration of the clay beds and creates conduits capable of carrying water of poor quality into the aquifer.

Twice during 1965, the Cambridge public-supply well at Fletcher Avenue (Dor-Ce 6) began to yield water high in chloride (30–50 mg/l). The well was pumped to waste, and the chloride content declined toward normal (8 mg/l). In the past 50 years, several Piney Point wells bordering on Cambridge Creek (about 1,500 feet from well Dor-Ce 6) have been abandoned and were improperly or poorly sealed. Corrosive saline water from the creek is believed to have migrated into the shallow aquifer, moved into an abandoned well or wells through holes corroded in the casings and finally into the Piney Point. This downward movement occurs because the hydraulic head is 80 to 100 feet lower in the Piney Point than in the shallower aquifer. All known abandoned wells of this type have now been sealed by the city of Cambridge, but there may be others that are not known. Eventually, these abandoned wells may

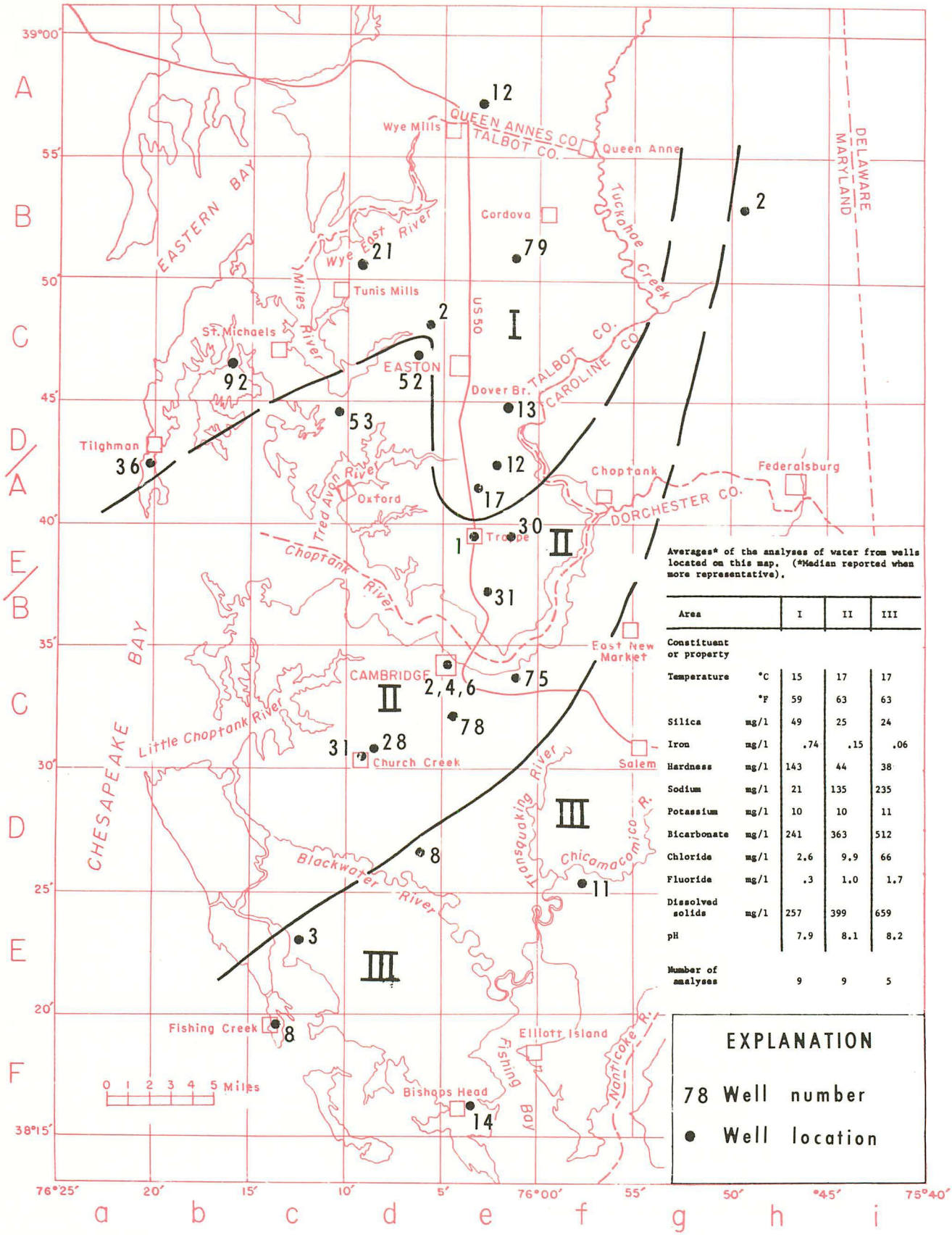


Figure 29—Map showing areal variation in chemical quality of water from the Piney Point Formation.

become sealed by sediment deposited from the water flowing into them. However, should the contaminating source be a salt-water aquifer transmitting little or no suspended debris, sealing might be slower and less effective. In either case, extensive contamination might occur before the wells become effectively sealed. The lateral movement of water from a more mineralized area of the Piney Point Formation would also cause a deterioration in the quality of water, but probably is not a serious hazard. Computations based on the permeability and hydraulic gradient (caused by present pumping) in the aquifer, indicate that several hundred years would be required to move water to Cambridge from the nearest known source of more mineralized water in the Piney Point, about 8 miles to the southeast. By the time the water reached the Cambridge area, it would have become diluted by less mineralized water moving toward Cambridge from other directions. Water resulting from this mixing would probably meet Public Health Service standards for drinking water.

Problems of Excessive Iron

The U.S. Public Health Service recommends that drinking water contain no more than 0.3 mg/l iron (1962, p. 7). Although water containing larger concentrations of iron has no toxic effect, concentrations above 0.3 mg/l are likely to be visible and to cause straining of laundry and plumbing fixtures.

High iron concentrations are one of the chief problems relating to the quality of ground water. Studies of iron in ground water are complicated because the plumbing and well casing may be sources of iron. Therefore, some of the iron concentrations reported in the analyses may not accurately represent the concentration of iron in the water in the formation. Despite the inaccuracies that may exist, the available data suggest that some water in the following aquifers in the areas indicated contains excessive iron:

Deposits of Pleistocene age	—West and south of U.S. 50.
Calvert Formation	—North of Easton in Talbot County. South of U.S. 50 and east of Vienna and Hurlock in Dorchester County.
Piney Point Formation	—North of Trappe
Aquia Formation	—Northeast of St. Michaels
Sands of Cretaceous age	—West of Oxford

SURFACE WATER RESOURCES

The surface-water resources of Dorchester and Talbot Counties are capable of only limited development for water supplies because: (1) the low relief is usually considered a deterrent to economic surface storage; (2) the high salinity of water in the major tidal streams decreases the utility of water for most purposes; and (3) the drainage basins of the small fresh-water streams are not large enough to provide adequate streamflow for most purposes. At present the only user of large amounts of surface water is an electric generating plant on the Nanticoke River at Vienna. Consumptive use of water is restricted to a small amount of pumpage for irrigation during dry periods.

This section describes briefly the streamflow characteristics and quality of surface water in the two counties. Emphasis is placed on an analysis of the low-flow characteristics of the nontidal streams and the classification of the surface water according to salinity.

Streamflow

The principal streams draining Dorchester and Talbot Counties are the Choptank and Nanticoke Rivers, which flow southwestward into Chesapeake Bay. Both rivers are tidal in the two-county area, as are many of their tributary streams. The drainage basins of these two rivers lie mostly outside the two-county area.

The Nanticoke River has the largest drainage basin on the Delmarva Peninsula—815 square miles, of which 325 square miles is in Maryland and 490 square miles is in Delaware. The Choptank drains 795 square miles, of which 692 is in Maryland and 103 is in Delaware.

Much of the two-county area is poorly drained. Swamps are found throughout the lower two-thirds of Dorchester County.

Streamflow measurements have been made at several continuous-record and partial-record sites in the two counties. The locations of stream-gaging sites are shown in figure 1. Stream discharge

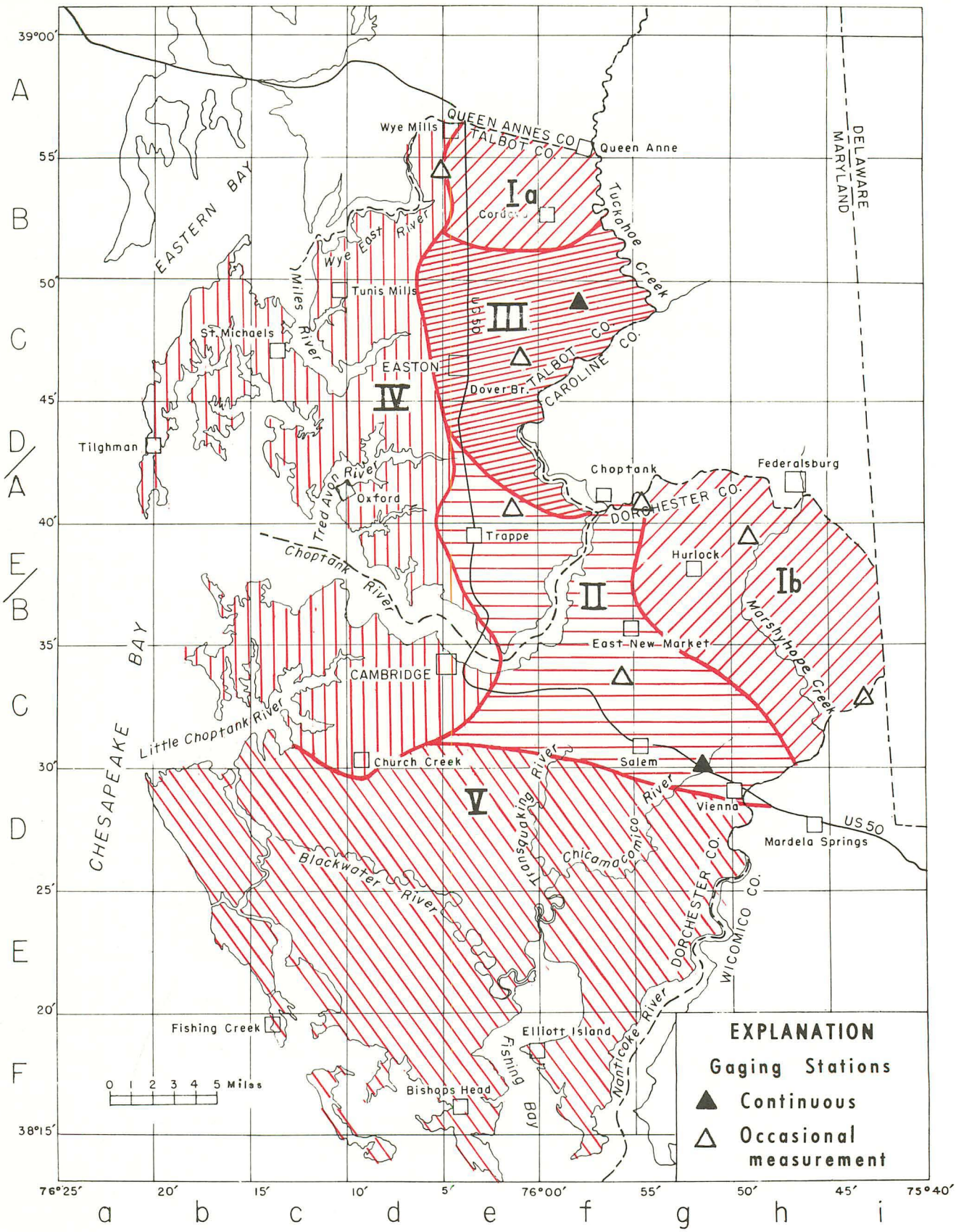


Figure 30—Map showing locations of five subdivisions having distinct streamflow characteristics.

data are published annually by the U.S. Geological Survey in cooperation with the State of Maryland and various other agencies in *Water Resources Data for Maryland and Delaware; Part I, Surface Water Records.* Streamflow data for the period prior to 1961 have been published annually in Water Supply Papers of the U.S. Geological Survery. A discussion of the surface-water resources of Caroline, Dorchester, and Talbot Counties, including many discharge records prior to 1955, is given in a report by Hulme (1957).

All stream discharge measurements have been made upstream from the tidal reaches. Determination of the net downstream fresh-water flow in tidal streams is more difficult and expensive than the measurement of the discharge of non-tidal streams.

Development of the Present Drainage System: Prior to the development of the present river system, older, now buried rivers drained the area now occupied by Dorchester and Talbot Counties and probably discharged to the east. The older rivers produced an erosional surface of much greater relief than the present land surface. Rising sea levels during Pleistocene time resulted in these rivers filling their channels and valleys with sediment. As sea level rose above its present level, much of the interfluvial area was mantled with the coarse-grained deposits found at the land surface today. The material deposited during Pleistocene time was characteristically more coarse than the older Tertiary sediments upon which it was deposited. After the mantling of this area, sea level again fell, and the modern drainage system developed. During low stands of the sea in the Quaternary period, the rivers also cut their channels far below the present sea level. As sea level rose to its present position near the end of the Pleistocene, the rivers filled their channels with sediment finer than that deposited previously. These sediments are predominantly silts and clays and contain only minor quantities of the coarse sands and gravels characteristic of the older sediments. This series of events has produced a varied mixture of surficial deposits, which influence the hydrologic characteristics of the drainage basins in the area.

Classification of Drainage Areas Based on Low-Flow Characteristics: Because Dorchester and Talbot Counties have little topographic relief, there are few sites where artificial storage can be developed with which to supplement the low flow of streams. The natural storage of a basin, which supplies the low flow, is, therefore, of considerable

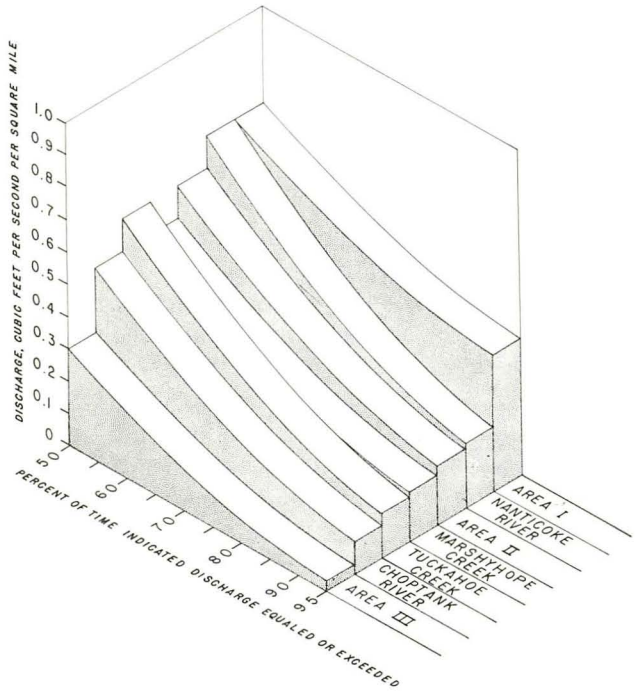


Figure 31—Graphs showing duration of low flow in Areas I, II, and III and for the major streams.

importance. A useful tool widely used to examine a basin's hydrologic characteristics, particularly its natural storage, is the streamflow-duration curve. This curve shows the percentage of time that any discharge has been equalled or exceeded. The shape of the curve indicates how the streamflow varies and also how much water is being derived from ground-water storage in the basin. The slope of the lower end of the duration curve is determined by the amount of ground-water storage in the basin. Relatively flat curves indicate a large percentage of the total runoff is from ground-water sources, whereas steep curves indicate a relatively small percentage of the total runoff is from ground-water sources. In Dorchester and Talbot Counties, ground water is discharged from surficial sands that are water-table aquifers. The low-flow parts of the flow-duration curves are indicative of the rate at which the water-table aquifers in the area discharge to streams, and of the variability of the rate of discharge.

Based on an analysis of flow-duration curves, particularly the low-flow part of these curves, Dorchester and Talbot Counties have been subdivided into five areas, each containing streams having similar hydrologic characteristics. The locations of these areas are shown in figure 30. A three-

dimensional representation of the low-flow parts of the flow-duration curves of three of these areas plus the curves for the major streams is shown in figure 31. The curves show the median rates of discharge that have been equalled or exceeded 50 to 95 percent of the time for the respective areas and streams. The hydrologic characteristics of the five areas shown in figure 30 are summarized as follows:

Area I: Little overland runoff. Large low flow supplied by ground water in storage.

Area II: Variable overland runoff and low flows. Streamflow characteristics intermediate between Areas I and III.

Area III: Appreciable overland runoff. Small flows supplied by ground water in storage.

Area IV: Area of drowned estuaries and very small fresh-water streams (no duration curve in figure 31).

Area V: Tidal marshes with negligible fresh surface water (no duration curve in figure 31).

The low-flow frequency curve is another useful tool for evaluating the hydrologic characteristics of a basin. This curve shows the average intervals of time between the recurrence of low flows of selected periods of given length. In this report, low-flow frequency curves are presented for areas I, II, and III, and for the Nanticoke River, Marshyhope Creek, Choptank River, and Tuckahoe Creek. These curves show the range in magnitude and frequency of the lowest flow for 7 consecutive days. The slope of the curves, as with flow-duration curves, reflects the contribution from ground-water storage during low flow. A steep slope indicates relatively little ground-water discharge, whereas a flat curve indicates relatively large ground-water discharge. Furthermore, a wide range of values for the 7-day minimum streamflow indicates a wide variation in the amount of ground-water discharge and variable surficial geology; a small range of values indicates a small variation in the amount of ground-water discharge and probably uniform geology.

In the following discussion, the individual areas are described and data are presented for each. These data and accompanying discussions are applicable only to streams with their drainage basins lying wholly within the individual areas. The major streams, which have appreciable parts of their drainage basins outside Dorchetser and Talbot Counties, are discussed separately. All the major streams are tidal in the area of investigation. Direct observations of discharge in these reaches, as discussed previously, are not available. The data presented, therefore, must be used with caution.

The accompanying illustrations, figures 32 to 38, show the range in values for streamflow duration (from 50 to 99 percent of duration) and for

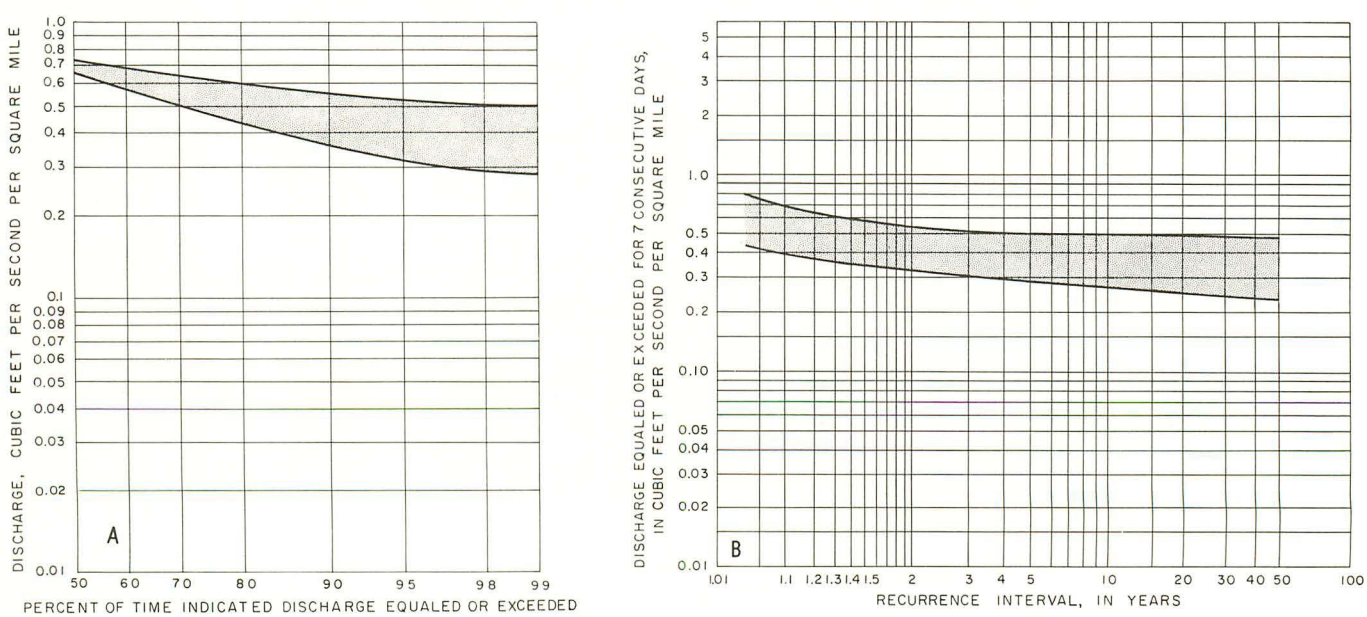


Figure 32—Graphs for Area I showing: A, range in low streamflow duration; and B, range in magnitude and frequency of 7-day minimum streamflow.

7-day minimum low flows, respectively, for areas I, II, and III, and the major streams. The curves were prepared from (1) records from continuous streamflow measuring stations, (2) low-flow data from partial-record and low-flow streamflow measuring sites, and (3) other published records. Duration and low-flow analyses for those sites with sufficient continuous record were prepared for an earlier study by Darling (1962).

Ground-water discharge to a stream in area I, in the absence of significant artificial storage, provides the dependable low-flow discharge. The low-flow discharge represented by the curve for Area I (fig. 32), is nearly all ground-water discharge.

The streamflow-duration values indicated are substantial at 90 percent of duration, ranging from about 0.36 to 0.56 cfs per sq mi (cubic feet per second per square mile). The curves show little variability, which, in turn, indicates substantial storage. This uniformity is reflected in the 7-day minimum flow values in figure 32-B. The 7-day minimum low flows with a 20-year recurrence are more than 80 percent of the 7-day minimum flows with a 2-year recurrence interval. The relatively large low-flow values and the stability of discharge from these streams in Area I is due to the relatively thick surficial deposits of permeable sands, which contain large quantities of water. Little, if any, overland runoff occurs in the area. Most precipitation infiltrates quickly, replenishing the surficial sand aquifers. Water that does not return to the atmosphere by evaporation or transpiration, or that does not recharge the deeper aquifers, is discharged to the streams. Though pumpage from irrigation wells in the surficial aquifers is increasing, the overall effect on the hydrology of these areas is presently insignificant.

Small surface impoundments can be used to increase water availability, though they may not be areally extensive. Such ponds reduce the hydraulic gradients to the streams on which they are constructed, thereby reducing the rate at which ground water is discharged to the reach affected by the impoundment. The net result is to increase the quantity of water retained in storage in the aquifer. Water retained in storage in this manner can be utilized to supplement low flows by lowering the water level in the pond during dry periods, thereby increasing the hydraulic gradient to the stream and consequently increasing the rate at which ground water discharges to the stream. The overall effect of this type of regulation is to reduce the slope of the duration curve.

The hydrologic characteristics of Area II are intermediate between those of Area I and Area III. Area II has more variability between streams than Area I, as is indicated by the wide range in the flow-duration curves in figure 33-A.

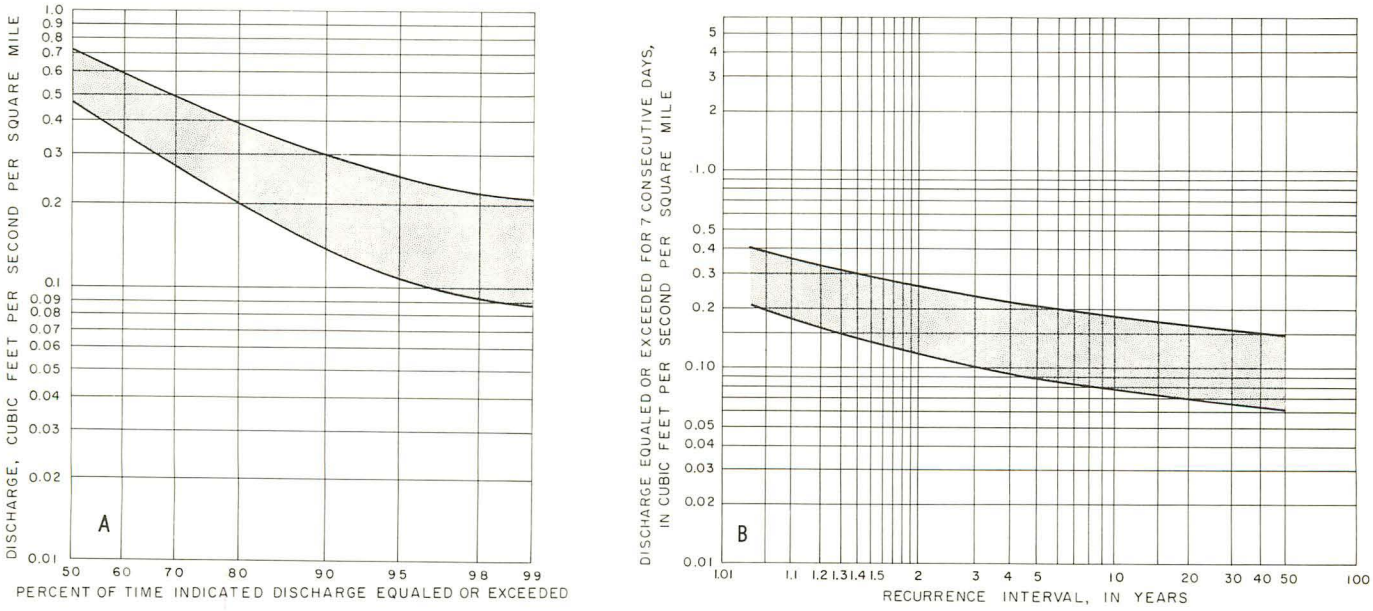


Figure 33—Graphs for Area II showing: A, range in low streamflow duration; and B, range in magnitude and frequency of 7-day minimum streamflow.

Steamflow is also more variable in any particular stream in Area II. Some parts of the area contribute significant quantities of water to streams as overland runoff. Flow-duration values for these streams are in the lower range of the values shown. The frequency curves in figure 33-B also show a relatively wide range for 7-day minimum flows. The development of reliable water supplies from many of the smaller streams in Area II could be accomplished only by supplementing low flows with surface storage, a difficult problem in this area because the flat terrain limits the availability of good reservoir sites. Large drainage basins in this area can be considered reliable sources of some water without surface storage.

Area III, in the east-central part of Talbot County (figure 30), offers little opportunity for the development of surface supplies. Even small supplies would be almost wholly dependent upon surface storage. Some streams that drain basins of several square miles in this area are perennial. However, as indicated by figure 34-A and B, other streams discharge little water and are frequently dry. Storage in the surficial sediments is small, infiltration is slow, and overland runoff is appreciable. During major storms, overland runoff from parts of this area may be many times as great as peak discharges resulting from similar storms in Area I.

Area IV consists of the western part of Talbot County and the northwestern part of Dorchester County (figure 30). The area has an irregular shore line, which is the result of the drowning of the lower reaches of the streams discharging into Chesapeake Bay. No streams with their headwaters in this area have drainage areas large enough to provide sufficient water to justify development as a water supply. The drowned reaches of streams in Area IV are tidal, and the water is salty. These drowned streams nevertheless are of great economic value. Their deep water and sheltered harbors led to the early settlement of this area, and the value of these streams is still in their utility as waterways, though primarily for recreational purposes rather than for commerce.

Area V consists of tidal marshes and sluggish meandering streams. The topography is flat; the land surface in most of the area is less than 10 feet above mean sea level. Most streams are tidal and salty. An area of this type has an essential role in the ecology of marine life, and this part of Maryland is well known for its seafood industry. This area has negligible usable fresh surface-water supplies. The changes necessary to develop such supplies would entail great expense.

Major Streams: The drainage basins of the large streams lie mostly outside the area. The data presented are applicable only to those reaches within the area of investigation. The streams are, without exception, tidal in Dorchester and Talbot

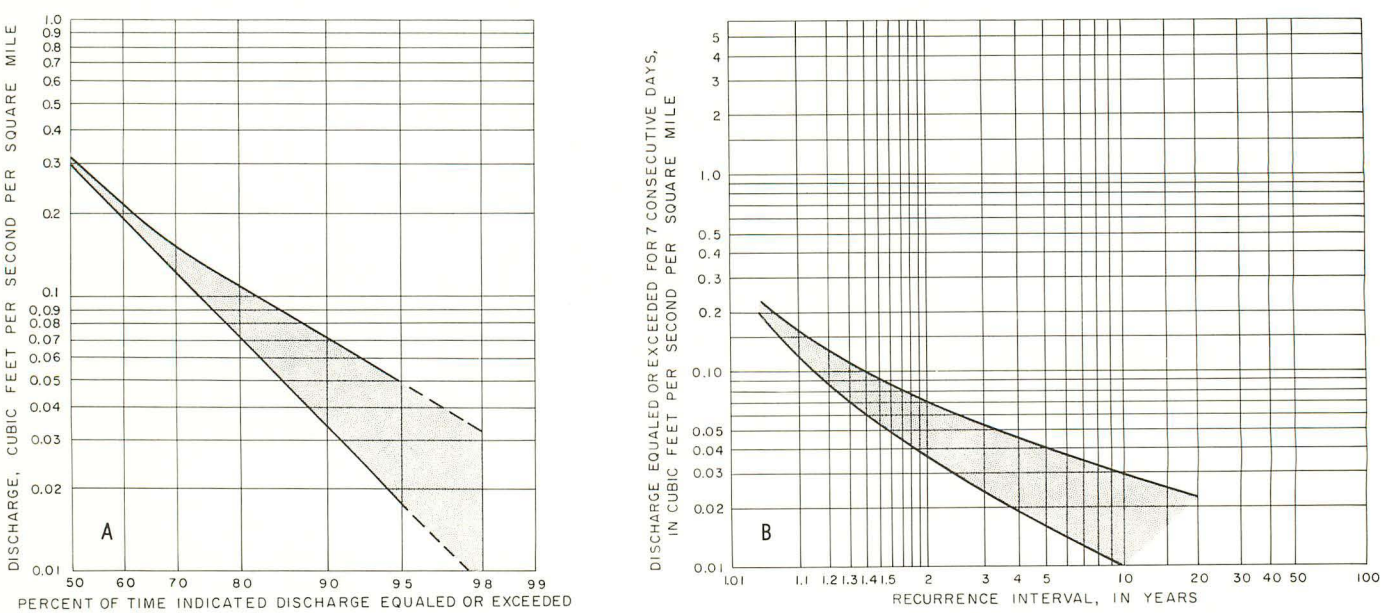


Figure 34—Graphs for Area III showing: A, range in low streamflow duration; and B, range in magnitude and frequency of 7-day minimum streamflow.

Counties and in general are salty. The low flow of the Nanticoke River is greater than that of the Choptank River.

The Nanticoke River has the largest drainage basin on the Delmarva Peninsula—393 square miles at the Delaware State Line, 415 square miles above its confluence with Marshyhope Creek, and 815 square miles at the mouth. A total of 490 square miles of the basin is in Delaware. Figure 35A shows the range in flow-duration values estimated for the reach between the Delaware State line and Vienna. For example, the fresh-water discharge that could be expected to be exceeded 90 percent of the time in this reach would be between 0.23 and 0.32 cfs per sq mi. Similar ranges are given for the minimum 7-day discharges in figure 35-B. The discharge at any point is influenced by the discharge characteristics of all the areas contributing to the stream. The spread in values, therefore, is indicative of the variability of discharge from the different contributing areas. For example, Marshyhope Creek has lower values of discharge (figure 36-A) at 90 percent of duration than the Nanticoke River. Discharge values on a unit-area basis would, therefore, be lower for the Nanticoke River below the confluence with Marshyhope Creek than above it. The relatively high rate of discharge of streams in Area I flowing directly to the Nanticoke River would have little overall influence because of their relatively small total drainage area. The values given in figure 35 do not take into consideration possible losses in the channel owing to seepage and evapotranspiration.

Marshyhope Creek drains 214 square miles of which 91 square miles is in Delaware. All the area contributing to this stream within Dorchester County is in Area I, and the contributing area is significant. The discharge characteristics of Area I, therefore, tend to increase the unit-area runoff of Marshyhope Creek. The degree to which this area modifies the streamflow characteristics of Marshyhope Creek at any particular point is dependent upon the relative size of the contributing area in Area I to the total drainage area of the stream.

On the Delmarva Peninsula, the Choptank River is second only to the Nanticoke River in the size of drainage area. At the mouth of the river the drainage area is 795 square miles, of which 103 square miles is in Delaware. The drainage area above Tuckahoe Creek is 263 square miles. Figure 37-A and 37-B show, respectively, the low-flow duration curves and the 7-day low-flow frequency curves for the Choptank River. Low-flow runoff for this drainage basin is, in general, smaller than for the Nanticoke River and does not have as wide a range, as a comparison of figures 35 and 37 shows. In general, the areas drained by the Choptank River are more homogeneous and have runoff values in the same range as Area II,

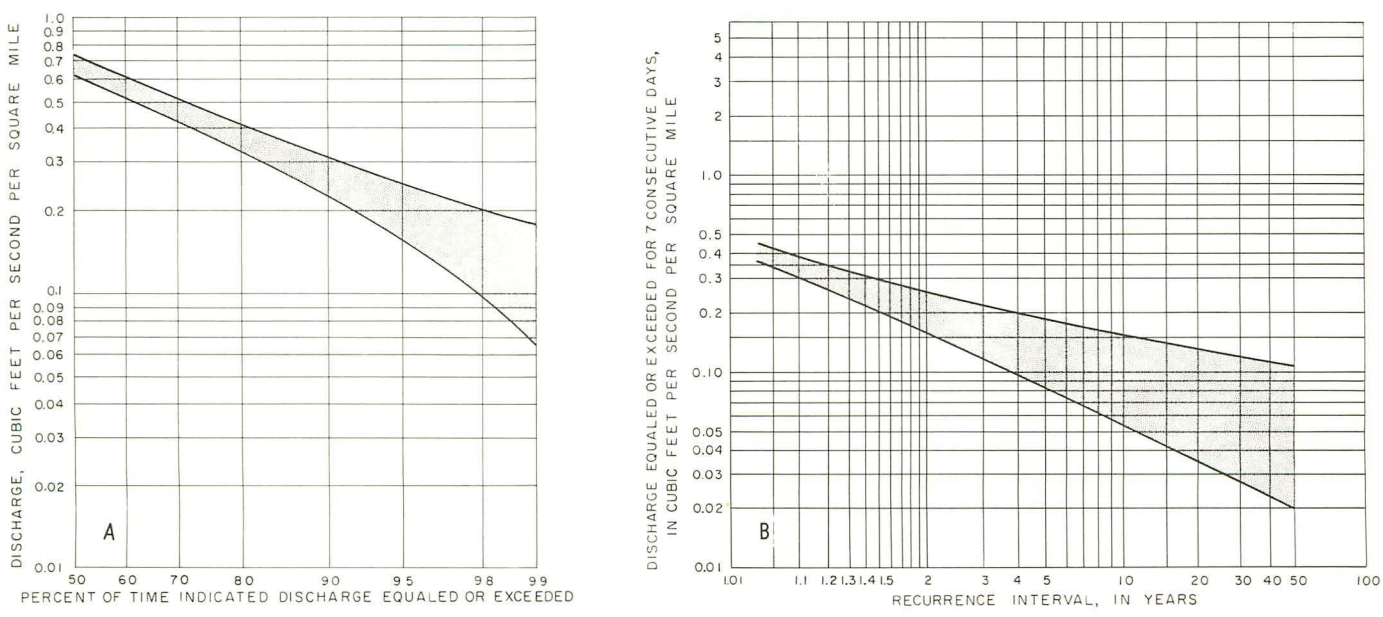


Figure 35—Graphs for Nanticoke River showing: A, range in low streamflow duration; and B, range in magnitude and frequency of 7-day minimum streamflow.

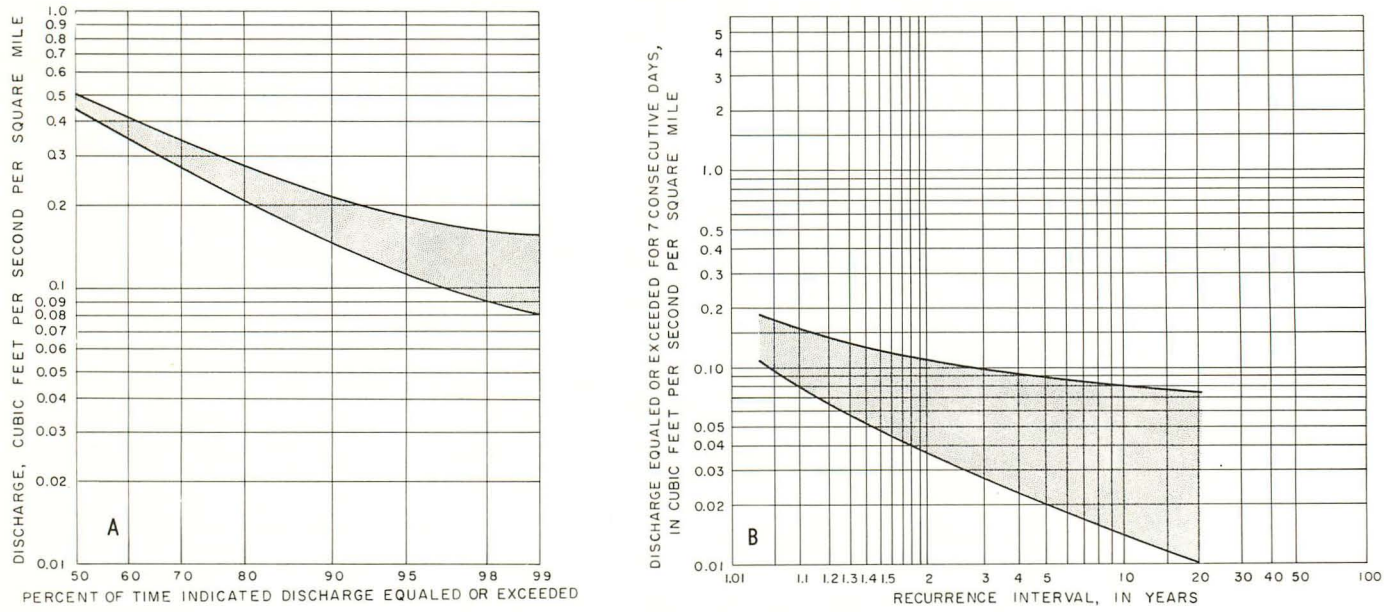


Figure 36--Graphs for Marshyhope Creek showing: A, range in low streamflow duration; and B, range in magnitude and frequency of 7-day minimum streamflow.

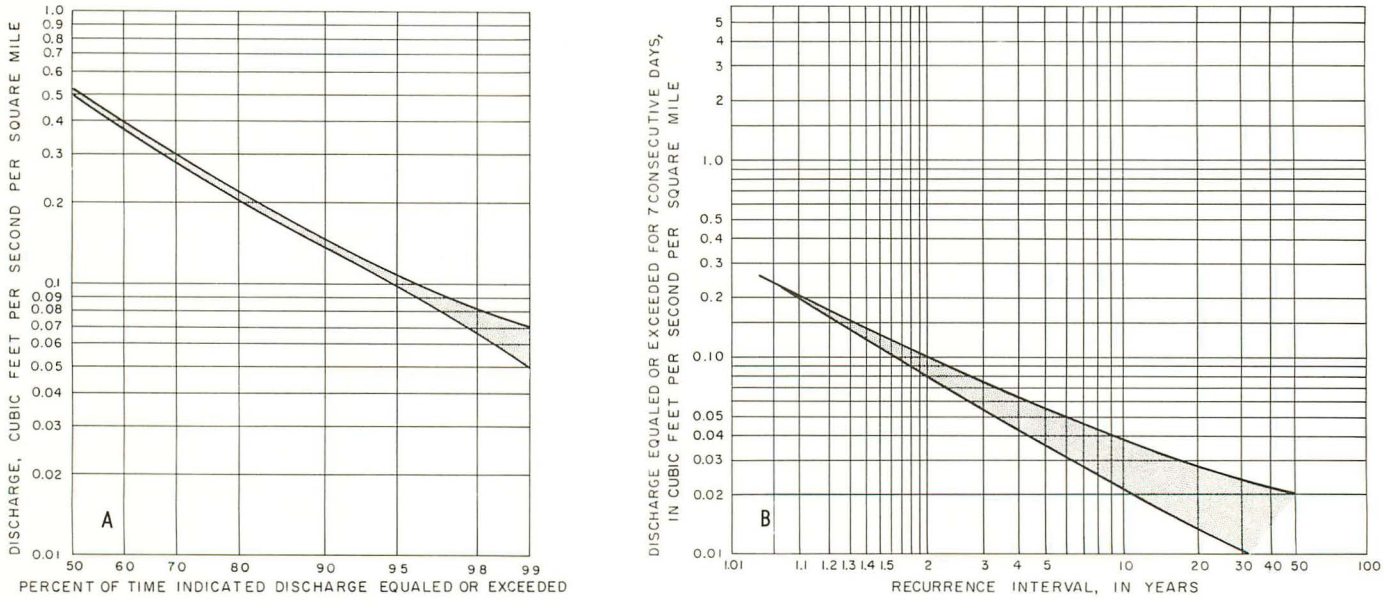


Figure 37—Graphs for Choptank River showing: A, range in low streamflow duration; and B, range in magnitude and frequency of 7-day minimum streamflow.

the most important contributing area in the reach within Dorchester and Talbot Counties.

Tuckahoe Creek is the principal tributary to the Choptank River. It drains a total of 152 square miles, most of which lies outside the study area. Figures 38-A and 38-B show low-flow duration curves and 7-day low-flow frequency curves for Tuckahoe Creek. The discharge characteristics of this stream are similar to those of the Choptank River, though low-flow runoff values of Tuckahoe Creek are somewhat higher. However, the differences are not large enough to affect significantly the low-flow characteristics of the Choptank River below its confluence with Tuckahoe Creek.

Quality of Surface Water

Surface water of Dorchester and Talbot Counties include (1) the fresh water of the streams flowing in topographically high areas, (2) the saline water of Chesapeake Bay and the lower reaches of its estuaries, and (3) mixtures of these two types in intermediate zones. Some surface water is used seasonally for irrigation. In order to describe the character and distribution of these waters in the two counties, they are arbitrarily placed into five groups on the basis of specific conductance, which is a measure of the dissolved-solids content or salinity of the water. The degree of salinity is one of several parameters limiting the use of water for irrigation. The five groups are described below and are summarized in table 12.

Type I Water (Fresh Water): Fresh water occurs in streams in the northern and central parts of Talbot County and in the northern part of Dorchester County. Table 13 presents the chemical analyses of water from five typical streams. Most of the water from the streams meets the chemical quality standards recommended by the U.S. Public Health Service for drinking water.[1] The water is generally soft, low in dissolved solids, and acidic. The waters in some streams in Talbot County contain iron concentrations that are objectionable for domestic use. For example, values for iron in samples from Mill Creek, near Skipton, and Kings Creek, 3 miles east of Easton, were 0.98 and 1.6 mg/l, respectively.

The quality of water in some streams has been modified by man. High nitrate concentrations occur in streams as well as in water-table aquifers in northeastern Dorchester County (see analysis for Skinners Run in table 13). The nitrate may be derived from fertilizers, which reach the water table after infiltrating the very permeable soils.

[1] Chlorination of all surface water used for drinking purposes is recommended.

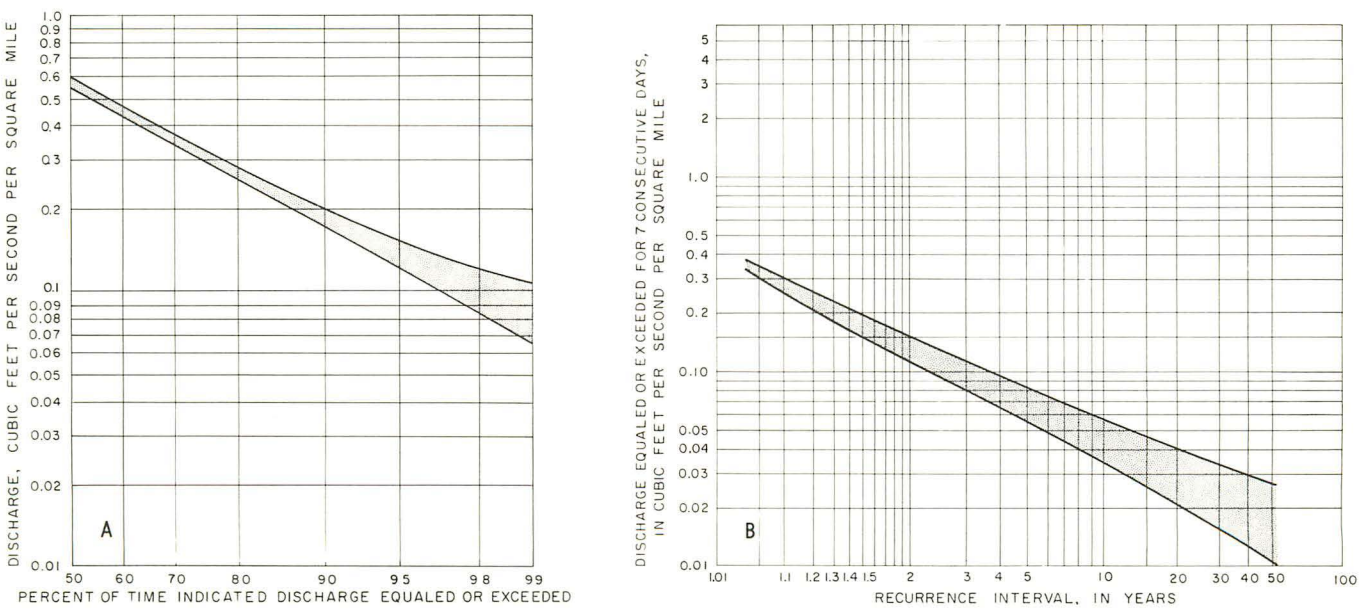


Figure 38—Graphs for Tuckahoe Creek showing: A, range in low streamflow duration; and B, range in magnitude and frequency of 7-day minimum streamflow.

Table 12. Classification of surface water in Dorchester and Talbot Counties according to specific conductance showing suitability for irrigation.

Type of water	Specific conductance (micromhos at 25° C)	Degree of hazard if used for irrigation [1]	Limitations to use for irrigation [1]	Distribution in Dorchester and Talbot Counties and nearby areas	
I (fresh)	0–250	Low	Satisfactory for most soils. Some leaching required.	Topographically high areas of northern Dorchester County and northeastern and central Talbot County.	
II (mixed)	250–750	Medium	Moderate amount of leaching required. Plants with moderate salt tolerance can be grown in most cases.	Tidal areas	Upper reaches of Choptank and Nanticoke Rivers.
III (mixed)	750–2250	High	Can possibly be used with special management techniques on soils with adequate drainage.		Variable—middle reaches of Choptank and Nanticoke Rivers.
IV (mixed)	2250–5000	Very high	May be used only under special circumstances where soils are permeable, drainage is adequate, excess leaching water is applied in profusion, and extremely salt-tolerant crops are grown.		
V (lower Chesapeake Bay water)	Greater than 5000	Destructive to soil and crops	Too mineralized to be considered for irrigation.		Chesapeake Bay and lower reaches of its estuaries.

[1] From Wilcox (1955, p. 9).

Some streams receive seasonal wastes from canneries and meat packing plants or effluent from sewage-treatment installations.

Types II, III and IV Waters (Mixed Waters): The quality of water in the upper reaches of the Choptank and Nanticoke Rivers fluctuates with time in response to variations in runoff, the phases of the tide, and the salinity of Chesapeake Bay. Most of the time, water satisfactory for irrigation can be obtained from these reaches. Occasionally, the water is too brackish for irrigation. The fluctuations in salinity result from a mixing of fresh water (type I) from upstream with saline water (type V) from Chesapeake Bay. The mixing occurs in a zone that varies in length and position.

Figure 39 is a graph showing the upstream part of the zone of mixing on the Choptank River and Tuckahoe Creek on September 9 and 10, 1964. Because streamflow during September 1964 was the September low during the 20 years of record, salinity was about as great as could be expected. Normally, the zone of water mixing is several miles downstream, and the water in the river is satisfactory for irrigation. Figure 39 shows that at high tide, specific conductance was 8,000 micromhos at Dover Bridge. Specific conductance decreased with distance upstream from Dover Bridge (type V water) to Greensboro (type I water). Comparison of the mileage scale on the graph with the scale for the water types shows that at high tide the reach of the Choptank above 18½ miles contains water of type II or type I quality. At low tide, the water of equal quality was as far downstream as the 16-mile point. Thus, the tide caused a 2½-mile fluctuation of the "fresh water" front. Type III water was as far downstream as the 13-mile point at high tide and the 9-mile point at low tide. The graph for Tuckahoe Creek shows that type III water could be obtained from its upper reaches during high tide.

Table 13. Chemical analyses of surface water in fresh-water reaches of streams.

(chemical analyses in milligrams per liter except pH)

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH	Color
															Calcium, magnesium	Noncarbonate			
Gales Creek Sampling location: Lat 38° 34′ 01″, long 75° 42′ 49″, at outlet to Galestown Millpond on State Route 531 at Galestown, Dorchester County, Md.																			
May 19, 1965	4.8	4.1	0.28	0.01	1.8	1.1	5.7	1.8	12	0.2	7.8	0.0	2.2	41	9	0	55	6.4	20
Skinners Run Sampling location: Lat 38° 39′ 46″, long 75° 48′ 38″, at bridge on unimproved road, 0.6 mile upstream from mouth, 1.0 mile northeast of Williamsburg, Dorchester County, Md.																			
May 19, 1965	3.2	11	0.00	0.01	3.8	4.0	5.1	2.9	8	2.4	10	0.0	22	77	26	20	95	6.2	—
Kings Creek Sampling location: Lat 38°47′20″, long 76°00′35″, at bridge on county road 0.8 mile downstream from confluence of Wootenaux Creek and Galloway Run and 3.5 miles east of Easton, Talbot County, Md.																			
May 19, 1965	1.9	16	1.6	0.04	12	2.7	7.0	1.8	41	4.6	11	0.1	3.8	98	41	8	121	6.6	45
Gravel Run Sampling location: Lat 38° 40′ 56″, long 75° 53′ 57″, at culvert on State Route 16, at Beulah, Dorchester County, Md.																			
May 20, 1965	6.3	8.9	0.14	0.04	3.8	2.3	5.7	2.8	12	1.8	7.7	0.0	15	64	19	9	82	6.3	—
Mill Creek Sampling location: Lat 38° 54′ 36″, long 76° 04′ 26″, at bridge on State Route 662, 1.4 miles northwest of Skipton, Talbot County, Md.																			
May 19, 1965	5.0	16	0.98	0.17	15	3.5	4.8	2.0	41	11	7.3	0.1	10	102	52	19	138	6.9	—

Table 14. Chemical character of water in Chesapeake Bay.[1]

Date	Salinity (mg/l)	Temperature		pH	Chloride (Cl) (mg/l)	Specific conductance (micromhos at 25° C)
		°C	°F			
June 28, 1963	13,500	23	74	6.6	7,490	21,000
October 11, 1963	17,900	--	--	6.9	9,900	26,400
January 15, 1964	17,300	1	34	7.4	9,600	23,600
April 13, 1964	10,300	9	49	7.0	5,700	16,600

[1] Collected at Solomons, Maryland, on Chesapeake Bay, a place believed representative of the study area.

Because of the variations in the quality of water in the sampled reaches of the Choptank and Nanticoke Rivers, the quality should be carefully monitored before the water is used.

The quality of water in the Choptank River has been studied by several other agencies, and the resulting published data are in the following references: Murphy, 1957; Hires and others, 1963; Stroup and Linn, 1963; and Longwell, 1967.

Reports on the chemical quality of water in the Potomac and Patuxent Rivers, which have characteristics similar to the Choptank, have been prepared by Durfor (1961) and Heidel and Frenier (1965), respectively.

Type V Water (Chesapeake Bay): The water in Chesapeake Bay is highly mineralized because it is diluted ocean water. Table 14, which lists the salinity and several other chemical characteristics of the water, shows that the water in Chesapeake Bay in the vicinity of the study area is most highly mineralized in the fall, when fresh-water inflow is lowest, and least mineralized in the spring, when fresh-water inflow is greatest. Maximum mineralization of water in the study area is about half the mineralization of sea water. Complete chemical analyses of this water are available from several publications (Heidel and Frenier, 1965; Murphy, 1957; Stroup, 1963; and Chesapeake Bay Institute Data Reports 17, 20, 22, and 24, 1954).

SUMMARY

Ground water is abundant in and near Dorchester and Talbot Counties, but fresh surface-water supplies are not readily available. Water in streams in the nontidal areas and in the explored aquifers is satisfactory for most purposes. However, water in Chesapeake Bay and most of the tidal reaches of its tributaries is too saline for a water supply.

The ground-water resources near Cambridge and Easton are not large for areas underlain by extensive Coastal Plain deposits. However, the available ground water is adequate for present needs, and should supply anticipated demand until at least the year 2000. Ground water is available from two sources: (1) water in the artesian aquifers that have distant sources of recharge or that are replenished by slow leakage through confining layers and that have fixed withdrawal limits, and (2) water in the shallow ground-water reservoirs that are subject to local replenishment by precipitation. Because of the high rates of recharge to the surficial aquifers, their potential as a source of water supply is large.

Water use (excluding withdrawals for cooling electric power generators) totaled 11 mgd in 1960. Pumpage of ground water averaged 10 mgd in 1960, and pumpage of surface water, mainly for irrigation, averaged 1 mgd in the same year. The largest water users were the cities of Cambridge (3.5 mgd in 1966) and Easton (about 1 mgd in 1964), and food-processing industries in the two counties.

The two-county area is underlain by a thick section of Coastal Plain sediments including sand, silt, clay, and minor amounts of gravel. The thickness of the sediments ranges from 2,200 feet in northwestern Talbot County to 4,200 feet in southeastern Dorchester County. However, only

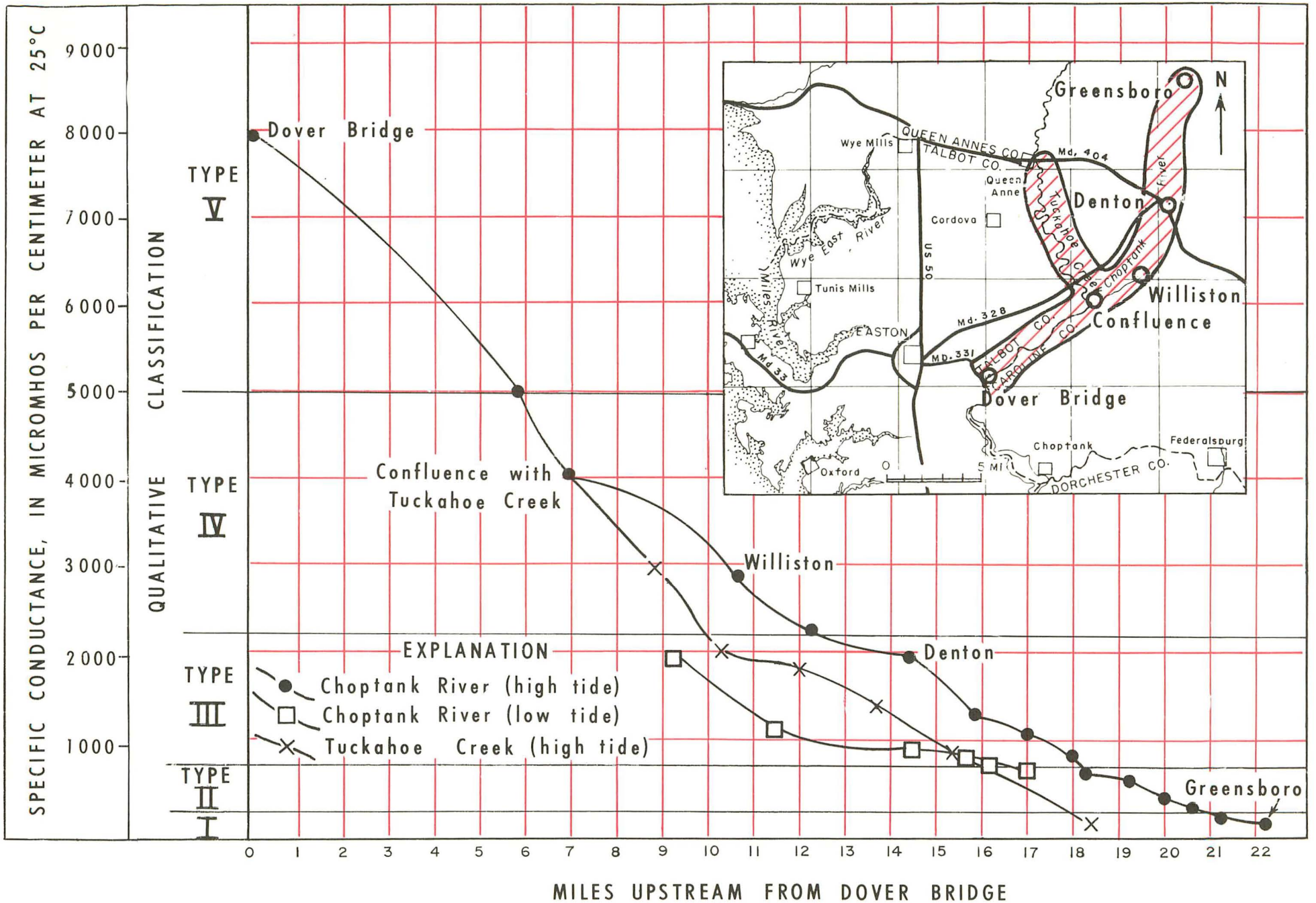


Figure 39—Graph showing specific conductance of water in the Choptank River and Tuckahoe Creek on September 9-10, 1964.

the uppermost 1,500 feet has been explored.

The principal aquifers include the sands in the Upper Cretaceous System (primarily the Magothy Formation), the Aquia Formation, the Piney Point Formation, the Calvert Formation, and the deposits of Pleistocene age. Exploratory drilling has disclosed the existence of potential aquifers in the sands of Cretaceous age in the interval from 1,100 to 1,500 feet. However, no supply wells have been constructed in these sands to date (1966).

The Magothy Formation yields water from permeable, lenticular sands that have an average transmissibility of 8,000 gpd per foot. Because it lies at depths of several hundred feet, wells completed in the Magothy have large available drawdowns, and the formation is capable of yielding larger amounts of water than are currently being pumped in the Cambridge and Easton areas.

The Aquia Formation is characterized by relatively low transmissibility (2,000 to 5,000 gpd per foot), and its greatest potential is for domestic wells in the rural areas.

The Piney Point Formation is the most important artesian aquifer in much of the area, and provides most of the water used at Cambridge, western Dorchester County, and southern Talbot County. The thickness of the water-bearing sands ranges from a few feet to more than 160 feet. The transmissibility is moderately high where tested, ranging from 9,000 to 45,000 gpd per foot.

The Calvert Formation consists of silts and thin, lenticular sands that constitute an aquifer of moderately low transmissibility (3,500 gpd per foot). These sands yield water to many wells in eastern Talbot and Dorchester Counties.

The deposits of Pleistocene age contain the most permeable sands in the area and are a highly productive aquifer in northeastern Dorchester County. The thickness of the Pleistocene deposits is variable, ranging from a few feet to more than 150 feet. Where these deposits attain their maximum thickness, the transmissibility is generally high (95,000 to 175,000 gpd), and wells yield as much as 1,500 gpm.

The city of Cambridge obtains all its water (about 3 mgd) from wells in the Piney Point and Magothy Formations. The Piney Point Formation has been the chief source of water since 1888. The deeper wells in the Magothy are less productive and have been used only since 1945.

A widespread cone of depression, centered around Cambridge, has developed in the potentiometric surface in the Piney Point Formation. It extends throughout much of the two-county area. During the past several decades the potentiometric head has declined to about 100 feet below sea level at Cambridge from an original static level of about 20 feet above sea level. The cone of depression is characterized by a relatively gentle gradient toward the center of pumping.

The amount of water that may be pumped from the Magothy and Piney Point Formations at Cambridge on a long-term basis is estimated to be 3 mgd and 8 mgd, respectively. Thus, the 1966 pumpage of 3.5 mgd from the two formations is considerably less than the combined potential yield of 11 mgd.

The city of Easton pumps about 0.92 mgd of water from wells in the sands in the Cretaceous System, the Aquia Formation, and the Calvert Formation. The Cretaceous sands are the principal source of Easton's water, supplying 72 percent of the water pumped in 1964.

The estimated long-term yields of the three principal aquifers in the Easton area are as follows: Calvert Formation, 0.3 mgd; Aquia Formation, 2.0 mgd, and the sands in the Cretaceous System, 3.0 mgd. Thus, the 1964 pumpage of 0.93 mgd is less than 17 percent of the estimated 5.3 mgd available on a long-term basis.

The long-term yields given for Cambridge and Easton are approximate figures, subject to the assumptions described in the preceding parts of this report. They are intended as guidelines for future planning and should not be taken as exact figures. To achieve the long-term yields will require that pumping levels in wells be lowered almost to the top of the aquifer being pumped. Such extensive lowering of the water levels will, of course, increase the cost of pumping water and may cause subsidence of the land surface.

The quality of the ground water is generally good, and the water from most formations can be used for nearly all purposes without treatment. There is a marked areal pattern in the quality of water from the four principal artesian aquifers. The Piney Point and Aquia Formations contain hard water in the northwestern part of the two counties, but the water is softer and higher in

dissolved solids toward the southeastern part. Water in the Magothy and Calvert Formations is low in dissolved solids in the western part of the area but high in dissolved solids in the central and southeastern parts. Water quality from the sands of Pleistocene age does not have an areal pattern. It is generally soft and low in dissolved solids throughout the entire two-county area. Some slight increased mineralization occurred temporarily in water from the Piney Point Formation at Cambridge, probably through movement of saline water from nearby creeks into abandoned wells.

The surface-water resources of the two counties are capable of only limited development because: (1) the very low relief lessens the opportunities for economic surface storage sites; (2) the high salinity of water in the major streams renders the water unsuitable for many purposes; and (3) the drainage areas of the fresh-water streams are too small to provide significant streamflow. To date (1966), surface water is used only for electric power generation and for limited irrigation purposes.

Much of the two-county area contains tidal marshes, or estuaries, or small, sluggish fresh-water streams, which have small discharge per unit area during fair weather. An exception to this generalization is northeastern Dorchester County, where the discharge of streams is substantial during low-flow periods. The somewhat high base flow of these streams is caused by ground-water discharge from the permeable Pleistocene sands.

The zone of mixing of fresh and brackish waters along the major streams changes in length and position according to variations in runoff and tidal heights in Chesapeake Bay. The quality of water in these zones of mixing, therefore, may be unsuitable for irrigation at certain times.

FUTURE MONITORING

To insure that the maximum benefits are obtained from the ground-water reservoirs utilized by the cities of Cambridge and Easton, the following types of future monitoring are suggested:

1. A network of 15 to 20 observation wells is needed for the Piney Point aquifer at Cambridge. The network would consist of existing unused wells and five or six new wells drilled for observation purposes. The wells should be spaced at regular intervals in a grid to cover the area around Cambridge. Water-level measurements should be made semiannually—once each spring and once during the peak of the canning season in the fall. From these measurements, current potentiometric maps could be prepared. The maps would delineate cones of depression and would pinpoint areas where overpumping (excessive drawdown) was occurring or is likely to occur in the near future. Pumping schedules could then be arranged to insure that water levels are not lowered excessively in one area while another area was relatively unaffected.
2. One or more observation wells is needed for the aquifers of the Cretaceous system at Easton. Inasmuch as these sands provide 70 percent of Easton's water and have the largest potential yield of any other aquifer, it is desirable to know the rate at which water levels are declining in them. It is difficult currently to assess the decline of water levels because most of the wells are screened in more than one aquifer. Thus, the measured water levels are a composite of the artesian head in several aquifers. Water-level measurements should be made on a semiannual basis in observation wells tapping only these sands. These data would show the trend of water levels in the aquifer.
3. A program of monitoring for land subsidence is needed at Cambridge—particularly, if pumpage from the Piney Point aquifer is greatly increased. This program should include:
   (a) Accurate determination of land-surface elevations by leveling from distant control points; this should be done every 5 years.
   (b) Installation of at least one subsidence recorder in an unused well screened in the Piney Point Formation in or near the center of pumping.

(c) Compaction tests should be made on cores taken from the clays and silts overlying the Piney Point Formation to evaluate possible future subsidence caused by removal of entrained water.

4. Precautions are needed to insure that the Piney Point aquifer is not contaminated by salt water at Cambridge. The deep cone of depression at Cambridge makes the hazard of salt-water contamination a distinct possibility. To guard against possible contamination, these measures should be adopted:

(a) All wells drilled to the Piney Point Formation should have the casing grouted securely from the top of the aquifer to land surface.

(b) Dredging in Cambridge Creek should be kept to a minimum. Such dredging disturbs the clay seal on the bottom of the creek and would permit infiltration of saline water into the underlying Choptank Formation. The saline water may then move into the Piney Point through holes in corroded well casings or through the annular space outside the casings.

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[1] The name of this agency was changed to the Maryland Geological Survey in June 1964.

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APPENDIX

The appendix included in this report supports preceding interpretive sections and makes selected data gathered in the course of the project readily available for reference.

Included in the appendix are lithologic logs for 10 wells or test holes and basic records for about 170 wells referred to in this report.

LITHOLOGIC LOGS

The characteristics of formations penetrated by test holes are best determined by joint utilization of geophysical logs and lithologic descriptions based on drilling data and sample descriptions. Most logs presented in table 15 were compiled in the field at the time of testing and are based on an integration of drilling and sample data. However, washed cuttings from two of the deepest test holes, Dor-Ce 77 and Tal-De 16, were studied and described in detail by J. A. Miller of the U.S. Geological Survey in Raleigh, North Carolina. These descriptions are given in table 15 with drilling data for these two test holes. Samples from the upper 500 feet of these holes are considered to be fairly representative of depths indicated. Samples from greater depths, particularly from clay beds, may be much less representative because of contamination from shallow zones. Therefore, in cases of conflicting evidence, the drilling data and geophysical logs are considered to be the best indicators of the character of the sediments at a specific depth.

Table 15. Lithologic logs of test holes.

Test hole Dor-Bh 9: 5½ miles east-southeast of Hurlock.

Thickness (feet)	Depth to base (feet)	Lithology
10	10	Sand, coarse, with some fine and medium, some gravel, silt, and clay, white
5	15	Sand, coarse, with some fine and medium, some gravel and silt, white.
5	20	Sand, fine to medium, white.
5	25	Sand, medium and coarse, with some fine, and gravel, some silt, white.
20	45	Sand, medium and coarse with some fine, and gravel, orange brown.
9	54	Sand, fine to coarse, with gravel and some silt, orange brown.
11	65	Clay and silt, organic, black.
5	70	Sand, fine to coarse, with gravel and some clay and silt, black and reddish brown.
5	75	Sand, coarse with some medium and fine, and gravel with some silt, dark brown.
5	80	Sand, fine with some silt and clay, dark brown.
16	96	Sand, fine and medium, with some clay and silt, dark brown.
4	100	Clay with a little silt, blue. Bottom of hole at 100 ft.

Test hole Dor-Bh 10: 2½ miles south of Federalsburg.

Thickness (feet)	Depth to base (feet)	Lithology
5	5	Sand, medium with some fine and coarse, some gravel, clay, and silt, light gray.
5	10	Sand, fine to coarse, with a little silt, light gray.
35	45	Sand, medium with some fine and coarse, with a little gravel, orange brown.
13	58	Sand, medium with a little fine and coarse, and a little gravel.
2	60	Clay, silt, and fine sand, blue. Bottom of hole at 60 ft.

Test hole Dor-Bh 11: 3 miles east-southeast of Hurlock.

Thickness (feet)	Depth to base (feet)	Lithology
1	1	Topsoil
19	20	Sand, medium with coarse, and gravel, white.
5	25	Sand, medium with coarse, and gravel, brown.
15	40	Sand, medium with coarse, and gravel, reddish brown.
75	115	Clay, with thin layers of silt and sand, blue gray.
25	140	Clay and silt, with some fine and medium sand, fossil fragments, blue gray. Bottom of hole at 140 ft.

Test hole Dor-Ce 77: 1½ miles east-southeast of Cambridge.

Thickness (feet)	Depth to base (feet)	Lithology	
		Driller's log (feet)	Sample description [1]
8	8	Sand, brown.	Sand, light-gray, medium- to coarse-grained, subangular to subrounded, clean. Trace white feldspar, black heavy minerals.
8	16	Clay, gray 8–10. Sand, brown 10–12. Clay, dark brown 12–16.	Clay and sand, dark-gray: 60 percent dark-gray clay matrix. 40 percent medium- to coarse-grained round sand. Trace chert (from broken gravel), fine-grained gravel.
4	20	Sand, gray.	Sand, light-gray, coarse- to very coarse-grained, subangular to subrounded, clean. White feldspar prominent.

[1] See discussion of these data in preceding text.

Table 15. Lithologic logs of test holes—(Continued)

Test hole Dor-Ce 77—(Continued)

7	27	Clay, gray 20–21. Sand, gray and white with gravel 21–27.	Gravel and sand, light-gray: 70 percent fine-grained subangular to subrounded gravel. 30 percent medium- to coarse-grained rounded sand. Trace garnet, light-gray clay.
5	32	Clay, gray.	Gravel, sand, and clay, light-gray: 50 percent medium-grained gravel. 30 percent fine- to medium-grained subangular sand. 20 percent light-gray clay matrix.
10	42	Clay, gray.	Clay, gravel, and sand, very light-gray: 50 percent very light-gray clay. 35 percent fine-grained gravel. 15 percent medium- to coarse-grained subangular to subrounded sand.
11	53	do.	Clay, very light-gray, pure. Fine to medium-grained gravel prominent. Trace coarse-grained rounded sand.
10	63	do.	Sand and clay, light-gray; 55 percent fine- to coarse-grained subangular to subrounded sand. 45 percent light-gray clay matrix.
16	79	do.	Clay, light-gray, pure. Trace shell fragments, very fine-grained muscovite.
14	93	Clay, green with shells.	Sand and shell, light-gray: 70 percent very fine to fine-grained angular to subangular sand. 30 percent shell fragments. Trace phosphate.
11	104	Clay, green with shells to 99 ft. Shells, hard, crusty 99–100. Shells with fine gray sand, and clay 100–104.	Shell hash, light-gray: Trace light-gray clay binder, coarse-grained rounded sand, pebble phosphate.
10	114	Same to 110. Hard rock from 110–112. Shells and clay, crusty 112–128.	Sandy shell limestone, light-gray: 40 percent light-gray coarse crystalline limestone matrix, fairly well indurated. 40 percent shell fragments, enclosed in limestone. 20 percent fine-grained rounded sand, enclosed in limestone. Rock layer from 110–112 feet.
10	124	Shells and clay, crusty.	Similar to above with 40 percent sand and 20 percent shell.
21	145	Clay, green with shells.	Similar to above with trace phosphate. Shell fragments very coarse.
10	155	Clay, green, with shells.	Sand and clay, medium-gray; 80 percent fine-grained subrounded well-sorted sand. 20 percent medium-gray clay. Glauconite, shell fragments prominent. Trace phosphate.
6	161	do.	Similar to above with no shell fragments.
25	186	Rock from 162–163. Crusty shells 163–171. Clay, sandy, green.	Sand, light-gray, very fine- to fine-grained, angular to subangular, light-gray clay prominent. Trace glauconite, shell fragments.
20	206	do.	Similar to above with no shell fragments.
21	227	do to 221.	Sand, light-gray, medium- to coarse-grained subangular to subrounded, water-polished. Trace light-gray clay, glauconite, phosphate.
7	234	Sand gray and crusty layers.	Clay and sand, very light-gray: 70 percent very light-gray clay. 30 percent very fine-grained angular sand. Trace glauconite shell fragments.
14	248	Clay, sandy, green.	Sand, light-gray, medium to very coarse-grained, subangular to subrounded, water-polished. Trace shell fragments, phosphate, light gray clay.
10	258	Clay, gray, with layers of crust and rock.	Sand and limestone, light-gray: 75 percent medium- to coarse-grained subrounded to rounded water-polished sand. 25 percent light-gray coarse crystalline limestone, probably as an intercalation. Trace shell fragments, phosphate.
10	268	Clay.	Sand, light-gray, fine- to medium-grained, subangular to subrounded. Trace phosphate, shell fragments, light gray clay.
31	299	Clay, sandy, green to 297. Hard and crusty 297–299.	Sand, light-gray, fine-grained, subangular, well sorted. Trace light-gray clay, shell fragments, phosphate.
10	309	Clay, green, sandy.	Clay and sand, light-gray: 50 percent light-gray clay matrix. 50 percent very fine- to fine-grained subangular sand. Trace coarse-grained sand, phosphate, shell fragments.
21	330	do.	Diatomaceous clay, light-gray: very fine- to coarse-grained angular to subrounded sand prominent. Trace muscovite, phosphate, shell fragments.

Table 15. Lithologic logs of test holes—(Continued)

Test hole Dor-Ce 77—(Continued)

40	370	Clay, sandy, green.	Similar to above with decrease in sand to trace but no phosphate or shell fragments.
7	377	Clay, sandy, green to 375. Rock 375 to 376. Sand, gray, some shells 376–393.	Clay and sand, light-gray: 60 percent light-gray clay. 40 percent fine- to coarse-grained angular to subrounded sand. Trace shell fragments, phosphate. Hard layer at 376 feet.
14	391	do.	Sand, medium-gray, medium- to coarse-grained, subrounded to rounded, water-polished. Trace dark-gray clay, phosphate, shell fragments.
10	401	Crusty, hard.	Similar to above with shell fragments prominent and a trace of glauconite.
10	411	Sand, gray and white with some shells.	Sand, light-gray with brown tinge, coarse-grained, subangular to subrounded. Light-brown shale fragments prominent. Trace glauconite
10	421	Sand and clay, gray and white.	Similar to above with glauconite prominent.
10	431	Sand, gray, brown and white with gray clay.	No sample.
10	441	do.	Similar to above with sand brown-stained in part.
11	452	do.	Sand, light-gray, medium- to very coarse-grained, subangular to subrounded, brown-stained in part. Trace shell fragments, brown (oxidized) glauconite, light-gray clay.
72	524	Sand, gray, brown, and white with gray clay to 478. Clay, green, sandy 478–524.	Similar to above with sand mostly medium-grained and green to brown (oxidized) glauconite prominent.
30	554	do.	Sand, light-gray: 70 percent medium-grained subangular sand. 15 percent coarse-grained subrounded sand. 15 percent dark-green glauconite. Trace shell fragments, light-gray clay.
12	566	do.	Similar to above, but with 20 percent glauconite, and 10 percent medium-grained sand.
10	576	do.	Glauconitic sand, medium-gray: 60 percent fine- to medium-grained subangular sand. 25 percent dark-green glauconite. 15 percent medium-gray clay matrix. Shell fragments prominent. Microfossils abundant.
10	586	Clay, soft, green.	Similar to above with trace light-gray limestone particles.
10	596	do.	Limestone, sand, and clay, light-gray: 50 percent light- to medium-gray limestone. 25 percent medium- to coarse-grained subrounded sand. 25 percent light-gray clay. Glauconite, shell fragments prominent.
21	617	do.	Similar to above with sand, fine- to medium-grained. Microfossils abundant.
10	627	Clay, soft, green, with sand.	Similar to above with 15 percent glauconite, 10 percent sand, and trace of phosphate.
10	637	Clay, green and brown, soft.	Glauconitic clay, light-gray: 50 percent dark-green glauconite. 35 percent light-gray clay matrix. 15 percent very fine- to fine-grained angular sand.
31	668	do.	Glauconitic clay, dark greenish-gray: 80 percent dark-green glauconite 20 percent medium-gray clay matrix. Fine- to medium-grained sand prominent. Trace shell fragments.
10	678	do.	Glauconitic clay and sand, light greenish-gray: 40 percent light-gray clay matrix. 30 percent fine- to medium-grained subangular sand. 30 percent glauconite. Trace pyrite, shell fragments, very coarse-grained sand.
10	688	do.	Similar to above with 40 percent glauconite and 30 percent clay.
41	729	Clay, sandy, tough, to 707. Clay, sandy, green 707–735.	Glauconitic clay, medium-gray: 50 percent medium-gray clay matrix. 40 percent glauconite. 10 per cent fine- to coarse-grained sand. Trace pyrite, shell fragments.
10	739	Clay, sandy, green.	Similar to above but with 60 percent clay, and 30 percent glauconite.
21	760	Clay, tough, gray and green with black sand.	Clay, light-gray, pure: glauconite, coarse-grained round sand prominent. Trace pyrite, shell fragments.
10	770	Clay, dark gray, soft.	Clay, light-gray: 85 percent lift-gray clay matrix. 15 percent glauconite. Fine-grained muscovite prominent. Trace coarse-grained sand, shell fragments.

Table 15. Lithologic logs of test holes—(Continued)

Test hole Dor-Ce 77—(Continued)			
21	791	do.	Clay, medium- to dark-gray, pure: glauconite, coarse-grained sand prominent. Trace pyrite, shell fragments, muscovite.
10	801	do.	Similar to above with very fine-grained angular sand prominent.
11	812	Clay, dark gray, soft.	Glauconitic clay and limestone, medium-gray: 40 percent medium-gray clay. 30 percent light-gray limestone particles. 30 percent glauconite. Trace pyrite, shell fragments, coarse-grained sand.
10	822	do.	Glauconitic clay, medium greenish-gray: 60 percent glauconite. 25 percent medium-gray clay matrix. 15 percent light-gray limestone particles (from 801–812 foot interval). Coarse-grained rounded brown-stained sand prominent. Trace shell fragments.
10	832	do.	Similar to above with 10 percent sand and 50 percent glauconite.
11	843	Sand and clay, dark brown.	Sand and clay, dark-gray: 60 percent very coarse-grained rounded brown-stained sand. 20 percent dark-gray clay matrix. 10 percent glauconite. 10 percent fine- to medium-grained sand.
20	863	do.	Similar to above with 80 percent coarse-grained sand and trace of clay.
10	873	do.	Glauconitic sand, greenish-gray: 80 percent medium- to very coarse-grained subrounded to rounded sand, brown-stained in part. 20 percent glauconite. Trace dark-gray clay, shell fragments, pyrite.
11	884	Clay, gray.	Similar to above with 30 percent glauconite and 70 percent sand.
10	894	do.	Glauconitic sand and clay, dark-gray: 40 percent green to brown (oxidized) glauconite. 40 percent very coarse-grained round sand. 20 percent dark-gray clay matrix. Fine-grained sand prominent. Trace shell fragments.
31	925	Clay, gray to 900. Clay, gray and sandy to 924.	Similar to above with sand medium- to very coarse-grained.
20	945	Clay, sandy, green to 935. Clay, tough, gray and green, with black sand to 965.	Similar to above with trace muscovite, lignite. Drilled like tough clay.
10	955	do.	Glauconitic sand and clay, medium-gray: 50 percent very fine- to fine-grained angular to subangular sand. 35 percent medium-gray clay matrix. 15 percent glauconite (probably cavings). Reddish-brown to brown siderite prominent. Trace lignite, coarse-grained sand, shell fragments.
10	965	Clay, white, and red.	Sideritic sand, light-gray: 55 percent very fine- to fine-grained angular to subangular sand. 30 percent brown to reddish-brown siderite. 15 percent light-gray clay matrix. Trace pyrite, phosphate, lignite, coarse-grained rounded sand.
11	976	Wood, 965–967. Sand, very coarse, white and pink 967–976.	Sand, coarse- to very coarse-grained, light-gray, angular to subangular, frosted, clean. Trace pyrite, siderite, lignite.
10	986	Clay, red.	Gravel, light-gray. Fine-grained, subangular, frosted, well-sorted. Light-gray clay, reddish-brown to brown siderite prominent.
10	996	Clay, tough.	Similar to above with trace pyrite.
11	1007	Clay, tough, red and gray.	Similar to above with clay prominent and 10 percent siderite.
20	1027	Clay, tough, red and gray to 1012. Clay, white to 1019. Clay, tough, red and white to 1038.	Sand and gravel, light-gray: 65 percent very fine- to fine-grained angular to sub-angular sand. 20 percent fine-grained gravel. 15 percent brown to reddish-brown siderite. Light-gray clay prominent. Trace shell fragments, hematite.
11	1038	Clay, tough, red and white.	Similar to above with decrease in gravel to trace, corresponding increase in clay and trace pyrite.
10	1048	Clay, hard, green.	Sideritic clay and sand, light-gray: 50 percent light-gray clay matrix. 20 percent medium- to coarse-grained subangular sand. 30 percent reddish-brown to brown siderite. Trace hematite, shell fragments, phosphate.
20	1068	Clay, hard, green to 1056. Sand, very fine, gray to 1058.	Sideritic sand, light-gray: 65 percent fine-grained angular sand. 35 percent reddish-brown to brown siderite. Light-gray clay prominent. Trace pyrite, hematite, shell fragments.

Table 15. Lithologic logs of test holes—(Continued)

Test hole Dor-Ce 77—(Continued)

		Clay to 1073.	
20	1088	Clay to 1073. Clay, very hard, green to 1109.	Sand, light-gray, fine-grained, well-sorted, subangular, clean. Siderite prominent. Trace hematite, phosphate, pyrite.
11	1099	do.	Sand and clay, light-gray: 55 percent very fine- to fine-grained angular to subangular sand. 30 percent light-gray clay matrix. 15 percent reddish-brown to brown siderite. Trace pyrite, lignite, hematite, shell fragments.
10	1109	do.	Sand and clay, light-gray: 50 percent coarse- to very coarse-grained rounded sand. 30 percent light-gray clay matrix. 20 percent reddish-brown to brown siderite. Pyrite, lignite prominent. Trace hematite, shell fragments.
10	1119	Clay, green interlayered with gray clay, dark.	No sample.
18	1137	do.	Sand and clay, light-brown: 50 percent very fine- to medium-grained angular to subangular sand. 20 percent reddish-brown to brown siderite. 20 percent light-brown clay matrix. 10 percent hematite. Trace pyrite.
3	1140	Clay, light gray with wood to 1161.	Sideritic sand, light reddish-brown: 60 percent fine- to medium-grained subangular sand. 30 percent reddish-brown to brown siderite. 10 percent hematite. Coarse-grained sand prominent. Trace pyrite, shell fragments, light-brown clay.
20	1160	Clay, light gray with wood.	Similar to above with 40 percent siderite and 45 percent sand.
10	1170	do.	Similar to above with pyrite prominent.
21	1191	Clay, very hard, gray.	Sand and clay, light-gray: 65 percent very fine- to medium-grained angular to subangular sand. 35 percent light-gray clay matrix. Hematite, siderite prominent. Trace pyrite, lignite.
11	1202	Clay, yellow, with wood.	Clay, sand, and siderite, yellow-brown: 50 percent yellow-brown clay matrix. 30 percent very fine- to very coarse-grained sand. 20 percent brown to reddish-brown siderite. Hematite, pyrite prominent.
10	1212	Clay, sandy, light gray and wood.	Sand and clay, light-gray: 75 percent very fine- to medium-grained angular to subangular sand. 25 percent light-gray clay matrix. Hematite, siderite, pyrite prominent.
20	1232	do.	Sand and clay, light-gray: 65 percent very fine- to fine-grained angular sand. 35 percent light-gray clay matrix. Muscovite prominent. Trace hematite, pyrite, siderite.
21	1253	Sand fine, light gray to 1243. Clay, sandy, light gray to 1273.	Sand, light-gray, fine- to medium-grained, angular to subangular. Siderite, light brownish-gray clay prominent. Trace muscovite, hematite.
10	1263	do.	Sand, light-gray, medium- to coarse-grained, subangular to subrounded, clean. Trace siderite.
10	1273	do.	Similar to above with siderite prominent.
10	1283	Clay, tough, very hard, gray to 1290. Sand, coarse, white to 1294.	Sideritic sand and clay, light-brown: 60 percent fine- to coarse-grained angular to subrounded sand. 20 percent brown to redish-brown siderite. 20 percent light-brown clay matrix. Trace hematite, pyrite.
10	1293	do.	Sand, light-brown, medium- to very coarse-grained, subangular to subrounded, clean. Trace light-brown clay, siderite, pyrite.
2	1295	do. Hard and crusty 1294–1295.	Similar to above with siderite prominent.
19	1314	Rock, very hard 1295–1296. Sand, coarse and medium, white to 1314.	Sand, light-brown: 70 percent medium-grained subangular sand. 30 percent coarse-grained sand. Trace light-brown clay, siderite.
10	1324	Clay, green.	Sand, light-brown, medium- to coarse-grained, subangular to subrounded. Trace light-brown clay, siderite, pyrite.

Table 15. Lithologic logs of test holes—(Continued)

Test hole Dor-Ce 77—(Continued)

10	1334	Clay, hard, green and gray.	Similar to above with sand fine- to medium-grained.
10	1344	Clay, tough, gray and white.	Similar to above with siderite prominent.
11	1355	do.	Sand, light-brown, medium- to coarse-grained, subangular to subrounded. Siderite, light-brown clay prominent.
20	1375	Clay, sandy, light gray.	Similar to above with sand fine- to medium-grained. Trace hematite, pyrite.
10	1385	do.	Sand, light-gray, fine-grained, subangular, well sorted. Trace light-gray clay, siderite, muscovite, pyrite.
10	1395	do.	Similar to above with sand fine- to medium-grained.
8	1403	Sand, crusty, gray and white.	Sand, light-brown, medium-grained, subangular, well-sorted. Trace siderite, light-brown clay.
4	1407	do.	No sample.
10	1417	Clay, brown, to 1409. Clay, tough, red to 1424. Clay, red and white to 1440.	Sand and clay, light-brown: 75 percent fine-to medium-grained angular to subangular sand. 25 percent light-brown clay matrix. Siderite prominent. Trace lignite, hematite, muscovite.
31	1448	Clay and hard green crust 1440 to 1468.	Similar to above with hematite prominent and trace of very coarse-grained sand.
10	1458	do.	Sand, light-red, fine-to medium-grained, angular to subangular. Hematite, light-red clay, siderite prominent. Trace coarse-grained sand.
20	1478	Same to 1468. Clay, very tough, gray from 1468 to 1488.	Similar to above with no coarse-grained sand.
10	1488	Clay, very tough, gray.	Sand and clay, light red: 40 percent very fine- to fine-grained angular sand. 30 percent light-red clay matrix. 15 percent siderite, brown to reddish-brown, 15 percent hematite. Trace pyrite,
17	1505	----------	Similar to above with fine-grained gravel prominent. Bottom of hole at 1505 ft.

Test hole Dor-Cg 21: 6 miles west of Brookview.

Thickness (feet)	Depth to base (feet)	Lithology
½	½	Sand, medium, yellow.
9½	10	Sand, medium to fine, with clay, gray.
5	15	Sand, medium to fine, with clay, gray.
5	20	Sand, medium with some fine, gray.
5	25	Sand, medium, with some fine and some coarse, white.
25	50	Sand, medium, with some fine, some coarse and some white gravel.
5	55	Sand, coarse and medium, with some fine and some gravel, white.
5	60	Gravel, with coarse and medium sand, orange brown.
5	65	Gravel, with sand from fine to coarse, and clay, white.
30	95	Sand from fine to coarse and gravel, orange brown.
5	100	Sand, fine to coarse, with silt and gravel, orange brown.
5	105	Sand, medium, with fine and coarse, and gravel, orange brown.
5	110	Sand, medium and coarse, with some fine, orange brown.
5	115	Sand, medium and coarse, with some fine, and gravel, orange brown.
5	120	Sand, from fine to coarse, with gravel, silt, and clay, brown gray.
5	125	Sand, medium and coarse, with some fine, and silt, gray.
5	130	Shell fragments, brown gray.
10	140	Sand, fine to coarse, with silt and clay. Bottom of hole at 140 ft.

Table 15. Lithologic logs of test holes—(Continued)

Test hole Dor-Cg 22: 5 miles west-southwest of Brookview.

Thickness (feet)	Depth to base (feet)	Lithology
10	10	Sand, fine to medium with clay and silt, gray.
5	15	Sand, fine to coarse, with gravel and silt, gray.
25	40	Sand, fine to coarse, with clay, silt, and gravel, orange brown.
5	45	Sand, medium with fine; some clay, silt, and gravel, orange brown.
15	60	Sand, fine to coarse, with gravel, silt, and clay, orange brown.
10	70	Sand, medium, with fine and coarse, orange brown.
10	80	Sand, medium and coarse, with fine, silt, and clay, brown.
10	90	Sand, coarse to medium, with fine, silt , and clay, reddish yellow.
10	100	Sand, coarse and medium, with fine; silt, clay, and gravel, reddish yellow.
5	105	Sand, fine with medium and coarse; gravel and clay, blue gray.
15	120	Clay, with fine to medium sand, gray. Bottom of hole at 120 ft.

Test hole Dor-Ch 26: 2¾ miles southeast of Rhodesdale.

Thickness (feet)	Depth to base (feet)	Lithology
10	10	Sand, fine to medium, brown.
5	15	Sand, fine and medium, with silt and clay, dark brown.
3	18	Clay, silt, sand, and gravel, dark brown.
12	30	Clay, silt, sand, and gravel, blue (layers of blue clay).
5	35	Clay, silt, sand, and gravel, brown (brown sand with clay layer).
5	40	Clay, silt, and from fine to coarse brown sand with clay layers.
5	45	Clay, silt, and sand from fine to coarse, blue to brown, alternating sand and clay layers.
5	50	Clay, with sand, medium, and gravel, blue and brown.
10	60	Clay, soft, with sand medium and gravel, gray.
5	65	Clay, gray, with brown sand, medium, and gravel in a layer.
5	70	Clay, some in balls, with silt and sand, some gravel, blue to brown.
5	75	Sand, clay, silt, gravel, brown.
5	80	Clay and gravel, with silt and sand, blue and brown.
20	100	Clay and some silt, blue. Bottom of hole at 100 ft.

Test hole Dor-Ch 27: 2½ miles northeast of Vienna.

Thickness (feet)	Depth to base (feet)	Lithology
5	5	Sand and silt with some clay, yellow brown.
5	10	Sand, fine to coarse, with gravel and some silt, yellow brown.
5	15	Sand, fine to coarse, with gravel and some silt, light brown.
10	25	Sand, fine to coarse, with gravel and some silt, light gray.
15	45	Sand, fine and medium with some coarse, with a little gravel and silt, orange brown.
5	50	Sand, fine to medium, with a little silt, orange brown.
5	55	Sand, fine to coarse, with a little silt and gravel, orange brown.
30	85	Sand, coarse with fine and medium, and some gravel and silt, rust brown.
25	110	Clay with some silt, blue. Bottom of hole at 110 ft.

Table 15. Lithologic logs of test holes—(Continued)

Test hole Tal-De 16: 5½ miles south of Easton, at Hambleton.

Thickness (feet)	Depth to base (feet)	Lithology: Driller's log (feet)	Lithology: Sample description [1]
10	10	Sand, gravel, and some clay, brown.	Sand and gravel, tan: 75 percent coarse-grained rounded sand. 25 percent fine-grained rounded gravel. Trace white feldspar, tan clay.
13	23	do.	Similar to above with 85 percent sand.
14	37	do.	Sand, tan, medium- to coarse-grained, subangular to subrounded. Trace hematite, white feldspar, fine-grained gravel, tan clay.
8	45	Clay, gray, sandy.	Sand, medium-gray, medium-grained, subangular to subrounded, well-sorted. Medium-gray clay prominent. Trace hematite, fine-grained gravel.
10	55	do.	Similar to above with 20 percent clay. Gravel prominent. Trace of brown clay.
10	65	Clay, sand, and shells, gray.	Sand and clay, gray to brown: 65 percent fine- to medium-grained subangular to subrounded sand. 20 percent medium-gray clay. 15 percent brown clay. Trace shell fragments, phosphate.
10	75	Clay, sand, and shell, gray.	Shell and sand, light-gray: 80 percent coarse broken water-worn shell hash. 20 percent fine-grained rounded water-polished sand. Trace phosphate.
11	86	do.	Shell hash, light-gray; very coarse fragments. Trace fine-grained rounded gravel.
10	96	do.	Sand and shell, light-gray: 65 percent fine- to medium-grained subangular to subrounded sand. 35 percent shell fragments. White limestone particles prominent.
6	102	do.	Sandy shell limestone, light-gray: 50 percent white to light-gray soft limestone matrix. 30 percent shell fragments. 20 percent fine-grained subrounded sand.
4	106	Clay, green, and shells.	Clay, light-gray, calcareous, pure. Shell fragments, fine-grained subrounded sand prominent.
10	116	do.	Sand and clay, light-gray: 55 percent fine- to medium-grained subangular to subrounded sand. 30 percent light-gray clay matrix. 15 percent shell fragments. Trace phosphate.
11	127	Sand, fine, and some clay, gray.	Sand, light-gray, fine-grained, subangular to subrounded, well-sorted. Shell fragments, phosphate prominent.
10	137	do.	Similar to above with sand fine- to medium-grained. Decrease phosphate to trace.
10	147	do.	Sand, light-gray, very fine- to medium-grained, angular to subangular. Shell fragments, fine-grained gravel, light-gray clay prominent. Trace phosphate.
10	157	do.	Sand, light-gray, fine- to medium-grained, subangular to subrounded, water-polished in part. Trace shell fragments, phosphate, coarse-grained sand.
10	167	Same to 163. Shells and some sand, crusty and gray 163–170.	Diatomaceous clay and sand, light-gray: 60 percent light-gray clay matrix. 40 percent very fine- to fine-grained angular to subangular sand. Diatoms prominent. Trace coarse-grained sand, shell fragments.
10	177	Clay, green, with streaks of shells to 358.	Diatomaceous clay and sand, light-gray: 80 percent light-gray diatomaceous clay. 20 percent very fine- to fine-grained subangular sand. Trace shell fragments.
11	188	do.	Diatomaceous clay, light-gray: Very fine- to coarse-grained angular to subrounded sand prominent. Trace shell fragments.
52	240	do.	Diatomaceous clay, light-gray: Trace very fine-grained subangular to angular sand.
10	250	Clay, green, with streaks of shell.	Diatomaceous clay and sand, light-gray: 80 percent light-gray diatomaceous clay. 20 percent fine-grained subangular to subrounded sand. Trace phosphate.

[1] See discussion of these data in preceding text.

Table 15. Lithologic logs of test holes—(Continued)

Test hole Tal-De 16—(Continued)

10	260	do.	No sample.
41	301	do.	Similar to above with sand very fine-grained, well-sorted and a trace of shell fragments.
10	311	do.	Diatomaceous clay and sand, light-gray: 75 percent light-gray diatomaceous clay. 25 percent medium- to coarse-grained subrounded water-polished sand. Trace phosphate.
11	322	do.	Similar to above with sand fine- to coarse-grained.
10	332	do.	Diatomaceous clay, light-gray: Medium- to coarse-grained subangular to subrounded sand prominent.
10	342	do.	Similar to above but diatoms more abundant.
10	352	do.	Diatomaceous clay and sand, light-gray: 75 percent light-gray diatomaceous clay. 25 percent medium- to coarse-grained subrounded water-polished sand. Trace shell fragments, phosphate.
10	362	Clay, green, with streaks of shell to 358. Sand, gray to 402.	Sand and clay, light-gray: 65 percent medium to coarse-grained subrounded water-polished sand. 35 percent light-gray clay. Trace phosphate.
21	383	do.	Sand, light-gray, medium-to coarse-grained, subangular to rounded, water-polished. Glauconite prominent. Trace light-gray clay.
10	393	do.	Similar to above with trace of shell fragments.
10	403	do. Hard rock, 402 to 403.	Similar to above but with sand coarse to very coarse-grained, green-stained in part.
32	435	Sand, gray.	Similar to above with sand medium- to coarse-grained. No green stain.
30	465	Sand, black, and brown with clay.	Similar to above with shell fragments prominent.
21	486	Clay, green with crusty layers.	Similar to above with 20 percent shell. Clay prominent.
10	496	do.	Sand and clay, light-gray: 40 percent fine- to medium-grained subangular sand. 40 percent light-gray clay matrix. 20 percent shell fragments. Tan clay prominent Trace glauconite, brown limestone particles.
8	504	Clay, green with crusty layers.	Limestone and clay, light-gray: 45 percent light-grown limestone. 40 percent light-gray clay. 15 percent shell fragments. Trace coarse-grained rounded sand. Microfossils very abundant.
10	514	Clay, green.	Similar to above with fine-grained sand prominent.
10	524	do.	Glauconitic clay, medium-gray: 70 percent black to very dark-green glauconite. 30 percent medium-gray clay matrix. Coarse-grained subrounded sand prominent. Trace shell fragments.
12	536	do.	Similar to above with 80 percent sand.
10	546	do.	Glauconitic clay and limestone, medium-gray: 40 percent dark-green glauconite. 30 percent medium-gray clay matrix. 20 percent medium-gray limestone. 10 percent coarse-grained rounded water-polished sand.
10	556	do.	Similar to above with 30 percent limestone and 30 percent dark-green glauconite. Microfossils very abundant.
10	566	do.	Glauconitic clay and limestone medium-gray: 45 percent medium-gray clay matrix. 30 percent medium-gray limestone. 15 percent dark-green glauconite. 10 percent coarse-grained rounded water-polished sand.
12	578	do.	Same as 546–556 foot interval.
10	588	do.	Glauconitic clay, medium-gray: 55 percent glauconite. 30 percent light-gray clay matrix. 15 percent very fine- to coarse-grained subangular to rounded sand. Microfossils abundant. Trace shell fragments, pyrite.
30	618	do.	Similar to above with 20 percent sand and 50 percent glauconite.
31	649	do.	Glauconitic sand, medium-gray: 60 percent medium-grained subangular sand. 25 percent dark-green glauconite. 15 percent medium-gray clay. Microfossils abundant. Trace shell fragments.
21	670	do.	Similar to above with increase in clay to 50 percent, decrease in sand to 25 percent.

Table 15. Lithologic logs of test holes—(Continued)

Test hole Tal-De 16—(Continued)			
10	680	do.	Glauconitic sand, light-gray: 40 percent light-gray clay. 40 percent fine-grained angular sand. 20 percent glauconite. Microfossils very abundant. Trace fine-grained gravel.
23	703	do.	Glauconitic clay, light-gray: 80 percent light-gray clay. 20 percent glauconite. Trace coarse-grained rounded sand.
20	723	Clay, green and brown.	Clay and sand, light-gray: 75 percent light-gray clay. 25 percent very fine-grained angular sand. Coarse-grained sand prominent. Trace glauconite, large *Nodosaria affinis*.
20	743	Same to 733. Clay, green to 763.	Sand and clay, light-gray: 60 percent light-gray clay. 20 percent fine-grained angular sand. 20 percent coarse-grained rounded sand. Glauconite prominent. Trace large *Nodosaria affinis*.
20	763	do.	Same as above with a trace of pyrite.
30	793	Clay, green and gray with crusty layers.	Similar to above with 40 percent fine-grained sand and 40 percent clay.
22	815	Clay, sandy, gray and brown.	Limestone, light-gray, medium crystalline, poorly indurated. Glauconite, fine- to coarse-grained sand prominent. Microfossils abundant. Trace shell fragments.
10	825	Clay, sandy, gray and brown.	Glauconitic limestone, greenish-gray: 55 percent white very fine crystalline poorly-indurated limestone matrix. 45 percent glauconite. Very fine-grained angular sand prominent. Trace shell fragments.
10	835	do.	Similar to above with 65 percent glauconite. 35 percent limestone. Trace phosphate.
41	876	Same to 855. Clay, sandy, dark gray with shells 855–908.	Glauconitic sand, greenish-gray: 65 percent medium- to coarse-grained subrounded sand. 35 percent very light-green to black glauconite. Light-gray clay prominent. Trace shell fragments.
21	897	do.	Glauconitic sand, medium-gray: 80 percent fine- to medium-grained subangular sand. 20 percent glauconite. Trace pyrite, shell fragments, light-gray clay.
10	907	do.	Similar to 876–897 foot interval but with 25 percent glauconite and 75 percent sand. Coarse-grained rounded sand prominent.
10	917	Sand, brown, with shells.	Glauconitic sand, medium-gray: 60 percent very fine- to medium-grained angular to subangular sand. 20 percent coarse-grained rounded limonite-stained sand. 20 percent glauconite. Gray clay prominent.
21	938	do.	Sand, light-gray: 65 percent coarse-grained rounded to subrounded limonite-stained sand. 35 percent very fine-grained angular sand. Glauconite prominent. Trace shell fragments.
10	948	do.	Sand, light-gray, very fine- to coarse-grained, angular to subrounded. Trace glauconite, limonite-stained sand, shell fragments.
10	958	do.	Similar to 938–948 above with glauconite prominent.
21	979	Clay, sandy, dark gray.	Sand, light-gray, medium- to very coarse-grained, subangular to rounded, water-polished, limonite-stained in part. Very fine-grained angular sand prominent. Trace glauconite, phosphate, shell fragments.
10	989	do.	Glauconitic sand, light-gray: 80 percent fine- to medium-grained angular to subangular sand. 20 percent brown glauconite (oxidized) Coarse-grained rounded sand prominent. Trace pyrite.
10	999	Crusty and very hard.	Sand, light-gray: 50 percent very fine- to fine-grained angular to subangular sand. 50 percent coarse-grained rounded sand. Brown (oxidized) glauconite prominent. Trace shell fragments.
11	1010	Clay, sandy, gray.	Similar to above with 80 percent coarse-grained sand and 20 percent fine-grained sand. Medium-gray clay prominent.
20	1030	do.	Glauconitic sand, medium-gray: 55 percent very fine- to fine-grained angular to subangular sand. 30 percent brown (oxidized) glauconite. 15 percent medium-gray clay matrix. Coarse-grained rounded sand prominent. Trace pyrite.
8	1038	do.	Sand, medium-gray: 40 percent very fine- to fine-grained angular to subangular sand. 30 percent coarse-grained rounded sand. 15 percent brown (oxidized) to black glauconite. 15 percent medium-gray clay matrix. Trace shell fragments.

Table 15. Lithologic logs of test holes—(Continued)

Test hole Tal-De 16—(Continued)

10	1048	do.	Similar to above. Add trace lignite.
10	1058	Clay, gray and green, with streaks of brown sand and some wood.	Sand, light-gray: 65 percent fine- to medium-grained angular to subangular sand. 35 percent coarse- to very coarse-grained rounded sand. Trace glauconite, pyrite.
12	1070	Clay, gray and green with streaks of brown sand and some wood.	Sand, medium-gray: 45 percent fine-grained to subangular sand. 30 percent coarse-grained rounded sand. 15 percent pyrite. 10 percent brown clay. Lignite prominent. Trace glauconite, shell fragments, lightgray clay.
10	1080	do.	Similar to above with 10 percent lignite and 20 percent coarse-grained sand.
10	1090	Clay, gray and green.	Clay and sand, medium-gray: 45 percent medium-gray clay matrix. 30 percent fine-grained subangular sand. 15 percent lignite. 10 percent brown (oxidized) to dark-green glauconite. Coarse-grained rounded sand prominent. Trace pyrite.
10	1100	do.	Sideritic sand, medium-gray: 65 percent fine- to medium-grained subangular sand. 25 percent light-brown siderite. 10 percent bright-green glauconite. Coarse-grained sand prominent. Trace lignite, pyrite.
11	1111	Same to 1106. Sand, white and gray, with some wood from 1106–1121.	Sand, light-gray, medium- to coarse-grained, angular to subangular, frosted, clean. Trace light-brown siderite, pyrite.
10	1121	do.	Similar to above with fine- to medium-grained sand.
10	1131	Sand, white, pink, red, with some green clay and wood.	No sample.
10	1141	do.	Sand, pink: 85 percent coarse-grained subangular to subrounded sand. 15 percent light-brown siderite. Trace shell fragments, pyrite.
10	1151	do.	Similar to above with 25 percent siderite and 75 percent sand. Hematite, light-gray clay prominent.
21	1172	Clay, green.	Sideritic sand, light-gray: 65 percent fine- to very coarse-grained angular to subrounded sand. 25 percent light-brown siderite. 10 percent hematite. Medium-gray clay prominent. Trace shell fragments, pyrite.
35	1207	Clay green, to 1181. Clay, dark gray 1181-1203. Clay, tough, green 1203-1279.	Glauconitic clay, light-gray: 65 percent light-gray clay. 20 percent bright-green glauconite. 15 percent hematite. Trace fine-grained sand, light-brown siderite. Glauconite probably cavings.
10	1217	Clay, tough green.	Hematitic sand and clay, pink: 35 percent pink to light-gray clay matrix. 25 percent hematite. 20 percent glauconite (probably cavings). 20 percent fine- to medium-grained subangular sand. Trace light-brown siderite, coarse-grained sand.
16	1233	do.	Glauconitic clay, light-gray: 80 percent light-green clay. 20 percent bright-green glauconite (probably cavings). Hematite, very fine-grained sand prominent. Trace light-brown siderite, coarse-grained rounded sand.
20	1253	do.	Sideritic clay, light-gray: 35 percent light-brown siderite. 30 percent hematite. 25 percent light-gray clay. 10 percent glauconite (probably cavings). Fine-grained sand prominent. Trace pyrite, coarse-grained sand.
10	1263	do.	Clay and sand, light-gray: 60 percent light-gray clay. 40 percent very fine-grained angular sand. Hematite prominent. Trace muscovite.
20	1283	Same to 1279. Clay, tough, red, gray, green to 1350.	Similar to above with 15 percent hematite and 45 percent clay. Trace light-brown siderite, pyrite.
14	1297	do.	Hematitic clay, gray with pink tinge: 35 percent pink to light-gray clay. 30 percent hematite. 20 percent fine- to coarse-grained angular to subrounded sand. 15 percent glauconite (probably cavings). Trace shell fragments, light-brown siderite, gravel.

Table 15. Lithologic logs of test holes—(Continued)

Test hole Tal-De 16—(Continued)

10	1307	Clay, tough, red, gray, green.	Similar to above with 30 percent sand and 20 percent hematite.
29	1336	do.	No sample.
10	1346	do.	Sand, pink, fine-grained, angular to subangular, frosted, fairly well-sorted. Hematite, light-brown siderite prominent. Trace pyrite, coarse-grained sand, pink clay.
10	1356	Same to 1350. Rock and hard, crusty layers, 1350–1357.	Similar to above with increase in siderite to 20 percent, corresponding decrease in sand.
31	1387	Clay, red, with some gray and white fine sand.	Cuttings similar to above.
12	1399	do.	Sand, gray with pink cast, medium-grained, subangular, well-sorted, frosted. Light-brown siderite prominent. Trace light-gray clay with pink cast, hematite.
20	1419	Sand, fine, white and gray to 1412. Clay, red, 1412 to 1429.	Sand, light-gray with pink cast, very fine-to fine-grained, angular to subangular, Light-brown siderite prominent. Trace hematite, light-gray clay with pink cast.
10	1429	do.	Similar to above with decrease in siderite to trace.
10	1439	Clay, gray to 1432. Hard, crusty layer 1432–1436. Clay, gray, red, & brown with mica 1436–1460.	Similar to above with clay prominent. Trace pyrite, muscovite.
10	1449	Clay, gray, red, and brown with mica.	Similar to above with siderite prominent.
10	1459	do.	Same as 1429–1439-foot interval.
10	1469	Sand, fine, white and gray.	Sand, light-gray with pink cast, fine- to medium-grained, subangular. Trace light-gray to pink clay, hematite, light-brown siderite.
22	1491	do.	Sand, light-gray with pink tinge, fine-grained, angular to subangular. well-sorted. Light-gray to pink clay prominent. Trace light-brown siderite, hematite.
21	1512	Sand, medium, brown and white.	Sand, light-gray with a pink cast, fine- to medium-grained, subangular to subrounded. Light-gray clay with pink cast prominent. Trace light-brown siderite.
10	1522	Sand, medium, brown and white to 1518, clay 1518–1522.	Sand and clay, light-gray with pink cast: 80 percent fine- to medium-grained angular to subangular sand. 20 percent light-gray clay with pink cast. Trace hematite, light-brown siderite. Bottom of hole at 1522 ft.

Test hole Tal-De 18: 2 miles south of Easton.

Thickness (feet)	Depth to base (feet)	Lithology
5	5	Clay, sandy, brown.
10	15	Clay, tan color.
18	33	Clay, gray.
19	52	Clay and some fine sand, gray green.
52	104	Clay, gray green and shell fragments.
9	113	Clay, green and brown with shell fragments.
1	114	Shell layer in tough clay, crusty.
23	137	Sand fine, and shell fragments, gray green.
1	138	Crusty, hard.
17	155	Sand, fine to medium, shell fragments, gray green.
10	165	Sand and clay, gray green.
11	176	Sand, fine to medium, and clay gray.
6	182	Sand, medium, and clay gray.
4	186	Clay, soft, green gray.
13	199	Clay, sandy, soft green gray.
2	201	Hard, cemented layer.
5	206	Sand with clay, and shell fragments, olive gray.
31	237	Clay, sandy, and shell fragments, olive gray.
3	240	Clay and sand interbedded, brown, green gray.

Table 15. Lithologic logs of test holes—(Continued)

Test hole Tal-De 18—(Continued)

18	258	Clay, sandy, olive green gray.
51	309	Clay, silty, olive green gray.
11	320	Clay, sandy and silty, olive green gray.
1	321	Rock, consolidated layer, hard.
7	328	Sand, medium to coarse, with shell fragments, gray.
1	329	Rock, consolidated, hard.
11	340	Sand, medium to coarse, with shell fragments, gray green.
10	350	Sand, fine to medium, with shell fragments, gray green.
15	365	Sand and clay with shell fragments, gray green.
36	401	Clay and sand, fine, tough, gray green.
10	411	Clay and sand, fine, glauconitic, gray green.
11	422	Sand, medium to coarse, in clayey matrix, dark green to black particles.
20	442	Sand, medium, in clayey matrix, glauconitic, dark green to black.
11	453	Sand, fine to medium, in greenish gray clayey matrix, black grains abundant.
20	473	Sand, fine, in greenish gray clay matrix, abundant black grains.
114	587	Clay, gritty, tough, gray green, black grains.
45	632	Clay, silty, tough, greenish gray, glauconitic (poor recovery of samples).
5	637	Sand, brown and black with shells.
7	644	Sand, fine, olive green.
35	679	Sand, medium to coarse, few shells, brown and black.
31	710	Clay, sandy, olive green.
10	720	Clay, sandy, olive green, crusty layers.
11	731	Clay, olive green with streaks of white, with thin layers of sand which is coarse to fine, black.
5	736	Similar to 720–731, but very fossiliferous.
2	738	Rock, consolidated layer, very hard.
3	741	Clay, sandy, gray and white; sand is very fine and fossiliferous.
1	742	Rock, consolidated layer, very hard.
4	746	Clay, gray to white, sandy.
½	746½	Rock, consolidated layer, very hard.
4½	751	Sand, gray and white, with crusty layers, very fossiliferous.
11	762	Clay, sandy, gray to white, very hard drilling, very fossiliferous.
10	772	Clay, sandy, gray, tough, fossiliferous, noticeable black sand.
11	783	Clay, sandy, gray, black sand prominent.
10	793	Sand, with clay, black to gray clay.
10	803	Sand, with clay, dark brown.
10	813	Sand, with clay, (sand very fine, black), (clay green, dark to light brown, gray and white).
20	833	Clay, with sand, predominantly green, tough.
11	844	Clay, green, with fine black and brown sand.
31	875	Sand, fine to medium, brown and black, with green to dark brown clay; drilled fast.
9	884	Clay, tough to soft, green to white.
21	905	Sand, fine, with clay, dark green, very glauconitic.
1	906	Rock, consolidated layer, hard.
10	916	Sand, fine to medium, thin consolidated layers, brownish gray, glauconitic.
20	936	Sand, fine to medium, greenish gray, less glauconitic, 80–90 percent quartz; easy drilling.
102	1038	Clay, olive green, with some lignite and sand, slow drilling, some hard layers.
6	1044	Similar to 936–1038 but contains much lignite.
19	1063	Sand, quartz, medium, white and gray, with lignite.
7	1070	Clay, light brown and olive green, with lignite, and some fine to medium sand.
10	1080	Similar to sample from 1063–1070, but includes more lignite.
10	1090	Clay, hard.
10	1100	Sand and clay, hard layers.
13	1113	Clay, soft, gray, with lignite.
7	1120	Clay, tough, gray, hard layers.
21	1141	Clay (white and light gray, soft), with thin layers of brown and white sand, some lignite.
20	1161	Clay (white and gray with streaks of red), with layers of fine to medium sand composed of white and pink grains.
11	1172	Clay (olive green, tough), with fine black and white sand.
10	1182	Clay, red and white, tough.
21	1203	Clay and sand, light gray to pink, abundant white, medium grained spherical particles (?).

Table 15. Lithologic logs of test holes—(Continued)

Test hole Tal-De 18—(Continued)

10	1213	Similar to 1182–1203 interval, soft.
10	1223	Sand, fine to medium, spherical particles (?) common.
51	1274	Clay, red and white, tough.
11	1285	Clay, sandy, light brown and white, poor recovery.
65	1350	Clay, gray brown, very tough; poor recovery.
16	1366	Sand; none recovered; drilled easy.
42	1408	Clay, red, brown, and white, very tough.
10	1418	Clay and sand; drilled easy.
32	1450	Sand; none recovered; drilled fast.
25	1475	Sand with layers of clay; none recovered; drilled fast.
18	1493	Clay and sand; none recovered. Bottom of hole at 1493 ft.

Table 16. Records of selected wells.

Well number State of Delaware	State permit number	Owner or name	Driller	Date completed	Altitude of land surface (feet)	Accuracy of LSD	Finish	Method of drilling	Depth of well (feet)	Diameter of well (inches)	Altitude at top of screen or bottom of casing (feet)	Length of screen or open hole (feet)	Water-bearing formation
Je 32-4	-	U.S. Air Force	C. W. Lauman	1957	23	4	G	H	391	6-4	-338	30	H
Je 32-5	-	do.	-	-	25	4	-	-	575	-	-	-	H
State of Maryland Caroline County													
Care-													
Dd 2	-	City of Denton	Shannahan Art. Well Co.	1938	35	5	-	H	402	8	-	-	H
Fc 28	42053	Fuchs Farms	E. R. Kauffman	1961	50	5	G	R	64	17	+50	64	Q
Fd 1	-	Town of Federalsburg	Kelley Well Co.	1928	35	5	S	-	45	24	+14	24	Q
Fd 2	-	do.	do.	1928	35	5	S	-	46	24	+12	23	Q

Accuracy of land surface datum

1 Instrument level, accurate to 0.5 ft.
3 From topo map, accurate to 5 ft.
4 From topo map, accurate to 10 ft.
5 From topo map, accurate to 20 ft.

Finish

G Gravel wall, commercial screen
O Open end
S Screen
T Sand point
X Open hole in aquifer
Z Other

Method of Drilling

D Dug
H Hydraulic-rotary
J Jetted
R Reverse rotary
V Driven

Water-bearing formation

C Raritan
D Magothy
E Matawan
G Aquia
H Piney Point
I Calvert
K Choptank
L St. Marys
P Pliocene
Q Pleistocene
R Holocene

Date Month	Date Year	Water levels above or below sea level (feet) Static	Water levels above or below sea level (feet) Pumping	Drawdown (feet)	Yield (gpm)	Hours pumped	Accuracy for drawdown	Specific capacity (gpm/ft)	Use of water	Temperature °F	Pumping equipment	Pumping power	Latitude	Longitude	Sequential number	Accuracy Lat Long	Remarks	Well number State of Delaware
3	57	+ 5^{m}	-	25	211	12	3	8.5	U	61.5	N	-	39°07'39"	75°28'59"	1	1	a, c. Logged to 1422 feet. Observation well.	Je 32-4
-	63	-	-	-	1000	-	-	9.6-5.6	T	-	N	-	39°07'39"	75°28'58"	1	1	a. Logged to 620 feet. Owner's well D.	Je 32-5

State of Maryland

Caroline County

																		Care-
-	-	-	-	-	-	-	-	-	P	63	T	5	38°53'	75°50'	-	4	b.	Dd 2
4	61	+44	+4	40	1300	2	3	32	I	-	-	-	38°41'56"	75°52'20"	1	1		Fc 28
7	48	+19^{m}	-	-	-	-	0	-	P	60	P	5	38°41'	75°46'	1	4	Care-Fd 1 and Fd 2 together yielded 500 gpm on 4/6/50 with 12 ft. of drawdown in Fd 1 after 10 hrs. pumping.	Fd 1
7	48	+22^{m}	-	-	-	-	-	-	P	60	P	5	38°41'	75°46'	2	4		Fd 2

Accuracy for drawdown

0 Measured, accurate to within 1 foot
3 From driller's log
5 Estimated
6 Reported

Water levels

m measured

Use of water

C Commercial
H Domestic
I Irrigation
Y Industrial
P Public supply
S Stock supply
T Institutional
U Unused

Pumping equipment

C Centrifugal
J Jet
N None
P Piston
S Submergible
T Turbine

Pumping power

1 Hand
3 Gasoline
5 Electricity

Remarks

a Electric log available
b Chemical analysis available
c Gamma log available

Accuracy Lat Long

1 Accurate to within one second
2 Accurate to within ten seconds
4 Accurate to within one minute

Table 16. Records of selected wells

Well number Dor-	State permit number	Owner or name	Driller	Date completed	Altitude of land surface (feet)	Accuracy of LSD	Finish	Method of drilling	Depth of well (feet)	Diameter of well (inches)	Altitude at top of screen or bottom of casing (feet)	Length of screen or open hole (feet)	Water-bearing formation
Ag 5	-	Norman Trice	—	-	36	5	T	V	20[est]	1½	-	-	Q
Ah 3	-	U.S. Geological Survey	R. K. Baldwin	1953	35	5	-	J	557	4	-	-	I
Bb 11	D65W65	Walter W. Korpman	Wm. R. Glazier	1964	5	5	S	J	502	2½-1½-1¼	-487	10	G
Bb 12	-	Robert Carpenter	Leon Jarrett	1962	5	5	S	J	880	4-2½-1½	-855	20	D
Bc 5	5859	Melvin Hurley	do.	1950	3	5	S	J	560	1½	-549	6	G
Bd 2	-	Carleton Slagle	Shannahan Art. Well Co.	1904	1	5	-	S	231[m]	6	-	-	H
Bd 10	D65W82	Allen Evans	Leon Jarrett	1965	10	5	S	J	646	4-2	-616	20	G
Bf 1	-	Town of Secretary	Shannahan Art. Well Co.	1936	27	5	-	S	471	8-6	-	-	H
Bf 20	-	do.	A. Wheatley	1920	4	5	-	J	168	1½	-	-	I,K(?)
Bf 24	-	U.S. Geological Survey	R. K. Baldwin	1953	35	5	-	J	301	4	-	-	I
Bf 25	-	do.	do.	1953	35	5	-	J	39	2	-	-	Q
Bf 27	-	do.	do.	1953	45	5	-	J	21	2	-	-	Q
Bf 29	-	do.	do.	1953	40	5	-	J	210	4	-	-	K
Bg 18	-	do.	do.	1953	40	5	-	J	361	4	-	-	I
Bg 32	12567	American Stores Co.	Sam Shannahan Well Co.	1953	40	5	S	J	83	8	- 26	16	Q
Bg 33	21806	U.S. Geological Survey	Shannahan Art. Well Co.	1955	40	5	S	H	90	4-3	- 45	5	Q
Bg 36	-	North Dorchester High School	Leon Jarrett	1962	47	5	S	J	248	2½	-	-	K
Bg 37	40214	John Wright Cannery	E. R. Kauffman	1960	42	5	G	R	68	17	+ 6	32	Q
Bg 38	D65W75	Inspection Farms, Inc.	do.	1965	43	5	G	R	90	17	0	90	Q
Bg 39	56187	Albert Frosch	do.	1964	49	5	G	R	85	22	+ 49	85	Q
Bg 48	-	Mr. Hurlock	—	-	46	5	T	V	40	-	-	-	Q
Bg 55	39420	American Stores Co.	Sam Shannahan Well Co.	1960	41	5	S	J	96	12	- 24	31	Q
Bh 6	37021	Donald E. Wheatley	E. R. Kauffman	1960	31	5	G	R	94	17	+ 26	89	Q
Bh 7	-	Lehman Baily	Kemp Adams	1964	42	5	-	-	48	-	-	-	Q
Bh 9	D66W71	U.S. Geological Survey	E. R. Kauffman	1965	45	5	-	H	100	4	None	-	-
Bh 10	D66W70	do.	do.	1965	50	5	-	H	60	4	None	-	-
Bh 11	D66W72	do.	do.	1966	20	5	-	H	140	4	None	-	-

Accuracy of land surface datum

1 Instrument level, accurate to 0.5 ft.
3 From topo map, accurate to 5 ft.
4 From topo map, accurate to 10 ft.
5 From topo map, accurate to 20 ft.

Finish

G Gravel wall, commercial screen
O Open end
S Screen
T Sand point
X Open hole in aquifer
Z Other

Method of Drilling

D Dug
H Hydraulic-rotary
J Jetted
R Reverse rotary
V Driven

Water-bearing formation

C Raritan
D Magothy
E Matawan
G Aquia
H Piney Point
I Calvert
K Choptank
L St. Marys
P Pliocene
Q Pleistocene
R Holocene

Date Month	Date Year	Water levels above or below sea level (feet) Static	Water levels above or below sea level (feet) Pumping	Drawdown (feet)	Yield (gpm)	Hours pumped	Accuracy for drawdown	Specific capacity (gpm/ft)	Use of water	Temperature °F	Pumping equipment	Pumping power	Latitude	Longitude	Sequential number	Accuracy Lat Long	Remarks	Well number Dor-
-	-	-	-	-	-	-	-	-	H	-	P	1	38°40'52"	75°54'02"	1	1	b.	Ag 5
-	-	-	-	-	-	-	-	-	U	-	N	-	38°40'28"	75°44'17"	1	1	Test hole. Casing pulled and hole filled in.	Ah 3
12	64	- 3[m]	-	-	25	6	3	-	H	-	-	-	38°37'00"	76°15'38"	1	1	c; logged to 464 ft.	Bb 11
4	65	Flowing	-	-	7	-	-	-	S	70	N	-	38°37'24"	76°16'42"	1	1	b. Drilled to 1000 ft.	Bb 12
10	51	do.	-	-	18	6	-	-	H	56	P	5	38°35'37"	76°12'02"	1	1	b.	Bc 5
7	51	- 64[m]	-	-	-	-	-	-	U	-	N	-	38°35'30"	75°05'23"	1	1	Drilled to 380 ft., cased to 335. Observ. well since 7/51.	Bd 2
4	65	- 5	-50	45	35	10	3	0.8	H	66	S	5	38°36'17"	76°08'30"	1	1	b.	Bd 10
4	36	+ 8	-	-	-	-	-	-	P	-	T	5	38°36'34"	75°57'08"	1	1		Bf 1
12	51	Flowing	-	-	-	-	-	-	P	63	N	-	38°36'38"	75°57'11"	1	1	b. Flowing 0.6 gpm, 4-28-65.	Bf 20
-	-	-	-	-	-	-	-	-	U	-	N	-	38°36'54"	75°55'11"	1	1	Casing pulled and hole filled in.	Bf 24
-	-	-	-	-	-	-	-	-	U	-	N	-	38°36'54"	75°55'15"	1	1	b. do.	Bf 25
-	-	-	-	-	-	-	-	-	U	-	N	-	38°36'59"	75°55'19"	1	1	b. Casing pulled and hole filled in.	Bf 27
-	-	-	-	-	-	-	-	-	U	-	N	-	38°36'54"	75°55'03"	1	1	Casing pulled and hole filled in.	Bf 29
-	-	-	-	-	-	-	-	-	U	-	N	-	38°38'44"	75°50'34"	1	1	do.	Bg 18
6	53	+ 32	+20	12	150	8	3	12	C	-	T	5	38°38'02"	75°51'47"	1	1		Bg 32
3	56	+ 35[m]	-	-	20	-	-	-	U	-	N	-	38°38'02"	75°51'47"	2	1	Drilled to 96 ft. Observ. well from 4/56 to 5/57.	Bg 33
4	65	+ 7[m]	-	-	-	-	-	-	U	-	N	-	38°35'12"	75°52'23"	1	1	c.	Bg 36
8	60	+ 31	+ 3	28	533	14	3	19	Y	60	T	5	38°38'14"	75°51'27"	1	1	b.	Bg 37
2 9	65 65	+ 31 + 31[m]	-10	41	1069	3	3	26	I	-	T	3	38°38'48"	75°53'56"	1	1		Bg 38
3 9	64 65	+ 42 + 39[m]	+21	21	1067	4	3	51	I	-	T	3	38°35'46"	75°52'12"	1	1		Bg 39
-	-	-	-	-	-	-	-	-	S	-	-	5	38°37'40"	75°54'55"	1	1	b.	Bg 48
7	60	+ 27	+ 7	20	600	8	3	30	Y	-	T	5	38°37'52"	75°51'35"	1	1	Well drilled to 106 ft.	Bg 55
4 9	60 65	+ 26 + 24[m]	-15	41	1110	3	3	27	I	-	C	3	38°35'06"	75°45'22"	1	1		Bh 6
-	-	-	-	-	-	-	-	-	H	59	C	5	38°37'57"	75°45'46"	1	1	b.	Bh 7
-	-	-	-	-	-	-	-	-	-	-	-	-	38°37'10"	75°45'49"	1	2	a. Test hole; filled in.	Bh 9
-	-	-	-	-	-	-	-	-	-	-	-	-	38°39'36"	75°46'32"	1	2	do.	Bh 10
-	-	-	-	-	-	-	-	-	-	-	-	-	38°37'03"	75°49'01"	1	2	do.	Bh 11

Accuracy for drawdown

0 Measured, accurate to within 1 foot
3 From driller's log
5 Estimated
6 Reported

Use of water

C Commercial
H Domestic
I Irrigation
Y Industrial
P Public supply
S Stock supply
T Institutional
U Unused

Pumping equipment

C Centrifugal
J Jet
N None
P Piston
S Submergible
T Turbine

Pumping power

1 Hand
3 Gasoline
5 Electricity

Remarks

a Electric log available
b Chemical analysis available
c Gamma log available

Accuracy Lat Long

1 Accurate to within one second
2 Accurate to within ten seconds
4 Accurate to within one minute

Table 16. Records of selected wells —— Continued

Well number Dor-	State permit number	Owner or name	Driller	Date completed	Altitude of land surface (feet)	Accuracy of LSD	Finish	Method of drilling	Depth of well (feet)	Diameter of well (inches)	Altitude at top of screen or bottom of casing (feet)	Length of screen or open hole (feet)	Water-bearing formation
Cc 37	1437	Leonard A. Simmons	Guy R. Bradshaw	1947	2	5	S	J	515	1½	-493	20	G
Cd 5	1587	Otis C. McGrath	do.	1947	10	5	X	J	380	2½	-310	60	H
Cd 17	-	E. B. Jones	Edgar C. Cusick	1935	5	5	S	J	934	2½-1½	-919	10	C?
Cd 28	6833	L. W. Fitzhugh	Leon Jarrett	1950	6	5	X	J	370	2½-1½	-330	34	H
Cd 31	7017	Church Creek Elem. School	do.	1950	6	5	X	J	375	1½	-339	30	H
Cd 40	10964	Riverside Apartment Corp	Shannahan Art. Well Co.	1953	5	5	S	H	400	6-4	-363	21	H
Cd 42	-	City of Cambridge	R. K. Baldwin	1954	15	5	X	J	420	2½-1½	-385	20	H
Cd 43	32096	Municipal Utilities Commission	Sam Shannahan Well Co.	1959	16	5	S	H	406	12-10-8	-320	70	H
Cd 44	49129	do.	do.	1963	16	5	X	J	428	4	-310	102	H
Cd 46	D65W78	Edward Wise	Leon Jarrett	1965	10	5	S	J	357	2½-1½	-327	20	H
Ce 1	-	Crystal Ice & Storage Co.	Shannahan Art. Well Co.	1945	18	5	S	J	966	6-4½-3	- 938	10	D
Ce 2	-	Municipal Utilities Commission	Virginia Machinery & Well Co.	1945	15	5	S	H	412	12	-347	50	H
Ce 3	174	do.	Shannahan Art. Well Co.	1946	15	5	S	H	977	10-8	-926	29	D
Ce 4	-	do.	do.	1931	18	5	X	J	372	10-8-6	-348	6	H
Ce 5	-	do.	do.	1931	18	5	X	J	405	12	-	-	H
Ce 6	-	do.	Layne-Atlantic Co.	1936	16	5	X	H	463	12-10	-350	37	H
Ce 9	-	do.	Shannahan Art. Well Co.	1936	25	5	-	J	413	12-8-6	-	-	H
Ce 10	-	do.	do.	1910	6	5	X	J	375	12-10-8	-329	40	H
Ce 12	1427	do.	do.	1947	18	5	S	H	432	10	-361	51	H
Ce 13	1645	do.	do.	1947	18	5	S	H	430	10	-357	51	H
Ce 15	1220	Carroll W. Thomas & Sons Inc.	do.	1947	6	5	S	H	974	10-8-6-4-3	-944	20	D
Ce 16	-	Coastal Foods Co.	do.	1903	15	5	-	J	293	6	-	-	I
Ce 17	-	do.	do.	1903	15	5	-	J	293	6	-	-	I
Ce 21	-	Eastern Shore State Hospital	do.	1914	12	5	S	J	370	8-4½	-	-	H
Ce 22	-	do.	do.	1921	12	5	S	J	411	8-6	-	-	H
Ce 61	9474	Coastal Foods Co.	do.	1952	15	5	S	H	442	10-8	-377	50	H
Ce 62	9902	Maryland Tuna Corp.	do.	1952	15	5	S	H	446	10-8	-377	54	H
Ce 72	24574	do.	do.	1956	25	5	S	H	450	10-8	-376	49	H
Ce 73	26604	Catalyst Research Corp.	do.	1957	20	5	S	H	446	8-6	-384	42	H
Ce 74	56055	Bonnie Brook Development	Sam Shannahan Well Co.	1964	15	5	S	J	422	4-2	-386	21	H
Ce 75	56056	do.	do.	1964	15	5	S	J	454	6-4-3	-388	21	H

Accuracy of land surface datum

1 Instrument level, accurate to 0.5 ft.
3 From topo map, accurate to 5 ft.
4 From topo map, accurate to 10 ft.
5 From topo map, accurate to 20 ft.

Finish

G Gravel wall, commercial screen
O Open end
S Screen
T Sand point
X Open hole in aquifer
Z Other

Method of Drilling

D Dug
H Hydraulic-rotary
J Jetted
R Reverse rotary
V Driven

Water-bearing formation

C Raritan
D Magothy
E Matawan
G Aquia
H Piney Point
I Calvert
K Choptank
L St. Marys
P Pliocene
Q Pleistocene
R Holocene

Date		Water levels above or below sea level (feet)		Drawdown (feet)	Yield (gpm)	Hours pumped	Accuracy for drawdown	Specific capacity (gpm/ft)	Use of water	Temperature °F	Pumping equipment	Pumping power	Latitude	Longitude	Sequential number	Accuracy Lat Long	Remarks	Well number Dor-
Month	Year	Static	Pumping															
-	-	-	-	-	-	-	-	-	Y	62	P	5	38°30'48"	76°13'31"	1	1	b.	Cc 37
-	-	-	-	-	15	8	-	-	H	-	J	5	38°34'26"	76°08'53"	1	1		Cd 5
6	40	Flowing	-	-	10	-	-	-	-	-	P	5	38°30'09"	76°09'10"	1	1	b.	Cd 17
10	51	+11																
10	50	-44	-	-	16	10	-	-	H	58	J	5	38°30'41"	76°08'26"	1	1	b.	Cd 28
11	50	-46	-	-	14	8	-	-	T	63	J	5	38°30'22"	76°08'59"	1	1	b.	Cd 31
6	53	-64	- 96	32	41	6	3	1	U	-	N	-	38°34'57"	76°06'34"	1	1	Observ. well from 10/57 to 4/70.	Cd 40
5	57	-89[m]	-	-	-	-	-	-	U	-	N	-	38°34'09"	76°05'32"	1	1	Observ. well from 5/57 to 1/70.	Cd 42
1	59	-	- 98	-	300	24	-	-	P	-	T	5	38°34'47"	76°05'23"	1	1	Owner's Glasgow St. well.	Cd 43
-	-	-	-	-	-	-	-	-	U	-	N	-	38°34'47"	76°05'23"	2	1	Use: to gravel pack Cd 43.	Cd 44
3	65	-55	-	-	30	8	-	-	H	-	J	5	38°31'52"	76°08'33"	1	4		Cd 46
5	45	+29	-	-	125	-	-	-	C	72	T	5	38°33'45"	76°04'29"	1	1	b. Reported to flow 20 gpm when drilled.	Ce 1
6	51	-87	-166	79	625	.5	3	8	P	64	T	5	38°33'53"	76°04'06"	1	1	b. Owner's Dorchester Ave. well 1.	Ce 2
4	46	+15	- 92	107	436	24	3	4	P	72	T	5	38°33'53"	76°04'06"	2	1	b. Owner's Dorchester Ave. well 2.	Ce 3
7	51	-82[m]	-	-	-	-	-	-	P	-	T	5	38°33'42"	76°04'13"	1	1	b. Owner's Washington St. well 1.	Ce 4
7	51	-82	-	-	600	-	-	-	P	-	T	5	38°33'40"	76°04'16"	1	1	Owner's Washington St. well 2.	Ce 5
5	65	-95[m]	-	-	500	-	-	-	P	-	T	5	38°34'01"	76°04'14"	1	1	b. Owner's Fletcher Ave. well.	Ce 6
7	51	-77	-	-	700	-	-	-	U	-	N	-	38°34'13"	76°94'48"	1	1	Observ. well in 1967. Owner's High St. well.	Ce 9
8	65	-87	-	-	585	-	-	-	P	-	T	5	38°34'35"	76°04'30"	1	1	Owner's Mill St. well.	Ce 10
7	47	-65	- 93	28	350	24	3	12	P	-	T	5	38°33'52"	76°03'44"	1	1	Owner's Nathans Ave. well 1.	Ce 12
10	47	-70	-127	57	350	24	3	6	P	-	T	5	38°33'52"	76°03'44"	2	1	Owner's Nathans Ave. well 2.	Ce 13
8	47	-74	-122	48	200	24	3	4	U	-	N	-	38°34'08"	76°04'24"	3	1	b. Observ. well since 8/59.	Ce 15
6	58	-13[m]																
5	51	-35	-	-	-	-	-	-	U	-	N	-	38°33'35"	76°04'01"	1	1	Reported depth of original well 375 ft.	Ce 16
5	51	-33[m]	-	-	-	-	-	-	U	-	N	-	38°33'35"	76°04'07"	1	1	Reported depth of original well 375 ft.	Ce 17
8	14	-27	- 40	13	180	-	3	14	U	-	N	-	38°33'46"	76°03'03"	1	1	Drilled to 415 ft. Observ. well since 8/56.	Ce 21
6	65	-84[m]	-102	18	185	-	0	10	T	-	T	5	38°33'46"	76°03'03"	2	1	Drilled to 720 ft.	Ce 22
5	66	-120	-163	44	540	4	0	12	Y	-	T	5	38°33'35"	76°03'59"	1	1		Ce 61
6	52	- 94	-179	85	513	24	3	6	Y	-	T	5	38°33'27"	76°03'56"	1	1	Owner's well 1.	Ce 62
8	56	-129	-206	77	510	24	3	7	Y	-	T	5	38°33'18"	76°03'52"	1	1	Owner's well 2.	Ce 72
5	57	- 76	- 80	4	56	24	3	14	U	-	T	5	38°33'32"	76°02'24"	1	1	Not operated in 1966.	Ce 73
6	64	- 67	-105	38	100	72	3	3	P	-	T	5	38°33'30"	76°01'12"	1	1		Ce 74
5	65	- 68[m]	- 90	22	60	4	0	3	P	-	T	5	38°33'25"	76°01'09"	1	1	b.	Ce 75

Accuracy for drawdown

0 Measured, accurate to within 1 foot
3 From driller's log
5 Estimated
6 Reported

Use of water

C Commercial
H Domestic
I Irrigation
Y Industrial
P Public supply
S Stock supply
T Institutional
U Unused

Pumping equipment

C Centrifugal
J Jet
N None
P Piston
S Submergible
T Turbine

Pumping power

1 Hand
3 Gasoline
5 Electricity

Remarks

a Electric log available
b Chemical analysis available
c Gamma log available

Accuracy Lat Long

1 Accurate to within one second
2 Accurate to within ten seconds
4 Accurate to within one minute

Table 16. Records of selected wells -- Continued

Well number Dor-	State permit number	Owner or name	Driller	Date completed	Altitude of land surface (feet)	Accuracy of LSD	Finish	Method of drilling	Depth of well (feet)	Diameter of well (inches)	Altitude at top of screen or bottom of casing (feet)	Length of screen or open hole (feet)	Water-bearing formation
Ce 76	-	Municipal Utilities Commission	Sam Shannahan Well Co.	1965	10	5	X	J	400	-	-	-	-
Ce 77	D65W117	U.S. Geological Survey	Shannahan Art. Well Co.	1965	30	5	-	H	1502	6	-	-	-
Ce 78	D66W26	Municipal Utilities Commission	Sydnor Pump & Well Co.	1965	16	5	G	H	503	22-12	-344	139	H
Ce 79	D65W83	James Jolley	Leon Jarrett	1965	26	5	S	J	280	2½-1½	-234	20	I
Cf 8	12341	G. Alvin Riggin	Edgar C. Cusick	1953	12	5	S	J	194	1½	-162	20	K
Cf 13	30911	Eastern Shore Rendering Co.	Shannahan Art. Well Co.	1958	21	5	S	H	36	4	- 5	10	Q
Cf 18	27653	do.	do.	1957	21	5	X	H	250	6	-122	107	I
Cg 8	40141	Mac Farms	E. R. Kauffman	1960	40	5	G	R	112	17	+ 40	112	Q
Cg 9	49773	Cloverdale Farms	do.	1963	37	5	G	R	111	22	+ 30	111	Q
Cg 16	-	do.	do.	1963	40	5	G	R	117	17	-	-	Q
Cg 18	40474	do.	do.	1960	41	5	G	R	104	17	+ 41	104	Q
Cg 19	35423	Mac Farms	do.	1959	43	5	G	R	100	17	+ 43	100	Q
Cg 20	-	do.	do.	1959	43	5	G	R	111	17	- 11	52	Q
Cg 21	D66W66	U.S. Geological Survey	do.	1965	28	5	-	H	140	4	-	-	-
Cg 22	D66W67	do.	do.	1965	30	5	-	H	120	4	-	-	-
Cg 23	D66W74	Cloverdale Farms	do.	1966	35	5	G	R	104	17	+ 35	104	Q
Ch 17	-	Donald E. Wheatley	do.	1964	25	5	G	R	60	17	+ 25	60	Q
Ch 21	D65W106	Mrs. Lottie Brinsfield	do.	1965	20	5	G	R	74	17	+ 20	74	Q
Ch 25	D65W50	Boy Scouts of America	Ideal Well Drillers	1964	14	5	G	H	78	4	- 54	10	Q
Ch 26	D66W69	U.S. Geological Survey	E. R. Kauffman	1965	32	5	-	H	100	4	-	-	-
Ch 27	D66W68	do.	do.	1965	20	5	-	H	110	4	-	-	-
Ci 3	D65W30	William C. Altvater	do.	1965	17	5	G	R	73	17	+ 17	73	Q
Ci 4	-	Orem Kelley	Orem Kelley	1960	20	5	O	V	40	1½	- 20	0	Q
Ci 5	D65W31	William C. Altvater	E. R. Kauffman	1964	17	5	G	H	75	4	- 43	15	Q
Db 4	5073	Dorchester County Board of Education	Leon Jarrett	1949	5	5	S	J	543	1½	-535	6	G
Dd 7	-	U.S. Fish and Wildlife Service	——	1932	3	5	S	H	800	6	-	-	D
Dd 8	53078	do.	Shannahan Art. Well Co.	1963	6	5	S	H	443	6-4	-406	31	H
Df 11	23029	H. Lloyd Willey	Edgar C. Cusick	1956	3	5	X	J	534	1½	-479	52	H
Dg 4	4299	T. B. Robbins	Guy R. Bradshaw	1949	3	5	X	J	290	6-4	-254	33	I

Accuracy of land surface datum

1 Instrument level, accurate to 0.5 ft.
3 From topo map, accurate to 5 ft.
4 From topo map, accurate to 10 ft.
5 From topo map, accurate to 20 ft.

Finish

G Gravel wall, commercial screen
O Open end
S Screen
T Sand point
X Open hole in aquifer
Z Other

Method of Drilling

D Dug
H Hydraulic-rotary
J Jetted
R Reverse rotary
V Driven

Water-bearing formation

C Raritan
D Magothy
E Matawan
G Aquia
H Piney Point
I Calvert
K Choptank
L St. Marys
P Pliocene
Q Pleistocene
R Holocene

Date Month	Date Year	Water levels above or below sea level (feet) Static	Water levels above or below sea level (feet) Pumping	Drawdown (feet)	Yield (gpm)	Hours pumped	Accuracy for drawdown	Specific capacity (gpm/ft)	Use of water	Temperature °F	Pumping equipment	Pumping power	Latitude	Longitude	Sequential number	Accuracy Lat Long	Remarks	Well number Dor-
-	-	-	-	-	-	-	-	-	-	-	-	-	38°34'08"	76°04'24"	3	1	Test hole.	Ce 76
-	-	-	-	-	-	-	-	-	-	-	-	-	38°33'41"	76°02'29"	1	1	a,c. Test hole; hole plugged and abandoned.	Ce 77
11	65	-84	-190	106	1200	48	0	11	P	63	-	-	38°32'43"	76°04'28"	1	1	a,b. Owner's Stone Boundary Rd. well. Drilled to 517 ft.	Ce 78
5	65	- 1	- 9	8	20	8	3	2.5	H	-	J	5	38°32'20"	76°00'03"	1	1		Ce 79
5	53	+ 9	+ 6	3	25	3	3	8	H	55	J	5	38°31'12"	75°55'28"	1	1	b.	Cf 8
4	58	+19	- 3	22	40	4	3	2.5	Y	60	-	5	38°33'22"	75°56'11"	2	1	b. Pumped with four other identical wells.	Cf 13
9	57	+10	- 37	47	120	4	3	2.5	Y	59	T	5	38°33'24"	75°56'10"	1	1	b.	Cf 18
8 9	60 65	+33 +33[m]	+ 12	21	1500	6	3	71	I	-	C	3	38°34'23"	75°52'06"	1	1		Cg 8
3 10	63 65	+32 +32	+ 18	14	1227	4	3	88	I	59	-	-	38°34'35"	75°53'21"	1	1	b.	Cg 9
-	-	-	-	16	1175	-	3	73	I	-	-	-	38°34'26"	75°52'38"	1	1		Cg 16
12	60	+34	+ 4	30	1120	2	3	37	I	-	-	-	38°34'53"	75°52'54"	1	1		Cg 18
8	59	+41	+ 21	20	1000	4	3	50	I	-	-	-	38°34'21"	75°51'32"	1	1		Cg 19
-	-	-	-	15	1110	-	3	74	I	-	-	-	38°34'37"	75°51'21"	1	1		Cg 20
-	-	-	-	-	-	-	-	-	-	-	-	-	38°33'30"	75°54'49"	1	1	a. Test hole. Filled in.	Cg 21
-	-	-	-	-	-	-	-	-	-	-	-	-	38°33'17"	75°52'52"	1	1	a. do. do.	Cg 22
2 2	66 66	+ 28 +28[m]	+ 15	13	1045	4	3	80	I	-	-	-	38°34'21"	75°53'28"	1	1		Cg 23
4	64	+21	- 5	26	919	-	3	35	I	-	-	-	38°34'46"	75°45'12"	1	1		Ch 17
6	65	+ 8	- 1	9	766	2	3	85	I	-	-	-	38°34'38"	75°46'06"	1	1		Ch 21
10 11	65 64	+ 9[m] + 4	- 16	20	200	6	3	10	T	-	T	5	38°32'47"	75°45'34"	1	1		Ch 25
11	64	+ 4[m]																
-	-	-	-	-	-	-	-	-	-	-	-	-	38°33'51"	75°48'09"	1	1	a. Test hole. Filled in.	Ch 26
-	-	-	-	-	-	-	-	-	-	-	-	-	38°30'58"	75°48'07"	1	1	a. do. do.	Ch 27
1 1	65 65	+10 +12[m]	- 28	38	1140	4	3	30	I	57	-	-	38°33'41"	75°43'47"	1	1	b. Static water level meas. 4.5 ft. below l.s., 1/26/65.	Ci 3
-	-	-	-	-	-	-	-	-	S	55	P	1	38°33'43"	75°43'19"	1	1	b.	Ci 4
8	64	+ 9	- 3	12	42	2	3	3.5	H	-	P	5	38°33'42"	75°43'47"	1	1		Ci 5
12	49	+ 3.5	-	-	15	6	-	-	T	65	P	5	38°28'04"	76°17'22"	1	1	b.	Db 4
12	65	+14	-	-	-	-	-	-	U	-	N	-	38°26'45"	76°05'49"	1	1	c. Blackwater Wildlife Refuge.	Dd 7
8	63	-44	- 63	19	120	24	3	6	T	65	S	5	38°26'45"	76°05'33"	1	1	b. do.	Dd 8
5	56	- 6	- 8	2	35	6	3	18	H	59	P	5	38°25'10"	75°57'40"	1	1	b.	Df 11
7	49	+ 4[m]	-	-	183	8	-	-	U	63	N	-	38°26'31"	75°54'22"	1	1	b. Flowing, 3.4 gpm, 10/23/51. Flow est. 1 gpm on 4/22/65.	Dg 4

Accuracy for drawdown

0 Measured, accurate to within 1 foot
3 From driller's log
5 Estimated
6 Reported

Use of water

C Commercial
H Domestic
I Irrigation
Y Industrial
P Public supply
S Stock supply
T Institutional
U Unused

Pumping equipment

C Centrifugal
J Jet
N None
P Piston
S Submergible
T Turbine

Pumping power

1 Hand
3 Gasoline
5 Electricity

Remarks

a Electric log available
b Chemical analysis available
c Gamma log available

Accuracy Lat Long

1 Accurate to within one second
2 Accurate to within ten seconds
4 Accurate to within one minute

Table 16. Records of selected wells —— Continued

Well number	State permit number	Owner or name	Driller	Date completed	Altitude of land surface (feet)	Accuracy of LSD	Finish	Method of drilling	Depth of well (feet)	Diameter of well (inches)	Altitude at top of screen or bottom of casing (feet)	Length of screen or open hole (feet)	Water-bearing formation
Dor-													
Dh 7	-	Town of Vienna	Shannahan Art. Well Co.	1934	10	5	-	J	305	6	-	-	Q
Ec 3	5899	George A. Keene, Jr.	Edgar C. Cusick	1950	3	5	X	J	398	1½	-336	59	H
Ef 1	-	Edwin Bell Lumber Co.	A. Wheatley	1934	3	5	-	J	516	1¼	-	-	H
Fc 8	885	Hoopers Island School	Guy R. Bradshaw	1946	6	5	X	J	406	1½	-337	63	H
Fd 17	-	——	——	-	-	-	-	-	340	-	-	-	-
Fe 14	2721	Garland Jones	Leon Jarrett	1948	2	5	X	J	504	1½	-	-	H
Queen Annes County													
QA-													
Ea 10	10585	Matthew C. Bean	William O. Aaron	1952	20	5	X	J	120	1½	- 80	20	G
Ec 83	13200	Pearl O'Donnell	do.	1953	10	5	X	J	205	1½	-171	24	G
Ed 36	-	Town of Queenstown	Shannahan Art. Well Co.	1931	15	5	X	-	320	6	-171	134	G
Ee 12	-	S. E. W. Friel	——	1947	40	5	X	-	205	6	-160	5	H
Ee 16	-	Phillips Canning Co.	Shannahan Art. Well Co.	1940	71	5	-	-	647	10	-448	-	-
Ee 21	QA66W158	S. E. W. Friel	do.	1966	39	5	S	H	229	6-5	-141	49	H
Fa 39	11712	David M. Nichols	William O. Aaron	1953	4	5	X	J	215	1½	-206	5	G

Accuracy of land surface datum

1 Instrument level, accurate to 0.5 ft.
3 From topo map, accurate to 5 ft.
4 From topo map, accurate to 10 ft.
5 From topo map, accurate to 20 ft.

Finish

G Gravel wall, commercial screen
O Open end
S Screen
T Sand point
X Open hole in aquifer
Z Other

Method of Drilling

D Dug
H Hydraulic-rotary
J Jetted
R Reverse rotary
V Driven

Water-bearing formation

C Raritan
D Magothy
E Matawan
G Aquia
H Piney Point
I Calvert
K Choptank
L St. Marys
P Pliocene
Q Pleistocene
R Holocene

Date Month	Date Year	Water levels above or below sea level (feet) Static	Water levels above or below sea level (feet) Pumping	Drawdown (feet)	Yield (gpm)	Hours pumped	Accuracy for drawdown	Specific capacity (gpm/ft)	Use of water	Temperature °F	Pumping equipment	Pumping power	Latitude	Longitude	Sequential number	Accuracy Lat Long	Remarks	Well number Dor-
-	-	-	-	-	-	-	-	-	P	-	T	5	38°29'05"	75°49'40"	1	1	b. Reported to flow when drilled.	Dh 7
6	50	-13	- 22	9	28	5	3	3	H	-	P	1	38°23'16"	76°11'43"	1	1	b.	Ec 3
4	65	- 6[m]	-	-	-	-	-	-	U	-	N	-	38°24'59"	75°57'24"	1	1	c.	Ef 1
-	-	-	-	-	20	12	-	-	T	64	P	5	38°19'27"	76°13'53"	1	1	b.	Fc 8
-	-	-	-	-	-	-	-	-	-	-	-	-	38°16'	76°05'	-	-	c.	Fd 17
6 11	48 58	- 1 - 3[m]	-	-	20	6	3	-	H	58	P	1	38°18'05"	76°04'13"	1	1	b. Static water level meas. 5.37 ft. below land surface, 11/14/51.	Fe 14

Queen Annes County

																		QA-
7	52	+ 4	- 5	9	20	5	3	2.2	H	54	P	5	38°58'	76°21'	-	-	b.	Ea 10
9	53	+ 8	- 15	23	30	6	3	1.3	H	59	P	1	38°58'	76°13'	-	-	b.	Ec 83
-	31	+ 6	-	-	212	-	-	-	P	54	T	5	38°59'	76°09'	-	-	b.	Ed 36
8	53	+ 22	-	-	200	-	-	-	Y	58	T	5	38°57'18"	76°03'46"	-	-	b.	Ee 12
7	53	+ 11	- 149	160	-	-	-	-	U	-	N	-	38°56'00"	76°01'04"	-	-	c.	Ee 16
5	66	+ 17	- 5	22	100	3	3	4.6	C	-	-	-	38°57'18"	76°03'47"	-	-	a.	Ee 21
2	53	- 3	- 7	4	12	6	3	3	H	-	P	5	38°52'35"	76°20'08"	-	-	b.	Fa 39

Accuracy for drawdown

O Measured, accurate to within 1 foot
3 From driller's log
5 Estimated
6 Reported

Use of water

C Commercial
H Domestic
I Irrigation
Y Industrial
P Public supply
S Stock supply
T Institutional
U Unused

Pumping equipment

C Centrifugal
J Jet
N None
P Piston
S Submergible
T Turbine

Pumping power

1 Hand
3 Gasoline
5 Electricity

Remarks

a Electric log available
b Chemical analysis available
c Gamma log available

Accuracy Lat Long

1 Accurate to within one second
2 Accurate to within ten seconds
4 Accurate to within one minute

Table 16. Records of selected wells -- Continued

Well number Tal-	State permit number	Owner or name	Driller	Date completed	Altitude of land surface (feet)	Accuracy of LSD	Finish	Method of drilling	Depth of well (feet)	Diameter of well (inches)	Altitude at top of screen or bottom of casing (feet)	Length of screen or open hole (feet)	Water-bearing formation
Ad 5	T65W37	Schluderberg-Kurdle Co.	Shannahan Art. Well Co.	1964	54	5	S	H	444	4-2	-375	15	G
Af 5	-	M. Chores	___	-	25	-	-	-	185	-	-	-	I
Af 10	41413	Fox Canning Co.	Shannahan Art. Well Co.	1961	10	5	S	H	845	10-6-4	-600 -760	35 70	G E
Bb 4	T65W133	Bayview Water Co., Inc.	do.	1965	15	5	X	H	366	4	-297	54	G
Bc 4	844	Gordon Fisher, Jr.	H. C. Burgess	1946	12	5	S	J	430	3-2	-410	8	G
Bd 21	8513	Morgan B. Schiller	Shannahan Art. Well Co.	1951	14	5	S	J	207	3-2	-178	15	H
Be 3	-	C. W. Kellog	___	1933	40	5	-	V	50	1½	-	-	Q
Be 6	-	do.	Shannahan Art. Well Co.	1937	11	3	S	J	466	4	-445	10	G
Be 44	-	U.S. Geological Survey	___	1953	18	5	-	V	35	1¼	-	-	Q
Be 74	-	Herbert T. Chance	___	-	70	5	-	J	165	3½	-	-	I
Be 79	29643	Talbot County Board of Education	Shannahan Art. Well Co.	1958	70	5	S	H	320	6-5	-239	11	H
Bf 14	-	John M. Wade	___	1903	65	5	-	D	23	42	-	-	Q
Bf 38	11747	J. McKinny Willis	H. C. Burgess	1953	55	5	X	J	147	3	- 60	32	I
Bf 66	462	Schluderberg-Kurdle Co.	Layne-Atlantic Co.	1947	45	5	S	H	990	14-8	-821 -930	20 15	E D
Bf 72	16235	do.	Shannahan Art. Well Co.	1954	42	5	S	H	52	10	+ 11	21	Q
Bf 73	21641	do.	do.	1955	42	5	S	H	288	4-2	-241	5	I
Bf 74	21805	do.	do.	1955	42	5	S	H	48	4	- 1	5	P
Bf 78	T65W101	do.	do.	1965	40	5	S	H	50	10	+ 15	25	Q
Cb 89	12546	Pan American Refining Corp.	Layne-Atlantic Co.	1953	13	5	S	H	1415	10-4	-930 -1340	30 40	D C
Cb 92	32955	Bozman Woman's Club	Shannahan Art. Well Co.	1958	10	5	S	H	170	2-1½	-155	5	H
Cc 29	-	Commissioners of St. Michaels	do.	1928	10	5	S	J	404	8	-370	24	G
Cc 32	T65W50	do.	do.	1965	15	5	S	H	458	10	-393	50	G
Cc 33	T66W56	Ray Kilmon & Harvey Gannon	do.	1965	5	5	S	H	512	4-2	-497	10	G
Cd 2	-	Frank Collins	do.	1943	13	5	S	J	260	4	-	-	H
Cd 48	T65W38	Harry S. Bayer	do.	1964	10	5	S	H	476	4-2	-446	20	G
Cd 49	T65W94	Clarence Chance	Heikes Well Co.	1965	15	5	S	H	564	4-2	-537	12	G
Cd 52	T65W12	Alfred Fairbanks	Shannahan Art. Well Co.	1964	16	5	X	H	352	2-1½	-243	93	H

Accuracy of land surface datum

1 Instrument level, accurate to 0.5 ft.
3 From topo map, accurate to 5 ft.
4 From topo map, accurate to 10 ft.
5 From topo map, accurate to 20 ft.

Finish

G Gravel wall, commercial screen
O Open end
S Screen
T Sand point
X Open hole in aquifer
Z Other

Method of Drilling

D Dug
H Hydraulic-rotary
J Jetted
R Reverse rotary
V Driven

Water-bearing formation

C Raritan
D Magothy
E Matawan
G Aquia
H Piney Point
I Calvert
K Choptank
L St. Marys
P Pliocene
Q Pleistocene
R Holocene

Date Month	Date Year	Water levels above or below sea level (feet) Static	Water levels above or below sea level (feet) Pumping	Drawdown (feet)	Yield (gpm)	Hours pumped	Accuracy for drawdown	Specific capacity (gpm/ft)	Use of water	Temperature °F.	Pumping equipment	Pumping power	Latitude	Longitude	Sequential number	Accuracy Lat Long	Remarks	Well number Tal-
11	64	- 2	- 9	7	16	4	3	2.3	S	63	S	5	38°56'34"	76°05'31"	2	1	b.	Ad 5
9	65	- 3[m]																
-	-	-	-	-	-	-	-	-	H	53	-	-	38°55'	75°57'	1	4	b.	Af 5
7	61	+ 4	-197	201	325	24	3	1.6	Y	-	T	5	38°55'00"	75°56'59"	1	1		Af 10
5	65	+ 1	- 13	14	40	8	3	2.8	P	60	S	5	38°50'20"	76°16'40"	1	1	b.	Bb 4
11	46	0	- 8	8	20	12	3	2.5	H	60	P	5	38°50'30"	76°11'18"	1	1	b.	Bc 4
10	51	+ 6	- 16	22	12	6	3	.5	H	57	P	5	38°50'23"	76°09'34"	1	1	b.	Bd 21
10	53	+23	-	-	-	-	-	-	H	-	P	1	38°53'55"	76°04'09"	1	1	b.	Be 3
10	37	+ 2	-	-	-	-	-	-	H	62	J	5	38°53'32"	76°04'41"	1	1	b.	Be 6
5	54	+12[m]	-	-	-	-	-	-	U	-	N	-	38°51'12"	76°03'39"	1	1		Be 44
-	-	-	-	-	-	-	-	-	H	-	P	5	38°50'06"	76°00'47"	1	1		Be 74
4	58	+32	- 41	73	38	4	3	.5	T	63	S	5	38°51'06"	76°01'03"	1	2	b.	Be 79
7	53	+50	-	-	-	-	-	-	H	53	P	5	38°52'46"	75°57'23"	1	1	b.	Bf 14
3	53	+47	-	-	-	-	-	-	H	53	P	5	38°52'22"	75°58'52"	1	1	b.	Bf 38
3	47	-45	-230	185	210	24	3	1.1	U	-	N	-	38°52'46"	75°59'28"	1	1	Abandoned and filled in.	Bf 66
9	54	+33	+ 17	16	175	4	3	11	Y	-	T	5	38°52'41"	75°59'36"	1	1		Bf 72
3	56	+15[m]	-	-	-	-	-	-	U	-	N	-	38°52'39"	75°59'36"	1	1	Observation well.	Bf 73
3	56	+31[m]	-	-	-	-	-	-	U	-	N	-	38°52'39"	75°59'36"	2	1	do.	Bf 74
3	65	+29	+ 24	5	50	6	3	10	Y	56	T	5	38°52'36"	75°59'27"	1	1	b.	Bf 78
-	-	Flowing	-	-	9	-	-	-	U	69	N	-	38°49'14"	76°17'32"	1	1	b. Drilled to 1,520 ft. gamma logged to 440 ft.	Cb 89
		do.			12													
11	58	+ 3	-	-	15	4	-	-	H	58	C	5	38°46'10"	76°16'15"	1	1	b.	Cb 92
-	28	+ 2	-	-	-	-	-	-	P	63	T	5	38°46'57"	76°13'42"	1	1	b. Drilled to 454 ft.	Cc 29
2	65	0	- 37	37	265	10	3	7	P	-	T	5	38°46'52"	76°13'15"	1	1	c.	Cc 32
10	65	-16	- 60	44	20	4	3	.5	H	64	S	5	38°45'02"	76°10'38"	1	1	b.	Cc 33
-	-	-	-	-	-	-	-	-	S	58	S	5	38°47'58"	76°05'20"	1	1	b.	Cd 2
10	64	-11	- 35	24	35	5	3	1.5	S	61	S	5	38°48'06"	76°09'48"	1	1	b. Drill cuttings available.	Cd 48
1	65	-10	-	-	52	8	3	-	H	-	J	5	38°46'39"	76°07'36"	1	2	c.	Cd 49
6	64	- 4	- 29	25	25	6	3	1.0	H	60	P	5	38°46'56"	78°06'19"	1	1	b.	Cd 52

Accuracy for drawdown

- 0 Measured, accurate to within 1 foot
- 3 From driller's log
- 5 Estimated
- 6 Reported

Use of water

- C Commercial
- H Domestic
- I Irrigation
- Y Industrial
- P Public supply
- S Stock supply
- T Institutional
- U Unused

Pumping equipment

- C Centrifugal
- J Jet
- N None
- P Piston
- S Submergible
- T Turbine

Pumping power

- 1 Hand
- 3 Gasoline
- 5 Electricity

Remarks

- a Electric log available
- b Chemical analysis available
- c Gamma log available

Accuracy Lat Long

- 1 Accurate to within one second
- 2 Accurate to within ten seconds
- 4 Accurate to within one minute

Table 16. Records of selected wells —— Continued

Well number Tal-	State permit number	Owner or name	Driller	Date completed	Altitude of land surface (feet)	Accuracy of LSD	Finish	Method of drilling	Depth of well (feet)	Diameter of well (inches)	Altitude at top of screen or bottom of casing (feet)	Length of screen or open hole (feet)	Water-bearing formation
Ce 1	-	Easton Utilities Commission	Shannahan Art. Well Co.	1901	15	5	S	J	1015	10-8-6 4½-3	- 85 -767 -985	10 6 15	I ? E
Ce 2	-	do.	——	1910	20	5	S	-	110	6-5	-	-	I
Ce 3	-	do.	——	1929	15	5	S	-	1025	12-10- 8-6	-625 -980	- 30	G E
Ce 4	-	do.	——	1929	20	5	-	-	112	10	-	-	I
Ce 5	2261	do.	American Drilling Co.	1947	30	5	S	-	1148	12	-1096	21	D
Ce 7	-	do.	——	-	13	5	S	-	104	4	- 82	7	I
Ce 9	957	A. J. Grimes, Jr. (Tidewater Inn)	Shannahan Art. Well Co.	1946	38	5	X	J	157	8	- 78	44	I
Ce 10	957	do.	do.	1946	38	5	X	J	160	8	- 78	44	I
Ce 35	5556	Abbotts Dairies	do.	1950	39	5	X	J	157	8	- 93	25	K+I
Ce 39	598	Mrs. D. N. G. Bartlett	L. Rude & Son	1946	50	5	-	J	67	3	-	-	K
Ce 50	8836	Easton Utilities Commission	Shannahan Art. Well Co.	1952	20	5	S	H	623	10-6	-550	53	G
Ce 60	37628	do.	do.	1960	21	5	S	H	1045	12-8	-989	35	E
Ce 61	46762	do.	do.	1962	35	5	S	H	1057	16-8	-883 -1006	9 16	E
Ce 62	T65W111	do.	do.	1965	56	5	Z	H	1099	-	-	-	-
Ce 64	48272	Harrison & Jarboe	do.	1962	51	3	S	H	64	2-1½	+ 19	32	K
Ce 66	T65W158	Seymour Builders, Inc.	do.	1965	54	5	S	H	146	2-1½	- 82	10	I
Ce 67	T66W12	Easton Utilities Commission	do.	1965	56	5	G	H	1092	16-8	-794 -1004	27 32	E
Da 36	5097	George Jensen	Albert L. Wilson	1949	10	5	X	J	210	1½	- 95	105	H
Db 38	5555	Tilghman Packing Co.	Shannahan Art. Well Co.	1950	5	3	S	H	442	6-3	-407	30	G
Db 60	26262	do.	Sam Shannahan Well Co.	1957	5	3	S	H	207	4	-192	9	H
Db 61	-	Silvertip Inc.	Shannahan Art. Well Co.	-	5	3	S	H	400	6	-	-	G
Dc 2	3172	Town of Oxford	do.	1949	6	5	S	H	559	10-8-6	-533	20	G
Dc 50	T65W56	—— Kelly	Heikes Well Co.	1964	5	5	S	H	513	4-2	-496	12	G
Dc 52	T66W41	Harry Layman	do.	1965	8	5	S	H	497	2	-477	12	G
Dc 53	32892	Royal Oak Community Church	Shannahan Art. Well Co.	1959	6	5	S	H	311	2-1½	-295	10	H
Dd 53	53609	Talbot Country Club, Inc.	do.	1963	10	5	S	H	640	8-4	-580	50	G
De 12	5694	Harrison & Jarboe	do.	1950	40	5	X	H	394	4-3	-336	18	H
De 13	46763	Easton Utilities Co. Commission	do.	1962	30	5	S	H	405	4-2	-325 -348	5 15	H
De 15	T65W89	Wightman Inc.	Heikes Well Co.	1965	55	5	S	H	182	2	- 94	12	I

Accuracy of land surface datum

1 Instrument level, accurate to 0.5 ft.
3 From topo map, accurate to 5 ft.
4 From topo map, accurate to 10 ft.
5 From topo map, accurate to 20 ft.

Finish

G Gravel wall, commercial screen
O Open end
S Screen
T Sand point
X Open hole in aquifer
Z Other

Method of Drilling

D Dug
H Hydraulic-rotary
J Jetted
R Reverse rotary
V Driven

Water-bearing formation

C Raritan
D Magothy
E Matawan
G Aquia
H Piney Point
I Calvert
K Choptank
L St. Marys
P Pliocene
Q Pleistocene
R Holocene

Date		Water levels above or below sea level (feet)		Drawdown (feet)	Yield (gpm)	Hours pumped	Accuracy for drawdown	Specific capacity (gpm/ft)	Use of water	Temperature °F	Pumping equipment	Pumping power	Latitude	Longitude	Sequential number	Accuracy Lat Long	Remarks	Well number
Month	Year	Static	Pumping															Tal-
-	01	+15	- 10	25	60	-	5	2.4	U	64	N	-	38°46'38"	76°04'38"	1	1	Owner's well 1. Observation well in 1966.	Ce 1
1	56	-13[m]	-	-	193	19	-	-	P	59	T	5	38°46'38"	76°04'38"	2	1	b. Owner's well 2.	Ce 2
8	50	- 7[m]	- 80	73	616	24	0	8	U	-	N	-	38°46'38"	76°04'38"	3	1	b. Owner's well 3.	Ce 3
-	-	-	-	-	-	-	-	-	-	-	N	-	38°46'45"	76°04'36"	1	1		Ce 4
1	49	+22[m]	- 37	59	415	2	0	7	U	78	N	-	38°46'29"	76°04'39"	1	1	b. Owner's West St. well.	Ce 5
4	66	-42[m]	-	-	-	-	-	-	U	-	N	-	38°46'45"	76°04'36"	3	1	Owner's well G. Observation well in 1966.	Ce 7
12	46	-45	- 93	48	200	6.5	3	4.2	C	-	T	5	38°46'27"	76°04'24"	1	1		Ce 9
12	46	-40	- 88	48	200	6.5	3	4.2	C	-	T	5	38°46'27"	76°04'24"	2	1		Ce 10
7	50	-34	- 54	20	40	8	3	2.0	U	-	N	-	38°46'07"	76°04'07"	2	1	c. Observation well in 1965. Logged to 132 ft.	Ce 35
7	46	+44	+ 38	6	20	12	3	3.3	H	-	P	5	38°46'08"	76°03'22"	1	1		Ce 39
1	52	- 9	-176	167	362	24	3	2	P	69	T	5	38°46'38"	76°04'38"	4	1	b. Owner's well 1B.	Ce 50
4	60	-22	-104	82	463	24	3	5.6	P	75	T	5	38°46'44"	76°04'46"	1	1	b. Owner's well 6.	Ce 60
7	62	-59	-217	158	494	24	3	3	P	-	T	5	38°46'01"	76°03'35"	1	1	Owner's well 7.	Ce 61
-	-	-	-	-	-	-	-	-	-	-	-	-	38°47'40"	76°04'00"	1	1	Test hole, drill cuttings available.	Ce 62
7	62	+43	+ 26	17	33	3	3	1.9	Y	59	C	5	38°46'13"	76°03'08"	1	1	b.	Ce 64
7	65	+20	- 21	41	12	4	3	.3	H	61	H	5	38°45'23"	76°03'30"	1	1	b.	Ce 66
3	66	-13	-215	202	500	48	3	2.4	P	76	S	5	38°47'40"	76°04'00"	2	1	b. Owner's well 8.	Ce 67
12	49	0	- 12	-12	11	3	3	.9	C	57	P	5	38°42'56"	76°20'10"	1	1	b.	Da 36
5	50	- 4	- 50	46	100	10	3	2.2	Y	62	T	5	38°42'27"	76°19'59"	1	1	b.	Db 38
4	57	+ 3	- 58	61	100	6	3	1.6	Y	-	T	5	38°42'32"	76°19'50"	1	1		Db 60
-	-	-	-	-	-	-	-	-	S	62	T	5	38°43'55"	76°16'45"	1	1	b.	Db 61
1	49	- 2	- 23	21	46	10	3	2.2	P	68	P	5	38°40'57"	76°10'20"	1	1	b. Drilled to 577 feet.	Dc 2
12	64	- 9[m]	-	-	32	6	-	-	H	-	J	5	38°44'12"	76°11'18"	1	1		Dc 50
9	65	- 6	- 14	8	25	8	3	3.1	H	61	J	5	38°42'44"	76°12'38"	1	1	b.	Dc 52
1	59	- 6	-	-	9	4	-	-	T	61	J	5	38°44'28"	76°10'44"	1	1	b.	Dc 53
9	63	- 22	-173	151	200	8	3	1.3	T	69	T	5	38°43'16"	76°05'45"	1	1	b.	Dd 53
6	50	- 25	- 50	25	25	6	3	1.0	Y	65	J	5	38°42'11"	76°02'30"	1	1	b.	De 12
7	62	- 12	-120	108	12	8	3	.1	T	63	S	5	38°44'52"	76°01'15"	1	1	b.	De 13
1	65	+ 17	+ 7	10	11	11	3	1.1	Y	61	J	5	38°43'38"	76°04'05"	1	1	b.	De 15

Accuracy for drawdown

0 Measured, accurate to within 1 foot
3 From driller's log
5 Estimated
6 Reported

Use of water

C Commercial
H Domestic
I Irrigation
Y Industrial
P Public supply
S Stock supply
T Institutional
U Unused

Pumping equipment

C Centrifugal
J Jet
N None
P Piston
S Submergible
T Turbine

Pumping power

1 Hand
3 Gasoline
5 Electricity

Remarks

a Electric log available
b Chemical analysis available
c Gamma log available

Accuracy Lat Long

1 Accurate to within one second
2 Accurate to within ten seconds
4 Accurate to within one minute

Table 16. Records of selected wells -- Continued

Well number Tal-	State permit number	Owner or name	Driller	Date completed	Altitude of land surface (feet)	Accuracy of LSD	Finish	Method of drilling	Depth of well (feet)	Diameter of well (inches)	Altitude at top of screen or bottom of casing (feet)	Length of screen or open hole (feet)	Water-bearing formation
De 16	T65W155	U.S. Geological Survey	Shannahan Art. Well Co.	1965	53	5	-	H	1523	7	-	-	-
De 17	T65W175	Douglas Sullivan	do.	1965	53	5	S	H	384	4-2	-316	15	H
De 18	T66W7	U.S. Geological Survey	do.	1965	40	5	-	H	1493	7	-	-	-
De 19	T66W36	Shore Homes Inc.	Heikes Well Co.	1965	40	5	S	H	372	2½-2	-300	24	H
Df 4	T65W80	William T. Skipper	Shannahan Art. Well Co.	1964	19	5	S	H	184	2	-150	15	I
Ed 8	T65W91	William K. DuPont	Carvel H. Rude	1965	10	5	X	J	378	2½	-284	34	H
Ee 1	-	Town of Trappe	Shannahan Art. Well Co.	1929	56	5	S	J	400	2	-	-	H
Ee 8	895	Trappe Frozen Food Corp.	do.	1946	55	5	S	H	948	10-6	-352 -858	20 12	H ?
Ee 30	T65W135	Bountiful Farms	do.	1965	50	5	S	H	413	4-2	-333	30	H
Ee 31	T65W144	Richard Lowery	Leon Jarrett	1965	20	5	S	J	399	2½-1½	-359	20	H
Ee 34	-	J. A. Draper	Carvel H. Rude	1962	22	5	-	J	180	2	-	-	I
Wicomico County													
Wic-													
Bc 52	-	James Everman	E. R. Kauffman	1964	10	5	G	R	136	13	- 2	124	Q

Accuracy of land surface datum

1 Instrument level, accurate to 0.5 ft.
3 From topo map, accurate to 5 ft.
4 From topo map, accurate to 10 ft.
5 From topo map, accurate to 20 ft.

Finish

G Gravel wall, commercial screen
O Open end
S Screen
T Sand point
X Open hole in aquifer
Z Other

Method of Drilling

D Dug
H Hydraulic-rotary
J Jetted
R Reverse rotary
V Driven

Water-bearing formation

C Raritan
D Magothy
E Matawan
G Aquia
H Piney Point
I Calvert
K Choptank
L St. Marys
P Pliocene
Q Pleistocene
R Holocene

Date Month	Date Year	Water levels above or below sea level (feet) Static	Water levels above or below sea level (feet) Pumping	Drawdown (feet)	Yield (gpm)	Hours pumped	Accuracy for drawdown	Specific capacity (gpm/ft)	Use of water	Temperature °F	Pumping equipment	Pumping power	Latitude	Longitude	Sequential number	Accuracy Lat Long	Remarks	Well number Tal-
-	-	-	-	-	-	-	-	-	-	-	-	-	38°41'44"	76°03'46"	1	1	a, c. Test hole, drill cuttings available.	De 16
6	65	- 17	-112	95	9	4	3	0.1	H	64	S	5	38°41'44"	76°03'46"	2	1	b.	De 17
-	-	-	-	-	-	-	-	-	-	-	-	-	38°44'31"	76°03'59"	1	1	a, c. Drill cuttings available.	De 18
9	65	- 2	- 26	24	10	10	3	.4	H	-	J	5	38°43'11"	76°04'21"	1	1	c.	De 19
11	64	+ 3	- 31	34	18	3	3	.5	H	62	J	5	38°40'58"	75°58'38"	1	1	b.	Df 4
1	65	- 50	-158	108	35	8	3	.3	H	-	J	5	38°37'45"	76°06'44"	1	1	c.	Ed 8
-	-	-	-	-	-	-	-	-	P	65	C	5	38°39'34"	76°03'30"	1	1	b.	Ee 1
6	46	- 13	-191	178	240	1.5	3	1.9	Y	-	T	5	38°39'27"	76°03'15"	4	1	Drilled to 1245 ft.	Ee 8
6	65	- 47	- 55	8	20	5	3	2.5	H	64	S	5	38°39'33"	76°01'56"	3	4	b.	Ee 30
5	65	- 65	-	-	35	8	-	-	H	64	J	5	38°37'12"	76°03'02"	1	1	b.	Ee 31
-	-	-	-	-	-	-	-	-	I	61	J	5	38°36'25"	76°00'01"	1	1	b.	Ee 34

Wicomico County

																		Wic-
7	64	+ 1	- 59	60	931	-	3	16	I	-	-	-	38°28'02"	75°47'45"	-	1		Bc 52

Accuracy for drawdown

0 Measured, accurate to within 1 foot
3 From driller's log
5 Estimated
6 Reported

Use of water

C Commercial
H Domestic
I Irrigation
Y Industrial
P Public supply
S Stock supply
T Institutional
U Unused

Pumping equipment

C Centrifugal
J Jet
N None
P Piston
S Submergible
T Turbine

Pumping power

1 Hand
3 Gasoline
5 Electricity

Remarks

a Electric log available
b Chemical analysis available
c Gamma log available

Accuracy Lat Long

1 Accurate to within one second
2 Accurate to within ten seconds
4 Accurate to within one minute

MARYLAND GEOLOGICAL SURVEY
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Reports of Investigation:

1. Chemical quality of water and trace elements in the Patuxent River Basin, by S. G. Heidel and W. W. Frenier, 1965, 52 p. ---- $1.00
2. Pleistocene stratigraphy of the Salisbury area, Maryland and its relationship to the lower Eastern Shore: a subsurface approach, by H. J. Hansen, 1966, 56 p. ---- 2.25
3. Water resources of the Salisbury area, Maryland, by D. H. Boggess, and S. G. Heidel, 1968, 69 p. ---- 3.00
4. Expandable clay in the St. Marys Formation of Southern Maryland by M. M. Knechtel, H. P. Hamlin, and J. W. Hosterman, 1966, 19 p. ---- 1.00
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