COMMONWEALTH OF VIRGINIA

DEPARTMENT OF CONSERVATION
AND ECONOMIC DEVELOPMENT

DIVISION OF MINERAL RESOURCES

Copy 1
(original)

GROUND-WATER RESOURCES OF THE NORTHERN NECK PENINSULA VIRGINIA

ALLEN SINNOTT

VIRGINIA DIVISION OF
RECEIVED
JUL 30 1969
MINERAL RESOURCES

~~BULLETIN~~

VIRGINIA DIVISION OF MINERAL RESOURCES
Prepared in cooperation with the Geological Survey, United States Department of the Interior
James L. Calver
Commissioner of Mineral Resources and State Geologist

CHARLOTTESVILLE, VIRGINIA
1969

CONTENTS

	Ms. Page
Abstract	1a
Introduction	1
Location of the area	3
Acknowledgements	4
Purpose of the investigation	6
~~Methods of field work~~	[illegible]
Previous investigations	6
General Geology	8
Introduction	8
Basement complex	9
Cretaceous System	10
Potomac Group	10
Cretaceous to Tertiary Systems	13
Upper Cretaceous and Paleocene	13
Mattaponi Formation	13
Tertiary System	14
Paleocene and Eocene Series	14
General stratigraphic relations	14
Aquia Formation	~~16~~ 15
Nanjemoy Formation	17
Chickahominy Formation	18
Miocene Series	19
Chesapeake Group	19

Ms.
Page

General Geology, cont.

Quaternary System..... 21

Pleistocene Series..... 21

Occurrence and lithology..... 22

Holocene Series..... 23

Basic well records..... 23

Records of materials penetrated..... 23

Drillers' logs..... 23

~~Water-bearing materials..... 24~~

~~Non-water-bearing sediments..... 25~~

Lithologic sample descriptions..... 26

Chemical character of ground water..... 26

Silica (SiO_2)..... 27

Iron (Fe)..... 27

Calcium (Ca) and Magnesium (Mg)..... 28

Carbonate (CO_3) and Bicarbonate (HCO_3)..... 28

Sulfate (SO_4)..... 29

Chloride (Cl)..... 29

Fluoride (F)..... 30

Nitrate (NO_3)..... 30

Dissolved solids..... 31

Specific conductance..... 31

Hardness..... 31

Ms. Page

County descriptions..... 42

Introduction..... 42

Eastern Stafford County..... 43

Location and development..... 43

Topography and drainage..... 44a

Geology and ground-water conditions..... 44b

Basement complex..... 44b

Cretaceous System—Potomac Group..... 45

Cretaceous to Tertiary Systems--Mattaponi Formation..... 47

Tertiary System..... ~~48a~~ 47

Aquia Formation..... ~~48a~~ 47

Other Eocene and Miocene rocks..... ~~48b~~ 48

Quaternary System--Columbia Group..... 49

Summary of ground-water conditions..... 50

Well records and chemical analyses..... 51

King George County..... 61

Location and development..... 61

Topography and drainage..... 62

Geology and ground-water conditions..... 63

Basement complex..... 63

Cretaceous System—Potomac Group..... 64

Water-bearing character..... 65

Cretaceous to Tertiary Systems--Mattaponi Formation. 66

Water-bearing character..... 67

Ms.
Page

Tertiary System

Aquia and Nanjemoy Formations..... 68

[redacted]

Water-bearing character..... 70

Chesapeake Group..... 71

Quaternary System--Columbia Group..... 72

Water-bearing character..... 72

Summary of ground-water conditions..... 73

Well records and chemical analyses..... 74

Westmoreland County..... 95

Location and development..... 95

Topography and drainage..... 96

Geology and ground-water conditions..... 97

Basement complex..... 97

Cretaceous System--Potomac Group..... 97

Cretaceous to Tertiary Systems—Mattaponi Formation. 99

Water-bearing character..... 99

Quality of water..... 101

Tertiary System..... 102

Aquia and Nanjemoy Formations..... 102

Water-bearing character..... 103

Chickahominy Formation..... 104

Water-bearing character..... 104

Ms. Page

Chesapeake Group..... 106

Water-bearing character..... 106

Quaternary System--Columbia Group..... 108

Water-bearing character..... 108

Quality of water..... 109a

Summary of ground-water conditions..... 109b

Well records and chemical analyses..... 110

Richmond County..... 136

Location and development..... 136

Topography and drainage..... 137

Geology and ground-water conditions..... 138

Basement complex..... 138

Cretaceous System--Potomac Group..... 139

Cretaceous to Tertiary Systems--Mattaponi Formation. 140

Water-bearing character..... 140

Tertiary System..... 143

Aquia and Nanjemoy Formations..... 143

Chickahominy Formation..... ~~144~~ 143

Chesapeake Group..... 145

Water-bearing character..... 146

Quaternary System--Columbia Group..... 147a

Summary of ground-water conditions..... 147b

Well records and chemical analyses..... 148

Ms. Page

Northumberland County..... 166

Location and development..... 166

Topography and drainage..... 167

Geology and ground-water conditions..... 168

Basement complex..... 168

Cretaceous System--Potomac Group..... 169

Cretaceous to Tertiary System--Mattaponi Formation. 170

Water-bearing character..... 171

Tertiary System..... 174

Aquia and Nanjemoy Formations..... 174

Chickahominy Formation..... 174

Water-bearing character..... 175

Chesapeake Group..... 177

Water-bearing character..... 178

Quaternary System--Columbia Group..... 181

Water-bearing character..... 181

Summary of ground-water conditions..... 183b

Well records and chemical analyses..... 184

Ms. Page

Lancaster County..... 214

Location and development..... 214

Topography and drainage..... 215

Geology and ground-water conditions..... 217

Basement complex..... 217

Cretaceous System--Potomac Group..... 217

Cretaceous to Tertiary Systems--Mattaponi Formation. 218

Water-bearing character..... 219

Tertiary System..... 224a

Aquia and Nanjemoy Formations..... 224a

Water-bearing character..... 224a

Chickahominy Formation..... 224b

Water-bearing character..... 224b

Chesapeake Group..... 226

Water-bearing character..... 226

Quaternary System--Columbia Group..... 228

Summary of ground-water conditions..... 229

Well records and chemical analyses..... 230

References..... 267

Index.....

ILLUSTRATIONS

Plate

1. Geologic sections across the Northern Neck peninsula..... In pocket

2. Principal geologic formations of the Northern Neck peninsula: their origin, lithology and water-bearing character..... In pocket

Figure | Page

1. Index map of eastern Virginia, showing the Northern Neck peninsula..... 3b

2. Map of Eastern Stafford County, showing location of wells described in Tables 1, 2, and 3..... 52

3. Indurated marl of the Aquia Formation at Fairview Beach..... ~~68b~~ 69

4. Map of King George County, showing location of wells described in Tables 4, 5, and 6..... 75

5. Exposure of rocks of the Chesapeake Group in Nomini Cliffs..... 96b

6. Map of Westmoreland County, showing location of wells described in Tables 7, 8, and 9..... 111

7. Map of Richmond County, showing location of wells described in Tables 10, 11, and 12..... 149

8. Map of Northumberland County, showing location of wells described in Tables 13, 14, and 15..... 185

9. Sands of the Columbia Group in cliff near White Stone, Lancaster County..... 228b

10. Map of Lancaster County, showing location of wells described in Tables 16, 17, and 18..... 231

TABLES

Ms.
Page

Eastern Stafford County

1. Records of wells..... 53
2. Logs of wells..... 55
3. Chemical analyses..... 58

King George County

4. Records of wells..... 76
5. Logs of wells..... 79
6. Chemical analyses..... 94

Westmoreland County

7. Records of wells.....112
8. Logs of wells.....116
9. Chemical analyses.....132

Richmond County

10. Records of wells.....150
11. Logs of wells.....153
12. Chemical analyses.....163

Northumberland County

13. Records of wells.....186
14. Logs of wells.....192
15. Chemical analyses.....208

Lancaster County

16. Records of wells.....232
17. Logs of wells.....236
18. Chemical analyses.....262

GROUND-WATER RESOURCES OF THE NORTHERN
NECK PENINSULA, VIRGINIA

By Allen Sinnott

ABSTRACT

That part of Virginia covered in this report consists of five counties and the eastern part of a sixth which together form the Northern Neck peninsula. This peninsula lies along the northern part of the Tidewater region, or Coastal Plain province. The counties in the area are, from west to east, eastern Stafford, King George, Westmoreland, Richmond, Northumberland, and Lancaster.

Fieldwork was begun in the area in about 1945, and carried on intermittently by several workers. Significant information on selected wells drilled as recently as 1966 has been incorporated in the appraisal of the ground-water conditions in the area.

The Northern Neck, as it is generally known, is largely rural in character, with many small villages and a few towns. Among the latter, the largest are Stafford, King George, Montross, Colonial Beach, Warsaw, Heathsville, Reedville, Lancaster, and Kilmarnock.

The only large city nearby is historic Fredericksburg, just across the Rappahannock River in Spotsylvania County. The George Washington Birthplace National Monument is in northwestern Westmoreland County. Nearby also is Stratford, the home of General Robert E. Lee.

The only major railroad is the Richmond, Fredericksburg, and Potomac, which traverses eastern Stafford County. The Northern Neck

is crossed also by U.S. Highway 1 and Interstate 95--also in eastern Stafford County, and U.S. Highway 301, which crosses King George County. There are excellent smaller highways throughout the area.

The Northern Neck is of low to moderate relief and thus is well suited to its agricultural economy. The climate is mild with moderate rainfall, and is especially favorable for truck farming. Other principal ~~industries~~ occupations on the Northern Neck are canning, fish and fish-oil processing, fishing (in part for shell fish), lumbering, dairying, and raising of livestock; recreation is becoming of greater importance, particularly sport fishing, swimming and boating. Several housing development projects have been started near some of the larger towns in recent years.

The basement bedrock complex has not been tapped directly for water in the area covered by this report. These rocks are erratic with respect to yield of ground water, and more dependable supplies can be had from the overlying sediments of the Coastal Plain deposits almost everywhere.

Immediately overlying the basement rocks is the Potomac Group of sediments. It consists of extensive beds of sands, clays, and minor gravel lenses, chiefly of deltaic origin. Downdip the Potomac may exceed a thickness of 1,400 feet. These beds have been tapped by a few wells near the Stafford-King George County line. They contain large reserves of ground water of excellent quality although in the easternmost part of the area wells much deeper than the present deep wells may develop brackish water and further, in eastern Lancaster County long continued heavy withdrawals from artesian wells of more moderate depth may induce

inland migration of brackish water from the high-chloride zone.

The Mattaponi Formation, of Late Cretaceous and Paleocene age, overlies the Potomac Group. It is characterized by mottled clays and contains [redacted] beds of water-bearing sands that are commonly more or less glauconitic. This formation furnishes moderate to large supplies of ground water of generally excellent quality to many wells in the entire Northern Neck peninsula. From the standpoint of the ground-water resources, it is the most dependable single source of supply in the peninsula. Several large-yield wells have been constructed from place to place throughout the area. The water ranges from moderate in sodium bicarbonate content in the western part of the area to high in the eastern area. The maximum chloride concentration, 113 ~~milligram~~ parts per ~~liter~~ million, is from a well in the southeasternmost part of the peninsula.

The Aquia Formation of Paleocene age, and the Nanjemoy Formation of early and middle Eocene age overlie the Mattaponi in the more westerly part of the area. They are characterized by glauconitic sands and marls. Downdip these formations appear to thin out. The Aquia is truncated by the Nanjemoy and, still farther downdip, the Nanjemoy is truncated by the late Eocene Chickahominy Formation. The Chickahominy is sandy, glauconitic and commonly contains thin limy strata. These three formations furnish small to moderate supplies to a number of wells in the peninsula. The Aquia is a poor aquifer, ~~but~~ the Nanjemoy is somewhat better. On the lower peninsula, sands of the Chickahominy are well developed and are drawn upon by

many domestic wells. The water is generally similar in chemical quality to that from the deeper formations.

The Chesapeake Group of formations of Miocene age unconformably overlies the older formations. It consists of marl, clays, diatomaceous earth, and minor sands. Small supplies of ground water of fair to good quality are developed from shallow wells although the water is commonly hard.

The land surface is nearly everywhere mantled by sands and gravels of the Columbia Group of Pleistocene age that range ~~up to~~ as much as ~~about~~ 50 or 60 feet in thickness. Many hundreds of dug or driven wells obtain small supplies from them for domestic use. Iron in the shallow ground water from these deposits is troublesome in places and nitrate may be excessive because of pollution from surface drainage.

The only deposits of Holocene [redacted] age that might warrant attention are beach deposits of limited extent above high tide level that might yield very small supplies for domestic or limited stock use.

There are no areas of excessive or even heavy withdrawals of ground water on the Northern Neck in that the economy is primarily agricultural and small commercial and recreational demands can be met by artesian well water supplies. Extensive use of artesian

water for irrigation is not anticipated, owing to the relatively high concentration of sodium found in that water. Thus, there appears to be ample additional ground-water supplies available for all foreseeable needs.

Location of the Area II

The area covered by this report includes the eastern part of Stafford County and all the counties of King George, Westmoreland, Richmond, Northumberland, and Lancaster. Together these counties form the peninsula known as the Northern Neck (Fig. 1). The

---

Figure 1.-- Map of the Virginia Coastal Plain, showing counties included in this report and location of the geologic sections on Plate 1.

Northern Neck is the northernmost of the peninsulas west of Chesapeake Bay in the Virginia Coastal Plain and is bounded on the north by the Potomac River and on the south by the Rappahannock River.

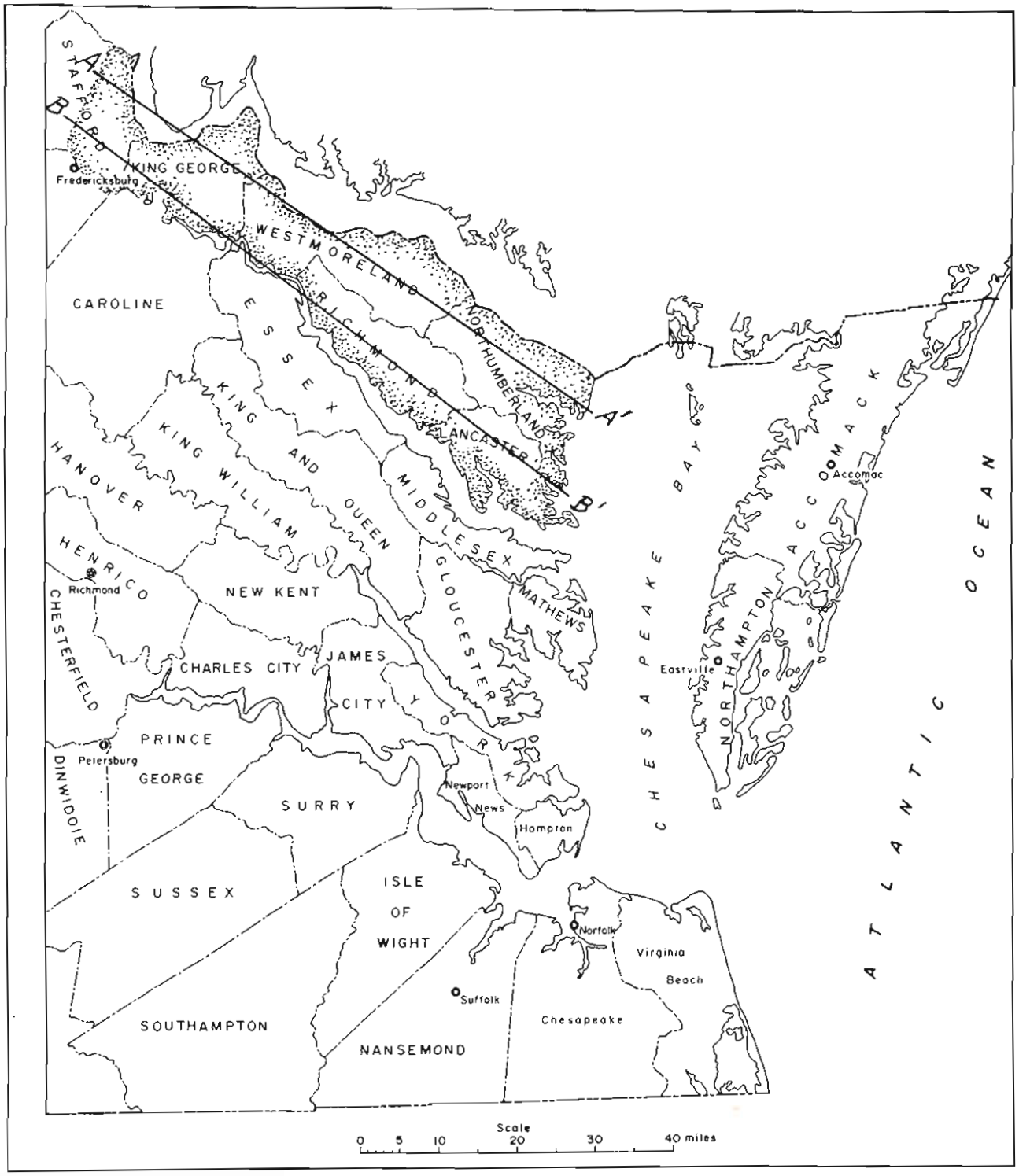


Figure 1.--Map of the Virginia Coastal Plain, showing the Northern Neck peninsula and the location of the geologic sections on Plate 1.

Introduction and Acknowledgments

This report summarized the results of an investigation of the ground-water resources of the Northern Neck Peninsula in Virginia which was begun in the middle 1940's as a cooperative project of the Division of Geology of the Virginia Department of Conservation and Economic Development and the U.S. Geological Survey. Work continued intermittently until 1957 and was completed in 1968.

Work was performed initially under direction of the late O. E. Meinzer, geologist-in-charge of the Ground Water Branch, U.S. Geological Survey and subsequently under the late A. N. Sayre who succeeded O. E. Meinzer. The work in 1968 was carried out under the general direction of G. E. Ferguson, Regional Hydrologist, Atlantic Coast Region, and J. Wyatt Gambrell, District Chief, of the U.S. Geological Survey. Virginia cooperating officials during the earlier years were the late Arthur Bevan and the late William McGill, State Geologists. In 1968, James L. Calver, State Geologist and Commissioner of the Division of Mineral Resources was the cooperating official.

The author is grateful to many of the well owners on the peninsula for their helpful cooperation in making available much of the basic well information and for granting access to their wells for the collection of samples for chemical analysis. Thanks are due also to the many well drillers and well-drilling firms that have furnished logs of wells, especially the following: J. W. Wilson and A. L. Wilson, Tilghman, Md.; W. S. Reynolds, Leonard Reynolds, and Bruce Norman, of Walkerton, Va.; James P. Prine, formerly of Norfolk, Va.; the late H. Lyons, of Tappahannock, Va.; Sydnor

Hydrodynamics, Inc. (formerly Sydnor Pump & Well Co., Inc.), of Richmond, Va.; Virginia Machinery & Well Co., of Richmond, Va.; Mitchell's Well & Pump Co. of Petersburg, Va.; and Leazer Pump & Well Co., of Fredericksburg, Va.

Information on file for a number of wells drilled since 1957 has been provided by the Virginia Division of Mineral Resources. This information has been incorporated with the discussion of the ground-water conditions, and descriptions of selected recent wells have been added to several of the tables.

The author's colleagues, Robert L. Wait and D. J. Cederstrom, reviewed the draft of the report and made many helpful suggestions for its revision.

Field work in the Northern Neck peninsula was begun in about 1945 by D. J. Cederstrom, then district geologist with the Branch of Ground Water. Carlos E. Milner did much of the field work in Northumberland County. In addition, Messrs. James H. Kempf, G. Chase Tibbitts, Jr., Seymour Subitzky, and G. C. Chaterji prepared lithologic descriptions of drill cuttings from several wells. Mrs. Frances H. Dowell, Mrs. Jo Ann T. Broscious, Miss Carolyn L. Crea, Mrs. Anne F. Bisset, and Miss Sharon Harlow, assisted in the preparation of the basic data tables; Mrs. Dowell also provided technical assistance with a subsurface geologic peg model used for developing the stratigraphic correlations.

Purpose of the Investigation

This investigation was undertaken to describe the general occurrence and chemical quality of ground water on the Northern Neck peninsula, in order to assist in effective utilization of that resource by municipalities, industries, farmers, and domestic users and to provide factual data, as far as it was possible to do so, for long-range planning.

Previous investigations II

Considerable information on the ground-water resources of the counties of the Northern Neck peninsula is contained in a report by Sanford (1913), published as Virginia Geological Survey Bulletin 5. A number of well records and several logs from that publication have been included in the present report.

Basic data pertaining to wells in the Northern Neck peninsula, descriptions and locations of representative wells, well logs, and chemical analyses of ground water, were released recently to the open file (Sinnott, 1967). These data are included in the present report.

More general information on various aspects of the ground-water conditions in the Virginia Coastal Plain, including the counties of the Northern Neck peninsula, have been published by several workers. Cederstrom (1946) discussed the chemical quality of the ground waters of the Coastal Plain and the occurrence of chloride (1943); Sinnott and Whetstone (1962) discuss the occurrence of fluoride in the ground waters. DeBuchananne (1968) has compiled a hydrologic atlas that includes the Northern Neck counties, based on available information from many sources.

General Geology (I)

Introduction (II)

The unconsolidated sedimentary rocks of the Virginia Coastal Plain dip very gently eastward at a rate of about 5 to 20 feet per mile. These sediments consist of sand, clay, and minor gravel lenses that rest unconformably on a broadly undulating surface of crystalline granitic and metamorphic basement rocks. These strata become progressively thinner westward, and disappear as a feather-edge along the Fall Zone--a belt of falls and rapids extending roughly southward from Washington through Fredericksburg, Richmond, Petersburg, and Emporia. Eastward, the sediments reach a thickness of perhaps more than 3,000 feet beneath eastern Northumberland County along the western shore of Chesapeake Bay (DeBuchananne, 1968, Sheet 1).

In the sections that follow, the stratigraphic units that occur in the northern part of the Virginia Coastal Plain are discussed, with particular reference to their occurrence on the Northern Neck peninsula. The relations among these units are shown in the descriptive chart of the rock formations (Plate 2, in pocket), together with brief summaries of their water-bearing character. More detailed discussion of the occurrence of ground water in these formations is presented in the county descriptions in the latter part of this report.

Basement Complex II

The basement complex is the hard bedrock underlying the unconsolidated Coastal Plain sedimentary rocks. It is believed to consist principally of crystalline granite, and gneiss, schist and other metamorphic rocks, but locally also there may be units of consolidated arkosic sandstones of Triassic age.

As shown by contours on the basement rocks (DeBuchananne, 1968, sheet 1), the upper surface of the basement slopes eastward at a rate of about 38 feet per mile, and may lie as much as 3,000 feet below sea level beneath the eastern part of the Northern Neck peninsula. However, bedrock lies about 2,200 feet below sea level at Mathews (Cederstrom, 1945a, p. 47), which is almost directly south of the eastern part of Lancaster County, so that 3,000 feet may be excessive.

Cretaceous System II

Sedimentary rocks making up the Potomac Group of Early Cretaceous age immediately overlie the basement rocks beneath the Virginia Coastal Plain.

Potomac Group III

In Maryland and Virginia, the basal sediments of Cretaceous age are the Potomac Group of formations. The oldest and most extensive of these is the Patuxent Formation, ~~which has been generally assigned to the Lower Cretaceous~~. For the purposes of this report, the Cretaceous rocks are treated as the Potomac Group, undifferentiated.

Outcrops of the Potomac Group are well exposed along road cuts on U.S. Highway 1 between Washington and Fredericksburg. These sediments are commonly arkosic cross-bedded sands, with interbedded clay and minor gravel lenses. The fossil assemblage and the character of the lithologic variation indicate deposition in a non-marine environment. Clark and Miller (1912), and Sanford (1913) suggest that the Potomac Group was deposited as a broad delta. Cederstrom (1945b, p. 21-25) compares these deposits to the sediments of the Mississippi River delta complex, described in detail by Russell and Russell (1939), and points out their similarity in lithology and probable similar origin.

Cretaceous to Tertiary Systems II

Upper Cretaceous and Paleocene Series III

Mattaponi Formation IV

Occurrence and Lithology V

Certain beds in the Virginia Coastal Plain, because of a distinctive lithology and foraminiferal fauna, and important associated water-bearing beds, have been designated the Mattaponi Formation by Cederstrom (1957, p. 17). One of the type wells (1b, Table 8) is at Colonial Beach on the south bank of Potomac River in Westmoreland County, and the other (2a, Table 8) is at the George Washington Birthplace National Monument, 4 miles southeast of Colonial Beach. Both wells contain distinctive Foraminifera of older aspect than those typical of the overlying Aquia Formation and are glauconitic to some degree. The latter well lacks the brightly colored and mottled clays noted in the Colonial Beach well that are generally characteristic of Mattaponi Formation.

Cederstrom (1957, p. 19) notes also two other wells in Westmoreland County near the type wells, at Oak Grove, 6 miles south-southwest of Colonial Beach and 5½ miles southwest of Washington's Birthplace, that show the range in lithologic character typical of the Mattaponi. (See logs for wells 73 and 74, Table 8.) Similar examples are cited for other wells in the Northern Neck and elsewhere in the Virginia Coastal Plain.

Based on its distinctive foraminiferal fauna, Cederstrom designated the age of the Mattaponi as ranging from Late Cretaceous to early Tertiary (Paleocene).

Tertiary System	II
Paleocene and Eocene Series	III
General Stratigraphic Relations	IV

Overlying the Mattaponi are certain beds characterized by abundant glauconite. These deposits first were described by Darton (1891) as the Pamunkey Group, from the valley of the Pamunkey River, where the beds are well exposed. The older beds, of Paleocene age, were named the Aquia Formation by Clark (1895), and the younger beds, of early and middle Eocene age, were named the Nanjemoy Formation by Clark and Martin (1901).

A late Eocene age has been determined for certain fossiliferous strata, overlying the Nanjemoy Formation. This unit has been named the Chickahominy Formation, and its foraminiferal fauna and subsurface occurrence have been described by Cushman and Cederstrom (1945). The type locality is at Yorktown.

Aquia Formation IV

Occurrence and Lithology V

The Aquia Formation of Paleocene age is widely distributed in the western part of the Virginia Coastal Plain. The type locality is on the banks of Aquia Creek, a tributary of the Potomac River in Stafford County. Several detailed sections in this vicinity have been published by Clark and Miller (1912, p. 93-96) and Cushman (1944) has described the foraminiferal fauna.

The Aquia consists chiefly of argillaceous glauconitic sands, or greensands, interbedded with glauconitic marls and shell beds. There are also minor lenses of quartz sand. In drill cuttings the

Aquia appears to be similar to the overlying Nanjemoy Formation, and in many wells it is difficult or impossible to differentiate between them.

In Stafford County, at the type locality, the Aquia Formation is about 100 feet thick according to Clark and Miller (1912, p. 91). As determined from wells, its thickness ranges from 50 to 100 feet wherever it can be differentiated from the other Eocene formations. Downdip, the Aquia becomes thinner and probably is absent in the easternmost part of the Northern Neck, having been eroded by the advancing early Eocene seas at the beginning of Nanjemoy time.

Nanjemoy Formation IV

Occurrence and Lithology V

The Nanjemoy Formation, like the Aquia, is widely distributed in eastern Virginia. It is largely covered by younger deposits and it crops out only in road cuts and stream valleys. Its type locality is along Nanjemoy Creek, a tributary of the Potomac River in Maryland, whence it was named by Clark and Martin in 1901 (~~op. cit.~~, p. 64).

The lithology of the Nanjemoy is characterized mainly by a high content of glauconite, recorded as greensand or black sand in drillers' logs. The sands are commonly interbedded with clay.

The Marlboro Clay Member, commonly pink or reddish in color, occurs at the base of the Nanjemoy Formation, resting directly on the Aquia beds. It is persistent along the Fall Zone, and is recognized at places downdip on the peninsula. This member is widely present in the northern part of the Coastal Plain, and may be noted in many logs of wells. The Marlboro Clay Member is an excellent marker bed where it is present.

Detailed sections at many localities in northern Virginia where the Nanjemoy Formation is exposed are given by Clark and Miller (~~op. cit.~~, p. 105-115).

Chickahominy Formation IV

Occurrence and Lithology V

At the upper part of the Eocene column, certain fossiliferous strata, unconformably overlying the Nanjemoy Formation at Yorktown, have been named the Chickahominy Formation (Cushman and Cederstrom, 1945).

The Chickahominy, at its type locality at Yorktown, is about 80 feet in thickness. There it is marly in large part, but in the Northern Neck the formation generally is sandy in character. However, it also contains beds of blue, gray, and dull brown clay.

The Chickahominy was deposited in a transgressive marine environment, and thus it removed a substantial part of the underlying Nanjemoy Formation during the marine advance in Late Eocene time. It in turn was truncated by the early Miocene (Calvert) marine advance, and it was completely removed westward of central Westmoreland County.

Miocene Series--Chesapeake Group III

The Chesapeake Group of Miocene age lies near the surface in the eastern part of the Virginia Coastal Plain, being covered only by deposits of the Columbia Group of Pleistocene age.

In the subsurface, as recorded in drillers' logs, the several formations of the Chesapeake Group are not readily distinguished one from another. Thus in most localities, where only drillers' logs are available, it has been impractical to attempt to differentiate among the component formations.

Quaternary System II

Pleistocene Series--Columbia Group III

The Columbia Group of Pleistocene age consists of a succession of nearly horizontal marine and estuarine deposits that mantle the older Cretaceous and Tertiary rocks of the Coastal Plain. These unconsolidated rocks are extensively developed in Tidewater Virginia. Their upper surface is characterized by a succession of terraces related to the major advances of the continental ice sheets across northern North America in the Pleistocene epoch. Each terrace has been regarded as the upper surface of a formation of the Columbia Group; the name of each terrace has been used also for an associated formation of the same name--whence the term "terrace formation." (See Wentworth, 1930.)

Subsequently, Moore (1956) showed that more than one terrace can be developed on a single formation. Oaks and Coch (1963) summarize the recent thinking on this subject based on detailed stratigraphic and morphologic studies that they made in the southern part of the Coastal Plain. For the present purpose, however, the Columbia Group has been treated as a single stratigraphic unit.

Occurrence and Lithology IV

The Columbia Group on the Northern Neck peninsula is represented by deposits consisting largely of unfossiliferous weathered clayey sands and gravels. Locally, the gravel may be very coarse; the sands are commonly distinctively yellow as compared with the grayer Miocene and Eocene rocks--likewise unconsolidated--which underlie them. The range of thickness of the Columbia Group on the peninsula is believed to be from a few feet to not much more than 50 feet.

Holocene Series

Deposits of Holocene (~~Recent~~) age in the Virginia Coastal Plain are represented by alluvium in creek beds, lagoonal deposits, and deposits forming dunes, beaches, bars, and spits. Except for beach deposits, the lateral extent of these deposits is limited and they are commonly very thin.

Basic Well Records

During the cooperative investigation, information was obtained on more than 300 wells in the Northern Neck peninsula, mostly by visits to the wells, supplemented by information from well owners, well drillers, and others. A few important wells have been listed from the early report by Sanford (1913) on ground water in the Virginia Coastal Plain.

Records of Materials Penetrated

Drillers' Logs

Most of the logs included in this report are based on drillers' records of subsurface samples. In order to maintain a more uniform terminology, many of the drillers' terms have been modified by the writer in accordance with the known lithologic character of the formations penetrated. Stratigraphic boundaries have been indicated by the writer, or by others as credited.

Lithologic Sample Descriptions

Many suites of samples were collected by drillers for the Geological Survey or by Survey personnel during the drilling of several wells in the Northern Neck. These samples have been studied in the laboratory and the lithology described in detail. Elsewhere, descriptions of the subsurface samples recorded by drillers have been helpful. In many places drillers' well logs provide the only available record of subsurface materials, ~~and~~ They are especially valuable ~~in~~ with respect to the occurrence of water-bearing material.

Chemical Character of Ground Water

In this report, chemical analyses of ground water from selected wells are given in tables for each county of the Northern Neck peninsula. These analyses were made in the laboratories of the Quality of Water Branch of the Geological Survey.

Chemical analyses are important in considering the fitness of the water for its intended use. Certain inorganic chemical constituents--commonly called mineral constituents--may not be tolerated above specific maximum concentrations which differ with the use to which the water is put. Methods of treatment are available for

removing or reducing the quantity of most of the objectionable dissolved mineral constituents.

The mineral matter contained in ground water is dissolved principally from the rocks and soils with which the water comes in contact. Commonly, ground water contains not more than one-tenth of 1 percent by weight--1,000 parts per million (ppm)--of dissolved mineral matter. The mineral constituents that have a particular bearing on the suitability of ground water for most purposes are silica, iron, calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, fluoride, and nitrate. Many of these dissolved constituents have characteristic effects when present in the water in sufficient concentrations. In the following paragraphs, these effects are briefly discussed. (Material for this section has been drawn largely from Bulletin 8 of the Virginia Division of Water and Power, Lamar and Whetstone, 1947.)

check if reference listed: OK

Silica (SiO_2).-- The silica concentration in water is chiefly of interest to industrial users. Silica in water used in boilers contributes to the formation of a hard scale and is particularly troublesome because the scale prevents rapid transfer of heat. At operating pressures in excess of 250 pounds per square inch, even small concentrations of silica--less than about 5 ppm--have adverse effects on the boilers. Silica concentrations determined in Northern Neck ground waters range between 8.7 and 59 ppm.

Iron (Fe).--In concentrations greater than 0.3 ppm, iron in water is objectionable because it causes brownish stains on porcelain

fixtures and on clothing and fabrics washed in the water. It may also impart an unplesant taste to drinking water. Water used in the manufacture of food and carbonated beverages, and in the textile and paper industries, should contain no more than 0.1 ppm of iron. Among the counties of the Northern Neck, more than 30 of the wells sampled yielded water containing iron in excess of 0.1 ppm. Water from the Columbia Group and from the Mattaponi Formation appears more likely to have iron in excess of 0.1 ppm. Two extreme cases were noted in eastern Stafford County: well 11, 15 ppm of iron, probably from the Mattaponi Formation and well 18, 13 ppm from the Potomac Group.

Calcium (Ca) and Magnesium (Mg).--Although calcium and magnesium are only slightly soluble in pure water, rain water containing carbon dioxide rather readily dissolves calcium and magnesium from rocks and soils. Hardness in water is usually caused by the presence of calcium and magnesium. These constituents also tend to form boiler scale. In the Northern Neck, ground-water samples analyzed ranged in calcium content from 0.7 to 40 ppm, and in magnesium from 0.2 to 18 ppm.

Carbonate (CO_3) and Bicarbonate (HCO_3).--Carbonate and bicarbonate in ground water results from the reaction of carbon dioxide in water upon carbonate minerals in the rocks. In the Northern Neck, concentrations of carbonate in the ground water range from 0 to 149 ppm, and of bicarbonate from 5 to 559 ppm, in the waters sampled for analysis ~~(Cederstrom, 1945, p. 10)~~. Except in the use

of waters for boiler feed, the higher concentrations of these consitituents in the Northern Neck ground waters, when they are not extreme, are not seriously objectionable.

Sulfate (SO_4).--In waters containing calcium and magnesium, sulfate causes the formation of boiler scale. Moreover, it may increase the cost of softening the water or restrict the choice of method of softening. In samples of ground water from Northern Neck wells, the concentration of sulfate ranges commonly from a few parts to 40 ppm, with extremes of up to 85 ppm.

Chloride (Cl).--The degree of chloride concentration in ground waters of coastal areas is usually a good indication of the extent of contamination of ground water with sea water, or of residual sea water left after marine sediments have been deposited. High concentrations

of chloride, particularly in waters that are also high in calcium and magnesium, affect the industrial usefulness of water. In the Northern Neck, the ground waters tested range in chloride concentration from 1 to ~~300~~ 113 ppm. Chloride, in concentrations greater than about 250 ppm as sodium chloride, imparts a salty taste to drinking water.

Fluoride (F).--Fluoride is largely of interest because of its effect upon human teeth. It results in the dental defect known as mottled enamel if water containing more than about 1.5 ppm is used for drinking by children during formation of the teeth (Dean, 1936). On the other hand, in concentrations of about 1 ppm, the presence of fluoride has been shown to lessen the incidence of tooth decay (Dean, 1942). In the samples of ground water analyzed from the Northern Neck, fluoride ranges in concentration from 0.0 to 3.8 ppm. Waters from the deeper aquifers commonly have the higher concentrations.

Nitrate (NO_3).--More than a few parts per million of nitrate in water is generally regarded as a possible indication of pollution by sewage or other organic waste. Locally, nitrate in water may result from the use of certain fertilizers. Water containing more than about 44 ppm of nitrate, if used in infant feeding formulas, may result in a serious toxic condition (cyanosis) characterized by a blue appearance of infants' skin caused by methemoglobinemia (Faucett and Miller, 1946; Waring, 1949; Maxcy, 1950).

In the Northern Neck, several samples of ground water were found to contain excessive nitrate concentrations. All of these were obtained from shallow wells and springs--sources which are the most susceptible to pollution. The nitrate concentration in ground waters tested ranges from 0.0 to 123 ppm.

Dissolved solids.--The concentration of dissolved solids is an index of the total mineralization of the water. In general, water with up to about 500 ppm of dissolved solids may be considered acceptable as a domestic or public supply. In the Northern Neck peninsula, several wells in eastern Northumberland and eastern Lancaster counties yield water of the sodium bicarbonate type, having concentrations of dissolved solids in excess of 500 ppm. Inasmuch as the water is used primarily for processing fish or washing oysters, rather than as a public supply, this degree of mineralization has not been regarded as objectionable.

The range in concentration of dissolved solids in the Northern Neck is 32 to 872 ppm in the waters sampled for analysis.

Specific conductance.--Specific electrical conductance, expressed as reciprocal ohms x 10^6 (micromhos) at 25°C., generally increases with the dissolved mineral content. For ground waters in the Virginia Coastal Plain, the specific conductance in micromhos, multiplied by 0.7, gives a figure approximating the concentration of dissolved solids in parts per million. For ground waters sampled in the Northern Neck, the range in specific conductance is 42.6 to 1,200 micromhos, representing a range in approximate dissolved solids of 30 to 840 ppm.

Hardness.--Hardness, expressed as calcium carbonate ($CaCO_3$), is an index of the soap-consuming capacity of water. Hard water--water with a hardness greater than about 120 ppm--requires excessive amounts of soap to produce a lather. The same constituents that cause hardness in water also form scale in boilers, water heaters, radiators, and pipes, resulting in loss of heat transfer, loss of

flow, or both. Water is usually considered soft when the hardness is 60 ppm or less; moderately hard, between 61 and 120 ppm; and hard, between 121 and 200 ppm. Very hard water (hardness greater than 200 ppm) usually requires softening for many ordinary uses. In the ground waters tested from the Northern Neck, hardness ranges from 3 to 416 ppm.

For a general discussion of the changes in water quality in the Virginia Coastal Plain, including the Northern Neck peninsula, the reader is referred to Cederstrom (1946). This paper discusses the mechanism by which water in the artesian aquifers is initially soft and of low mineralization shortly after it enters the aquifers along the Fall Zone. As the water migrates easterly down the dip in response to artesian pressure, the concentration of dissolved solids increases and the water becomes hard and characterized by high calcium and bicarbonate. Subsequently, slow contact of the water with glauconite or other material loaded with exchangeable sodium in the artesian sediments, however, allows softening by base-exchange to take place, the calcium going out of solution and replaced in the ground water by sodium. The water thus is gradually softened during its eastward movement. Accompanying this softening is a moderate gain in fluoride.

Discussion of the available analyses of ground water from the several aquifers of the northern Coastal Plain is given in each of the county descriptions later in this report.

County Descriptions

Introduction

In each of the six county chapters that follow, general information on each county is presented. The geologic formations in each ~~county~~ are discussed, together with their water-bearing character, including the chemical quality of ground water. The text in each chapter is followed by tables describing factual data on wells based on information obtained during the well canvass and information furnished by drillers, and lithologic sample descriptions for selected wells for which drill cuttings were obtained. Tables of chemical analyses show the quality of ground water available in the area and the formation from which the water was derived.

The locations of the wells listed in the tables are shown on the maps preceding the tables in each chapter.

Eastern Stafford County I

Location and Development [1] II

The eastern part of Stafford County, about 100 square miles in area, lies in the Coastal Plain province. It lies just west of the five principal counties of the Northern Neck peninsula.

This area is bounded on the west by the Fall Zone, near U. S. Highway 1, and on the northwest by Prince William County and the Potomac River. On the east and south lie King George, Caroline, and Spotsylvania Counties. The southern boundary follows the Rappahannock River.

Part of the U. S. Marine Corps reservation (Quantico) lies at the northernmost part of the area. Commercial fishing in the Rappahannock and Potomac is an important industry along with lumbering, dairy products, and livestock. Corn, wheat and soybeans are among the field crops.

The area is traversed by two major highways, U. S. Highway 1 and the recently completed Interstate Highway 95. State Routes 18 and 3 extend from the Fredericksburg just across the Rappahannock at the southeastern part of the county, westward into King George County. The Richmond, Fredericksburg and Potomac Railroad also traverses the county north-south.

---

[1] For further information on the economic development of Stafford County, see Va. Div. of Planning, (1965), Economic Data Summary, Stafford County.

The total relief in the eastern part of Stafford County is on the order of 200 feet. The Pleistocene terraces in the area mapped by Wentworth (1930) are the Brandywine, with parts of other terraces, and low areas near the major streams representing the Chowan (Talbot) and Dismal Swamp (Pamlico) terraces. These terraces are nearly flat-lying.

Aquia, Accakeek, and Potomac Creeks drain roughly eastward into the Potomac River. Two smaller creeks drain the southernmost part of the area, and empty into the Rappahannock River.

Geology and Ground-Water Conditions II

The eastern part of Stafford County lies on the farthest westward reach of the Coastal Plain. The unconsolidated sediments here thin out westward against the older hard rocks of the Piedmont along the Fall Zone. Thus, although mantled by the Columbia Group of Pleistocene age, as is the entire Coastal Plain, many of the older units are missing in whole or in part, and the basement bedrock surface lies progressively nearer the land surface westward and finally becomes the surface formation.

Basement Complex III

The hard rocks of the basement complex in eastern Stafford County are relatively poor-water-bearing formations. Practically no subsurface information is available on them. However, well 11, 1.4 miles northeast of Fredericksburg, was drilled to a total depth of about 1,100 feet (about 940 feet below sea level), and must certainly have penetrated at least 700 feet of basement rock. No record is available beyond the note that water is obtained from black sand at a depth of 170-180 feet in the overlying Coastal Plain sedimentary rocks. Coastal Plain sands near the Fall Zone are characteristically poor aquifers.

The basement complex is not regarded as a desirable source of ground water where it is overlain by the much more permeable sandy beds of the Coastal Plain deposits. However, where the latter are thin or where they may be overlain by relatively impermeable clays or sandy clays, wells drilled into the weathered material of the crystallines may provide small to moderate of ground water.

Cretaceous System--Potomac Group III

Based on records available, only three stratigraphic units have been tapped for ground water in eastern Stafford County; the deepest of these is the Potomac Group of Early Cretaceous age.

Well 3 at Arkendale, north of Aquia Creek, penetrated nearly 500 feet of the Potomac sediments. (See log, Table 2.) The material is described as largely clay and "marl," gray, red, and brown in color. Several beds of sand are reported, two of which, aggregating 38 feet, are noted as water-bearing.

One other well (18) was drilled into the Potomac Group, at Sherwood Forest Farm, 4 miles southeast of Fredericksburg on State Route 3. The Potomac Group was penetrated between 105 and 195 feet below the surface, and consists largely of sand with 20 feet of white clay from 120 to 140 feet and 15 feet of water-bearing sand and gravel from 180 to 195 feet.

Well 18 is reported to yield 20 gpm. However, moderately large yields from properly developed wells 6 to 8 inches or more in diameter can be obtained, as is demonstrated by well 3b. This well, $6\frac{1}{4}$ inches in diameter and 319 feet deep, was drilled in 1965 along the Potomac River east of Arkendale, and yielded on test about 500 gpm. The ~~easterly~~ easternmost part of Stafford County is much the more favorable for development of large supplies because the section there is thicker and the sands are more permeable.

Water from the Potomac Group in eastern Stafford County was sampled for chemical quality at two wells (1, 2) in the northern part of the area and at well 18 east of Fredericksburg in the southern part. (See analyses, Table 3.) The water is slightly hard, hardness being present largely as calcium bicarbonate, but total mineralization is low. Artesian water near Widewater is reported to be highly corrosive ~~due~~ owing to dissolved free carbon dioxide. On that account, the very high iron content, 2.5 ppm from wells 1 and 2, and 13 ppm from well 18, is not unexpected. Removal of iron from such waters by aeration or otherwise would be required in order to avoid an unpleasant taste as well as the staining of laundry and plumbing fixtures.

Cretaceous to Tertiary Systems--Mattaponi Formation III

The Mattaponi Formation, of Late Cretaceous and Paleocene age, is believed to underlie eastern Stafford County except in the extreme western reach near the Fall Zone. Virtually nothing is known of its character in this part of the peninsula beyond the 80 feet of clay and "marl" tentatively assigned to it in well 18, 4 miles southeast of Fredericksburg. Well 11, about a mile northeast of Fredericksburg, is reported to obtain water from black sand (probably glauconitic sand in the Mattaponi) at a depth of 170-180 feet.

Although the sands in this formation are very important as aquifers farther downdip on the peninsula, few data are available on the potential of the Mattaponi in eastern Stafford County.

The well (11) in the area that taps the Mattaponi(?) also yields a slightly hard calcium bicarbonate water. The specific conductance of 132 micromhos suggests a dissolved solids content of less than 100 ppm. However, as in ground water from the Potomac Group in this area, iron (15 ppm) may be a serious problem requiring removal by aeration or otherwise for domestic use.

Tertiary System III

Aquia Formation IV

The Aquia Formation, of Paleocene age, is well exposed at its type locality along Aquia Creek, a tributary of the Potomac River. (See map, Fig. 2; and Section A-A' on Plate 1.) However, no data are available on wells ending in this formation.

Other Eocene and Miocene Rocks (IV)

The Nanjemoy Formation of early and middle Eocene age and units of the Chesapeake Group of Miocene age have been removed by erosion in eastern Stafford County.

In eastern Stafford County, deposits of the Columbia Group of Pleistocene age are largely clay layers and red, brown and white sands, reaching perhaps 30 to 50 feet in thickness. (See logs, wells 9 and 18, Table 2.)

The Columbia Group of Pleistocene age furnishes small supplies for domestic use to dug and bored wells in eastern Stafford County.

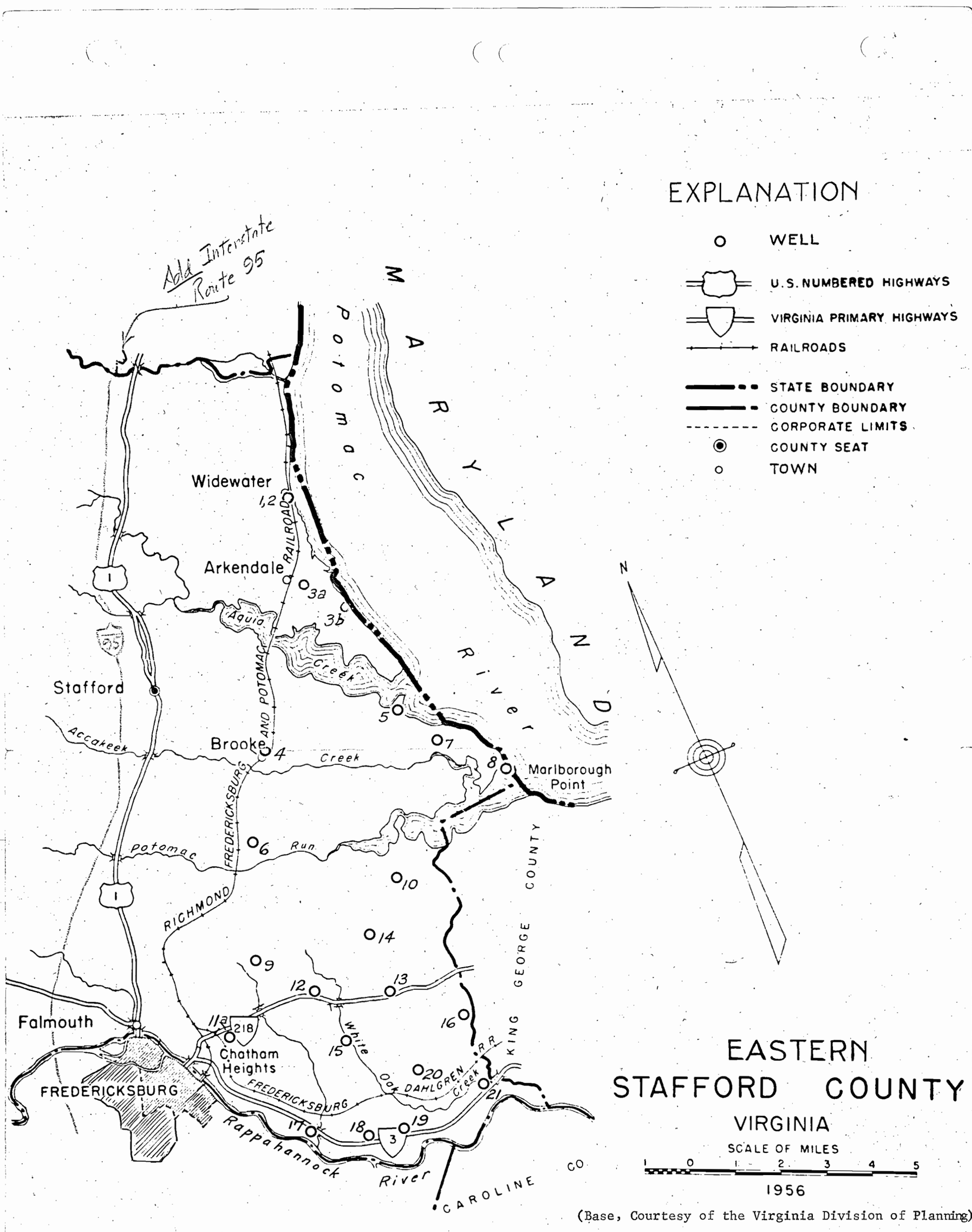
Water from these deposits is everywhere soft, and of low mineralization. Although iron is not a serious problem, it is present in concentrations approaching the U. S. Public Health Service (1962) recommended maximum of 0.3 ppm.

The constituent that appears to cause the greatest difficulty in water from the Pleistocene deposits is nitrate. Among those wells for which it was determined, only one (15) had a low concentration (0.8 ppm). The others (4, 6, 12, 14, and 17) all had nitrate concentrations strongly suggesting organic pollution. The very high concentration of 46 ppm in water from well 4, at Brooke in the middle of the area, renders such water unsuitable for use in infant feeding formulas. (See discussion under nitrate in the section on chemical constituents earlier in this report.)

There are few large users of ground water in eastern Stafford County. Most of the area is rural, and ground-water is used chiefly for domestic purposes and for stock raising--neither of which require large quantities of water. With respect to furture increased requirements for water, however, probably as much as 500 gpm or more can be obtained in the extreme eastern part of the county from properly constructed and developed wells drilled into the sands of the Potomac Group. The quality should be satisfactory, although hardness may be somewhat high.

Well Records and Chemical Analyses II

Records of wells, available logs, and chemical analyses of water samples in eastern Stafford County are given in Tables 1, 2, and 3 on the pages that follow. Locations of wells listed in Tables 1 through 3 are given in Figure 2 preceding the tables.



(Base, Courtesy of the Virginia Division of Planning)

ES

~~146a~~

Table ~~16~~ 1. —Records of wells in Eastern Stafford County, Virginia

Type of well: D, drilled; J, jetted; B, bored
Use of water: D, domestic; S, stock; I, industrial

gpm, gallons per minute
Temp., temperature (degrees Fahrenheit)

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
1	Widewater	Murray Decatur		ca. 1937	15	D	210	6	Cretaceous	Potomac Group	(+)			See analysis, Table ~~18~~ 3.	1
2	Do.	do		ca. 1940	15	D	290	6	do	do	(+)			See analysis, Table ~~18~~ 3.	2
3a	Arkendale	Arkendale Farm	W. S. Reynolds		25	J	490		do	do			D,S	See log, Table ~~17~~ 2.	3a
3b	1.5 mi. SE of Arkendale	Gen. Hall	J. T. Ellington	1965	10?	D	319	6¼	do	do	-12		D	Pumped at 500 gpm during 12-hour test	3b
4	Brooke	Fanny Milton			100	Dug	55	48	Pleistocene	Columbia Group	-51		D	See analysis, Table ~~18~~ 3. Temp., 56°F.	4
5	3 mi. NW of Marlboro Point	J. Hoyt Reed		1909	15	Dug	37	36	do	do	-32		D	See analysis, Table ~~18~~ 3. Temp., 55°F.	5
6	2 mi. SSW of Brooke	Meta Jett			100	Dug	41	36	do	do	(-)		D	See analysis, Table ~~18~~ 3. Temp., 58°F.	6
7	1.7 mi. NW of Marlboro Point	R. J. McCloskey		1919	30	Dug	16	24	do	do	(-)		D,S	See analysis, Table ~~18~~ 3. Temp., 65°F.	7
8	Marlboro Point	James Ashby, Sr.		1913	20	Dug	20	36	do	do	-17		D	See analysis, Table ~~18~~ 3. Temp., 63°F.	8
9	3 mi. NE of Fredericksburg	Frank A. Stevens	Frank A. Stevens	1949	210	Dug	22	34	do	do	-18½		D	See log, Table ~~17~~ 2; analysis, Table ~~18~~ 3. Temp., 61°F.	9
10	3.6 mi. WSW of Marlboro Point	Roy Newton			80	Dug	27½	48	do	do	-21		D	See analysis, Table ~~18~~ 3. Temp., 56°F.	10
11	1.4 mi. NE of Fredericksburg	W. W. Lupton	Leazer Well & Pump Co.	1949	160	D	1,102½	6	Late Cretaceous and Paleocene	~~Potomac Group~~ Matteponi (?) Fm			D,S	See analysis, Table ~~18~~ 3. Water from black sand, 170-180 ft.	11
12	3.3 mi. ENE of Fredericksburg	R. E. Wright			175	Dug	27	36	Pleistocene	Columbia Group			D	See analysis, Table ~~18~~ 3. Reported soft. Iron taste. Temp., 58° F.	12
13	4.5 mi. E of Fredericksburg	T. J. Fines		Prior to 1861	220	Dug	33	36	do	do	-25			Reported soft. Temp., 56°F.	13
14	5 mi. ENE of Fredericksburg	Erwin Allen		1930	200	Dug	25	36	do	do	-20		D	See analysis, Table ~~18~~ 3. Temp., 62°F.	14
15	3.5 mi. E of Fredericksburg	M. Robertson		1941	170	Dug	22	36	do	do	-19		D	See analysis, Table ~~18~~ 3. Temp., 56°F. Water level measured in 1941.	15
16	6 mi. E of Fredericksburg	John S. Hudson		1934	190	Dug	30	24	do	do	-26		D	Reported soft. Temp., 59°F.	16
17	3 mi. SE of Fredericksburg	L. P. Graves		1800	40	Dug	40	60	do	do	-33		D,S	See log, Table ~~17~~ 2; analysis, Table ~~18~~ 3. Temp., 70°F. Another similar well nearby.	17
18	Sherwood Forest Farm, 4 mi. SE of Fredericksburg	J. L. Pratt	L. L. Martin	1930	90	D	195	8	Cretaceous	Potomac Group	-55	20	S	See log, Table ~~17~~ 2; analysis, Table ~~18~~ 3.	18

1466

ES

~~1461~~

Table 1~~6~~. —Records of wells in Eastern Stafford County, Virginia

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
19	5 mi. SE of Fredericksburg	John F. Barrett			70	Dug	65	24	Pleistocene	Columbia Group	-53		D	See analysis, Table 3~~18~~. Temp., 61°F.	19
20	5 mi. ESE of Fredericksburg	Wm. White, Sr.			140	Dug	16	36	do	do	-13		D,S	See analysis, Table 3~~18~~. Temp., 58°F.	20
21	6.5 mi. ESE of Fredericksburg	Jesse Olive	Jesse Olive	1946		B	21		do	do			I	~~See geology Table 13~~ See analysis, Table 3~~18~~. Temp., 65°F.	21

Table 2.--Logs of wells in eastern Stafford County, Virginia

Well 3, Arkendale; Arkendale Farm

(Log furnished by W. S. Reynolds drillers; correlations by A. Sinnott)

Altitude, 25 feet

	Thickness (feet)	Depth (feet)
Potomac Group (Cretaceous):		
Clay, red and yellow	30	30
Marl, gray	27	57
Clay, brown	11	68
Sand, white, hard	2	70
Marl, gray	42	112
Sand, white, hard	10	122
Marl, gray	21	143
Marl, dark red	20	163
Marl, brown	19	182
Marl, gray	7	189
Marl, hard red	10	199
Marl, gray	91	290
Sand; water-bearing	6	296
Marl, red; fossil wood	12	308
Marl, gray	67	375
Sand, gray	12	387
Marl, red	69	456
Sand; water-bearing	32	488
Pre-Cretaceous:		
Granite	2	490

Table 2.--Logs of wells in eastern Stafford County, Virginia-GContinued

Well 9, 3 miles northeast of Fredericksburg; Frank A. Stevens

(Dug by owner; log and correlation by G. C. Tibbitts, Jr.)

Altitude, 210 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Sand, fine, red	15	15
Sand, fine, dark red; water-bearing	5	20
Clay, brown and gray, interbedded	2	22

Table 2.--Logs of wells in eastern Stafford County, Virginia--Continued

Well 18, Sherwood Forest Farm, 4 miles southeast of Fredericksburg;

J. L. Pratt

(Log by L. L. Martin, driller; correlation by A. Sinnott)

Altitude, 90 feet

	Thickness (feet)	Depth (feet)
Columbia(?) Group (Pleistocene):		
Clay, red	25	25
Unclassified:		
Mattaponi(?) Formation (Paleocene and Upper Cretaceous):		
Clay, yellow	60	85
Marl, blue	20	105
Potomac Group (Cretaceous):		
Sand, gray	15	120
Clay, white	20	140
Sand, and blue marl	26	166
Sand, gray; water-bearing	3	169
Sand, and blue marl	11	180
Sand, and gravel, gray; water-bearing	15	195

Table ~~16~~ 3.--Chemical analyses of ground waters from wells in eastern Stafford County, Virginia
(Parts per million, except specific conductance and pH)

Well number	1	2	4	5	6	7
Location	Widewater	Widewater	Brooke	NW of Marlboro Point	SSW of Brooke	NW of Marlboro Point
Depth (feet)	210	290	55	37	41	16
Geologic age	Cretaceous	Cretaceous	Pleistocene	Pleistocene	Pleistocene	Pleistocene
Formation or Group	Potomac Group	Potomac Group	Columbia Group	Columbia Group	Columbia Group	Columbia Group
Date	April 26, 1940	April 26, 1940	June 14, 1949	June 15, 1949	June 15, 1949	June 15, 1949
Silica (SiO_2)	--	--	--	--	--	--
Iron (Fe)	2.3	2.6	.12	--	.24	--
Calcium (Ca)	--	--	--	--	--	--
Magnesium (Mg)	--	--	--	--	--	--
Sodium (Na)	--	--	--	--	--	--
Potassium (K)	--	--	--	--	--	--
Carbonate (CO_3)	--	--	--	--	--	--
Bicarbonate (HCO_3)	54	56	14	76	10	24
Sulfate (SO_4)	18	25	1	15	4	1
Chloride (Cl)	1	2	17	8	6	4
Fluoride (F)	.0	.0	.0	.0	.0	.2
Nitrate (NO_3)	.0	.0	46	--	22	--
Dissolved solids	--	--	--	--	--	--
Hardness as $CaCO_3$	63	72	33	63	21	21
Specific conductance (micromhos at 25°C)	--	--	177	190	47.4	51.6
pH	--	--	--	--	--	--

Table 3.--Chemical analyses of ground waters from wells in eastern Stafford County, Virginia--Continued
(Parts per million, except specific conductance and pH)

Well number	8	9	10	11	12	14
Location	Marlboro Point	Fredericksburg	WSW of Marlboro Point	Near Fredericksburg	Fredericksburg	Near Fredericksburg
Depth (feet)	20	22	27	1102½	27	25
Geologic age	Pleistocene	Pleistocene	Pleistocene	Late Cretaceous and Paleocene	Pleistocene	Pleistocene
Formation or Group	Columbia Group	Columbia Group	Columbia Group	Mattaponi (?) Formation	Columbia Group	Columbia Group
Date	June 15, 1949	June 16, 1949	June 17, 1949	Sept. 23, 1953	June 16, 1949	July 17, 1949
Silica (SiO_2)	--	--	--	--	--	--
Iron (Fe)	--	--	--	15	.12	.28
Calcium (Ca)	--	--	--	13	--	--
Magnesium (Mg)	--	--	--	5.5	--	--
Sodium (Na)	--	--	--	} 5.4	{ --	--
Potassium (K)	--	--	--		--	--
Carbonate (CO_3)	--	--	--	0	--	--
Bicarbonate (HCO_3)	40	34	8	64	10	10
Sulfate (SO_4)	4	5	6	11	1	3
Chloride (Cl)	6	4	58	1.8	58	16
Fluoride (F)	.0	.1	.4	.1	.0	.0
Nitrate (NO_3)	--	--	--	.2	34	17
Dissolved solids	--	--	--	--	--	--
Hardness as $CaCO_3$	66	18	39	55	24	21
Specific conductance (micromhos at 25°C)	132	88.5	260	132	304	113
pH	--	--	--	6.8	--	--

Table 3.--Chemical analyses of ground waters from wells in eastern Stafford County, Virginia--Continued
(Parts per million, except specific conductance and pH)

Well number	15	17	18	19	20	21
Location	ESE of Fredericksburg	Fredericksburg	SE of Fredericksburg	N of Butzner Corner	Fredericksburg	Fredericksburg
Depth (feet)	22	40	195	65	16	21
Geologic age	Pleistocene	Pleistocene	Cretaceous	Pleistocene	Pleistocene	Pleistocene
Formation or Group	Columbia Group	Columbia Group	Potomac Group	Columbia Group	Columbia Group	Columbia Group
Date	June 17, 1949	June 14, 1949	Dec., 1943	June 17, 1949	June 14, 1949	June 14, 1949
Silica (SiO_2)	--	--	--	--	--	--
Iron (Fe)	.29	.28	13	--	--	--
Calcium (Ca)	--	--	--	--	--	--
Magnesium (Mg)	--	--	--	--	--	--
Sodium (Na)	--	--	6	--	--	--
Potassium	--	--	--	--	--	--
Carbonate (CO_3)	--	--	--	--	--	--
Bicarbonate (HCO_3)	20	80	79	30	8	30
Sulfate (SO_4)	2	14	17	1	3	6
Chloride (Cl)	12	10	3	6	8	16
Fluoride (F)	.0	.0	.3	.0	.0	.0
Nitrate (NO_3)	.8	26	.0	--	--	--
Dissolved solids	--	--	--	--	--	--
Hardness as $CaCO_3$	33	75	74	24	15	48
Specific conductance (micromhos at 25°C)	99.4	238	--	97.6	51.0	112
pH	--	--	6.7	--	--	--

King George County I

Location and Development[1] II

King George County is the westernmost of the five principal counties of the Northern Neck peninsula. It is bounded on the west by Stafford County, on the north by the Potomac River, on the east by Westmoreland County, and on the south by Caroline and Essex Counties across the Rappahannock River. Its land area is about 178 square miles, and its population as of 1960 was 7,243. General crops, truck gardening, and livestock are important. Fresh- and salt-water fish also are important food products.

A small railroad connects Dahlgren, in the northeastern part of the county, with Fredericksburg. Federal highway 301 and State highways 3 and 218 traverse the county; they in turn are linked by State highways 205 and 206. In the central part of the county is King George, the county seat. Other towns are Dogue, Taliaferro, Rollins Fork, and Port Conway. The U. S. Naval Weapons Laboratory, and proving grounds, is at Dahlgren, in the northeastern part of the county.

---

[1] For further information on the economic development of King George County, see Va. Div. of Planning, (1967), Economic Data Summary, King George County.

The total relief in King George County is over 200 feet. The large middle part of the county consists of the Sunderland terrace, with locally developed remnants of the Coharie terrace (Wentworth, 1930). Bordering the Potomac and Rappahannock Rivers are smaller areas of low relief representing the Talbot terrace.

The principal stream is Machodoc Creek, which drains most of the northern half of the county, and is a tributary of the Potomac River. Many small minor creeks drain northward and eastward to the Potomac.

The southern half of King George County is drained by numerous small creeks and runs, none of which approach the size of Machodoc Creek however. The drainage divide extends roughly southeastward through the middle of the county. In places, there are small areas of marshy ground along the flats bordering the Rappahannock River.

Geology and Ground-Water Conditions

The deposits at the surface in King George County are chiefly of Pleistocene age, and consist of unconsolidated sands and gravels of the Columbia Group. They are exposed in roadcuts and along the banks of streams. Locally along the south bank of the Potomac River there are beach deposits of Holocene (Recent) age; smaller beach deposits occur along the Rappahannock River, flanking the southern border of the county. Minor deposits of alluvium are found along the banks of streams and in stream chennels.

Underlying these surficial deposits are the older sedimentary rocks of the Coastal Plain, which in turn are underlain by the crystalline basement rocks.

Basement Complex III

So far as known, no wells have penetrated the full thickness of Coastal Plain sediments and reached the underlying basement rock in King George County. The basement complex here probably consists largely of crystalline granitic and metamorphic rocks, or Triassic arkosic sandstone. It would be expected to lie at depths of from 500 to 2,000 feet below the surface, according to DeBuchananne (1968, Sheet 1). However, test drilling may show that depth to bedrock is somewhat less.

Cretaceous System--Potomac Group

III

Resting on the basement complex in King George County are the sands of the Potomac Group of Cretaceous age. Records of only two wells are available that were drilled deep enough to reach the Potomac Group. A 780-foot well (30), drilled for the Department of the Navy at the Proving Ground at Dahlgren, may have reached the top of the Potomac beds ~~probably~~ at a depth of about ~~628~~ 600 feet below the surface, passing at that depth from sand with glauconite to silt and fine quartz sand. Although a few pebbles were found below 730 feet, most of the material is interbedded sand, clay, and silt.

White clay underlain by white sand occurs from 750 to 894 feet below the surface in well 32 along Route 301 about 5 miles southwest of Dahlgren. The water-bearing zone in this well consists of white sand, and lies at 850 to 894 feet below the surface.

The Potomac Group is of considerable potential in the eastern part of King George County, where it is thickest. A 780-foot well (30) at the Naval Proving Ground at Dahlgren obtains water from these deposits; the yield although not reported, is understood to be more than ample. Judging from the high productivity of the Potomac water-bearing sands elsewhere in the Coastal Plain, it is likely that properly developed wells 8 inches or more in diameter and drilled even deeper in the Potomac Group in this part of King George County could produce 500 gpm or more. Two domestic wells (29, 31) in the Dahlgren area also tap the Potomac Group. Well 31 is reported to yield 14 gpm by pumping.

At Port Conway, a composite of three wells (24) have a combined artesian flow of 7.5 gpm. These wells were sampled for chemical analysis in 1949 and 1953 (Table 6). As contracted with artesian water from wells nearer the Fall Zone the water was found to be very soft. The water is a sodium bicarbonate type, with low total mineralization (dissolved solids, 170 ppm). Iron is high in the one sample at hand, 0.32 ppm, about at the maximum recommended concentration for public supply.

The chemical character indicated in these analyses is probably fairly representative of the quality of the ground water from the Potomac Group in most of King George County. In westernmost King George County, it is possible that artesian water will be slightly hard.

The Mattaponi Formation, of Late Cretaceous and Paleocene age, is characterized by clays of various colors, chiefly red and yellow, or mottled in King George County, as elsewhere in the Virginia Coastal Plain. Beds of sand, commonly low in the Mattaponi, are important as aquifers. Some glauconite is generally present, although this mineral is not as characteristic of the Mattaponi as it is of the overlying Aquia and Nanjemoy Formations.

A detailed description of a typical suite of samples from the Mattaponi is given for well 30 at the Naval Proving Ground, Dahlgren (Table 5).

Adequate supplies of ground water are obtained from the Mattaponi Formation in King George County. Among the larger wells tapping the Mattaponi are the King George County School well (13), an industrial well (22) 2 miles southeast of King George, and a well (28) at the U. S. Naval Proving Ground at Dahlgren. In the latter, good water-bearing sand of the Mattaponi was reached from 509 to 521 feet. In well 14, in the town of King George, two water-bearing sands were found at 500 to 510 and 577 to 597 feet, and in well 7a at Fairview Beach, at 128 to 150 feet, from which 86 gpm with 59 feet of drawdown is pumped for public supply.

Two recent (1965) large-capacity wells (22b and 27a) indicate the potential of the Mattaponi Formation as an aquifer. Well 22b, about 2.5 miles southeast of King George, was drilled for a canning company and produced 300 gpm in a 12-hour test, with 87 feet of drawdown. Well 27a, nearly 2 miles northwest of Dahlgren, yielded 632 gpm on a 72-hour test, With 180 feet of drawdown. These wells are 6 and 8 inches in diameter, respectively. Both probably also draw some water from the Potomac sands, although the formational contact between the Mattaponi Formation and the Potomac Group cannot be determined with certainty.

Two comprehensive analyses were made of water from wells tapping the Mattaponi. Well 4, near Sealston in western King George County, as might be expected, yields slightly hard water of low mineralization. Iron (5 ppm) is high and treatment for its removal would be desirable if it were to be used for domestic purposes. Hydrogen sulfide odor was reported in water from this well, which is used for watering stock.

Water from well 13 at the King George County School and more to the east is a soft sodium bicarbonate type of water with low total mineralization. Chemically it is of excellent quality, well suited as a supply for the more than 500 pupils at the school.

Tertiary System
Aquia and Nanjemoy Formations

The type locality of the Aquia Formation, as pointed out earlier in this report, is along the outcrops on Aquia Creek in northeastern Stafford County. This formation is penetrated in the subsurface by a number of wells in King George County. (See logs in Table 5 for wells 11, 22, 28, 30, and 32.) It commonly consists of sandy glauconitic clay, glauconitic sand, with shell fragments. Locally, as at Fairview Beach on the Potomac, it consists of indurated marl and abundant fossil shells. (See Figure 3.)

Like the Aquia Formation, the Nanjemoy commonly contains glauconite. It consists of sandy clay and sand with some shells. Locally, thin beds of limestone are found. A persistent pink, red, or brown clay, known as the Marlboro Clay Member, lies at the base of the formation; this member is well developed in this part of the Northern Neck. (See logs in Table 5 for wells 22, 28, 30, 31, and 32.)

For certain logs in Table 5 (7a, 14), it has not been possible to distinguish between the Aquia and Nanjemoy; accordingly, they have been listed as undifferentiated.

Figure ~~4~~ 3. --Indurated marl of the Aquia formation of ~~early Eocene~~ Paleocene age at Fairview Beach, King George County. The great abundance of fossil shells is characteristic at this Locality.

Water-Bearing Character V

The Aquia and Nanjemoy Formations in King George County are not, locally, important sources of ground water. This can probably be attributed to the fact that the better water-bearing sands in the Mattaponi are readily available within a convenient depth range.

However, records are at hand for three wells which were drilled to these formations. Well 7b at Fairview Beach is used as a public supply well; information on its yield is not available but presumably it is adequate--perhaps on the order of at least 20 gpm. Well 8, a little over a mile eastward from Fairview Beach, is a domestic well and probably has a low but adequate and dependable yield.

In regard to the quality of the water from the Aquia and Nanjemoy Formations, one analysis is available (7b, Table 6). This public supply well at Fairview Beach yields very hard calcium bicarbonate water; the hardness is 270 ppm. Other constituents are low. Farther east in the county it would be expected that water from these formations would be soft, owing to the natural softening effect of the glauconite commonly present in these sediments.

Chesapeake Group IV

The Chesapeake Group of formations of Miocene age, undifferentiated in this report, consists of sands and blue clays. It is apparently absent in the northern part of the county, and elsewhere reaches a maximum thickness of a little over 100 feet. No wells ending in Miocene beds are known in King George County.

The Columbia Group of Pleistocene age consists of yellowish sands and clays with some gravel. These deposits are more than 50 feet thick in places. They occur nearly everywhere in the county and are exposed at the surface in many road cuts and in the banks of streams.

Water-Bearing Character

Many dug wells have been sunk in King George County in the deposits of the Columbia Group, providing small supplies to many rural homes, farms and a summer camp. Ordinarily these requirements are low, and the supply is more than adequate.

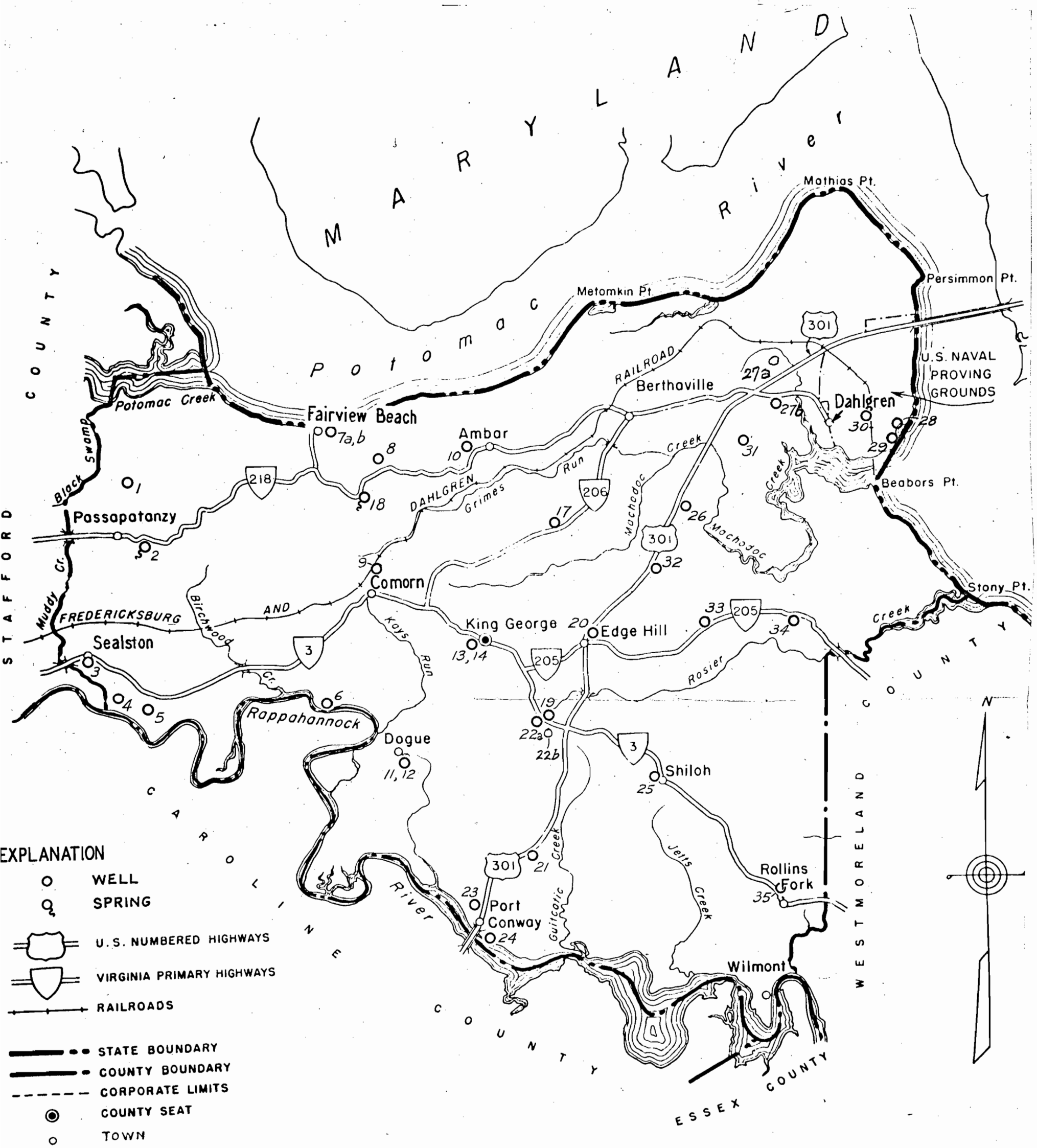
The water from a typical dug well (19) in the Columbia Group was sampled for chemical analysis; it is of very low mineralization--probably about 70 ppm of dissolved solids, estimated from the specific conductance. It is very soft, with a hardness of only 17 ppm, and other constituents are fairly low. However, the nitrate content of 4.2 ppm, coupled with the chloride concentration of 15 ppm, suggests the possibility of organic pollution--a common hazard among dug wells.

Most of the users of wells tapping the Columbia Group report that the water is soft although water from well 21, 3 miles southwest of Shiloh, is reported to be hard. Iron in the water may be a problem locally, as reported from wells 10, 12, and 35 at Ambar, Dogue and Rollins Fork.

In the eastern half of King George County, where the Coastal Plain formations are thicker, properly constructed and developed wells 8 or more inches in diameter, 350 to 750 feet deep and tapping the Mattaponi Formation and perhaps the upper sands of the Potomac Group, should produce 700 gpm (about 1 million gallons per day), or even more, per well ~~if properly spaced~~. The quality of the water should be generally excellent--soft, and of only moderate mineralization.

Well Records and Chemical Analyses II

Records of wells, available logs, and chemical analyses of water samples in King George County are given in Tables 4, 5, and 6 on the pages that follow. Locations of wells listed in Tables 4 through 6 are given in Figure 4 preceding the tables.



KING GEORGE COUNTY
VIRGINIA

(Base, Courtesy of the Virginia Division of Planning)

SCALE OF MILES
1 0 1 2 3 4 5

1956

KGeo - ~~127~~

Table ~~13~~ 4.—Records of wells in King George County, Virginia

Type of well: Spr., spring; J, jetted; D, drilled; Dv, driven
Use of water: D, domestic; S, stock; PS, public supply; I, industrial

gpm, gallons per minute
Temp., temperature (degrees Fahrenheit)
Fm, formation

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
1	1 mi. N of Passapatanzy	W. Henderson		1910	160	Dug	36	36	Pleistocene	Columbia Group	-33		D,S	Temp., 56°F. Water reported soft.	1
2	Passapatanzy	Virginia Construction Camp No. 2			150	Spr.	-	-	do	do			D	Temp., 52°F. Spring, developed and covered; Water is pumped to camp.	2
3	Sealston	H. M. Chinn	W. B. Jenkins	1936	80	Dug	30	42	do	do	-26		D	Temp., 52°F. Nearly dry in summer.	3
4	1 mi. ESE of Sealston on Rt. 3	L. P. Graves; W. J. Howard, tenant	Lyons	1914	55	J	201	3	Late Cretaceous and Paleocene ~~Late Cretaceous~~	Mattaponi Fm	- 8		S	Temp., 62°F. See analysis, Table ~~15~~ 6. Sulfide odor reported in water.	4
5	2 mi. ESE of Sealston, off Rt. 3	W. D. Taylor		1937	55	J	?	6	--	---	+9		D,S	Temp., 60°F. Probably more than 200 ft deep.	5
6	2 mi. WNW of Dogue	Steamboat Co.			3	J	245		Late Cretaceous and Paleocene ~~Late Cretaceous~~	Mattaponi Fm	(+)				6
7a	Fairview Beach	Sydnor Hydrodynamics, Inc.	Sydnor Hydrodynamics, Inc.		36	D	188		do	do	-27	86	PS	See log, Table ~~14~~ 5; analysis, Table ~~15~~ 6. Drawdown 59 feet after pumping at 86 gpm.	7a
7b	Do.				36	D	105		Paleocene and Eocene	Aquia and Nanjemoy Fms ~~Pamunkey Group~~			PS	See analysis, Table ~~15~~ 6.	7b
8	1.3 mi. ESE of Fairview Beach	Mrs. Tayloe		1934	160	D	235	6	do	do	-85		D		8
9	0.5 mi. N of Comorn	Mrs. F. W. Clark		1938	160	Dug	28	36	Pleistocene	Columbia Group	-24		D	Temp., 56°F. Water reported soft.	9
10	Ambar	C. E. Daniels			150	Dug	65	36	do	do	-50		D	Temp., 57°F. Supplies two houses. Water reported hard; contains iron.	10
11	Dogue	W. M. Grigsby			92		409		Late Cretaceous and Paleocene ~~Late Cretaceous~~	Mattaponi Fm	(-)	7	D	See log, Table ~~14~~ 5.	11
12	Do.	do.			92		24		Pleistocene	Columbia Group	(-)		D	Water reported to contain a little iron.	12
13	King George	King George County School		1939	185	J	400	8-4	Late Cretaceous and Paleocene ~~Late Cretaceous~~	Mattaponi Fm	(-)	11	D	See analysis, Table ~~15~~ 6. Water reported soft. Supplies 550 pupils.	13
14	Do.	E. R. Morris, Sr.	Leazer Well & Pump Co.	1955	205	D	616	6	do	do				See log, Table ~~14~~ 5. Screens set at 500-510 and 587-597 ft.	14
17	3 mi. NE of King George	T. S. Cheadle		1947	150	Dug	22	36	Pleistocene	Columbia Group	-18.5		D,S	Temp., 55°F. Water reported soft; supply barely adequate.	17

K600

~~128~~

Table 4 ~~13~~.—Records of wells in King George County, Virginia

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
18	1.8 mi. SSW of Fairview Beach	L. W. Fitzgerald, Sr.			200	Spr.	-	-	Pleistocene	Columbia Group			D,S	Temp., 51°F. Water reported soft.	18
19	1.7 mi. SSW of Edge Hill	Hanzel Brooks			160	Dug	35	36	do	do	-30		D	See analysis, Table ~~15~~ 6. Water reported soft.	19
20	Edge Hill	E. R. Morris, Jr.		1947	180	Dug	58	36	do	do	-54		D	Water reported soft.	20
21	3 mi. SW of Shiloh	R. E. Owens		Prior to 1850	55	Dug	40	30	Pleistocene	Columbia Group	-36.5		D	Water reported hard.	21
22a	2 mi. SE of King George	Pickle factory	Sydnor Hydrodynamics, Inc.	1946	180	D	562	8	Late Cretaceous and Paleocene	Mattaponi Fm	-184		I	See log, Table ~~14~~ 5.	22a
22b	2.3 mi. SW of King George	Mount Rose Canning Co.	Sydnor Hydrodynamics, Inc.	1965	180(?)	D	915	18-8-6	Late Cretaceous and Paleocene	Mattaponi Fm	-168		I	Drawdown 87 ft after pumping 300 gpm for 12 hrs. Probably also taps Potomac Group.	22b
23	Port Conway	Belgrove Farm			10	J	320	1½	do	do	(+)			Chief aquifer is glauconite sand at 300-320 ft. Flows 10 gpm.	23
24	Do.	J. P. Hooker		1908, 1908, & 1934	5	J	401	3	Cretaceous	Potomac Group	(+)		PS	See analyses, Table ~~15~~ 6. Three flowing wells; combined flow, 7.5 gpm. Water level more than 3 ft above land surface.	24
25	Shiloh	J. D. Owens			160	Dug	50	48	Pleistocene	Columbia Group	-43		D,S	Temp., 56°F. Water reported hard.	25
26	3.5 mi. NE of Edge Hill	A. C. Rollins		1946	160	Dug	32	30	do	do	-28		D	Temp., 57°F. Water from white sand; reported soft.	26
27a	1.8 mi. NW of Dahlgren	Bayberry Estates		1965	15(?)	D	1,050	8	Late Cretaceous and Paleocene	Mattaponi Fm	-10½		PS	Drawdown 180 ft after pumping 632 gpm for 72 hrs.	27a
27b	1.2 mi. WNW of Dahlgren	B. Johnson		1940	15	Dv	16	1½	Pleistocene	Columbia Group	-12		D	Temp., 53°F. Water reported soft.	27b
28	1.4 mi. E of Dahlgren	Dept. of the Navy	Washington Pump & Well Co.	Prior to 1938	15	D	521		Late Cretaceous and Paleocene	Mattaponi Fm			D	See log, Table ~~14~~ 5. Next deeper aquifer reported to be at 732-750 ft.	28
29	1.3 mi. ESE of Dahlgren	A. P. Berry Farm	W. S. Reynolds	1936 ?	10	J	749		Cretaceous	Potomac Group			D,S	Aquifer is medium sand, 742-749 ft.	29
30	0.7 mi. E of Dahlgren	Dept. of the Navy	Virginia Machinery and Well Co.	1952 ?	19	D	780		do	do			D	See log, Table ~~14~~ 5.	30
31	1.8 mi. WSW of Dahlgren	W. H. Washington	Leazer Well & Pump Co.		80	D	720		do	do		14	D	See log, Table ~~14~~ 5.	31
32	2 mi. NE of Edge Hill	Union Bethel Church	Reynolds & Norman	1952	160	J	894		do	do			D	Cased to 850 ft. Aquifer is white sand, 850-894 ft. See log, Table ~~14~~ 5.	32
33	2.5 mi. E of Edge Hill	S. B. Tellis			155	J	265	1½	Eocene	Nanjemoy Fm				Temp., 54°F. Water reported poor; not used.	33

128b

KGeo

~~128~~

Table ~~15~~ 4.—Records of wells in King George County, Virginia

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone		Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
									Geologic age	Stratigraphic unit or named aquifer					
34	4.2 mi. E of Edge Hill	R. Rolling		1938	100	Dug	48	36	Pleistocene	Columbia Group	-44		D	Temp., 54°F. Water reported soft.	34
35	Rollins Fork	F. Ashby		1900	100	Dug	52	36	do	do			D,S	Equipped with windmill. Temp., 56°F. Water reported soft; iron taste.	35

Table 5.--Logs of wells in King George County, Virginia--continued

Well 7a, Fairview Beach; Sydnor Hydrodynamics, Inc.

(Log modified from driller's record furnished by Sydnor Hydrodynamics, Inc.; correlations by D. J. Cederstrom)

Altitude, 36 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Sand, yellow and clay	10	10
Aquia Formation (Paleocene):		
Mud, blue	17	27
Marl, indurated; fossiliferous	8	35
Sand; shells	10	45
Mud, blue	10	55
Sand; shells	15	70
Mud, blue; sand; shells	45	115
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Mud, blue	5	120
Clay, yellow; Foraminifera	8	128
Sand, white and blue	12	140
Sand, white; some glauconite	10	150
Clay, yellow and white; Foraminifera	30	180
Clay, reddish brown	8	188

Table 5.--Logs of wells in King George County, Virginia--Continued

Well 11, Dogue; W. M. Grigsby

(Log modified from record by Leonard Reynolds, driller; correlations by A. Sinnott and D. J. Cederstrom)

Altitude, 92 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Sand, yellow, and clay	24	24
Chesapeake Group (Miocene):		
Clay, blue	15	39
Nanjemoy Formation (Eocene):		
Sand, black	$\frac{1}{2}$	$39\frac{1}{2}$
Marl, blue; glauconitic	$70\frac{1}{2}$	110
Aquia Formation (Paleocene):		
Marl, blue; glauconitic	30	140
Clay, sandy, blue	35	175
Limestone	1	176
Marl, blue; glauconitic	24	200
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Clay, brown and light brown	20	220
Clay, light brown to light blue; hard	97	317
Clay, brown	23	340
Undescribed (no sample)	7	347
Sand, white, fine	1	348

Table 5.--Logs of wells in King George County, Virginia--Continued

Well 11, Dogue; W. M. Grigsby--Continued

	Thickness (feet)	Depth (feet)
Mattaponi Formation--Continued		
Undescribed (no sample)	11	359
Limestone	10	369
Limestone(?)	17	386
Sand and limestone(?)	23	409

Table 5.--Logs of wells in King George County, Virginia--Continued

Well 14, King George, E. R. Morris, Sr.

(Drilled by Leazer Well & Pump Co.; log by Seymour Subitzky and J. P. Prine; correlations by D. J. Cederstrom)

Altitude, 205 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Clay, yellow	14	14
Sand, silty, red, very fine	7	21
Clay, white; fine sand with some gravel	14	35
Chesapeake Group (Miocene):		
Sand, fine to medium-coarse; limonitic, with some clay; water-bearing	36	71
Clay, yellow	3	74
Clay, green	54	128
Clay, green; trace of black minerals	2	130
Clay, silty, green	10	140
Clay, silty, green, and shells	13	153
Nanjemoy(?) Formation (Eocene):		
Clay, green, sticky; black sand and shells	7	160
Clay, green, sticky; black sand, with streaks of indurated shell beds and shells	10	170
Clay, silty, green, sticky; very fine black sand; shells	30	200
Clay, silty, green, sticky; indurated shell beds; fine black sand and shells	10	210
Undifferentiated:		
Clay, silty, green, sticky; fine black sand; shells	42	252
Rock	4	256

Table 5.--Logs of wells in King George County, Virginia--Continued

Well 14, King George; E. R. Morris, Sr.--Continued

	Thickness (feet)	Depth (feet)
Undifferentiated--Continued		
Clay, blue, with shells; fine black silty sand	34	290
Rock, soft; fine sand; shells	10	300
Limestone, soft, mixed with blue clay	20	320
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Clay, gray, red, and blue; sticky	30	350
Clay, gray	22	372
Clay, red and gray, sticky	92	464
Marl and gray clay, interbedded	16	480
Rock and sand, interbedded	20	500
Marl and gray clay, interbedded; water-bearing	10	510
Clay	67	577
Rock and sand, interbedded; water-bearing	20	597
Rock and clay, interbedded	19	616

Table 5.--Logs of wells in King George County, Virginia--Continued

Well 22a, 2 miles southeast of King George; Pickle Factory

(Log from driller's record furnished by Sydnor Hydrodynamics, Inc.; correlations by A. Sinnott and D. J. Cederstrom)

Altitude, 180 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Clay, silty, yellow; soil on top	25	25
Chesapeake Group (Miocene):		
Sand; gravel	17	42
Sand; clayey; gravel	23	65
Clay, blue	57	122
Sand	10	132
Clay, blue; sticky	36	168
Nanjemoy Formation (Eocene):		
Sand	19	187
Mud, blue	3	190
Silt, blue	6	196
Mud, blue; shells	5	201
Mud, blue	65	266
Sandstone	5	271
Marlboro Clay Member:		
Mud, pink	24	295
Aquia Formation (Paleocene):		
Mud, blue	7	302
Sand, gray	18	320
Mud, blue; sticky	9	329

Table 5.--Logs of wells in King George County, Virginia--Continued

Well 22a, 2 miles southeast of King George; Pickle Factory--Continued

	Thickness (feet)	Depth (feet)
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Mud, blue, and sand	3	332
Sandstone	8	340
Mud, blue, sticky	6	346
Mud, blue; underlain by black sand	6	352
Clay, silty, blue; some black sand	16	368
Clay, brown; hard	9	377
Clay, blue, and brown; tough	103	480
Clay, blue; sticky	40	520
Clay, brown, sticky	23	543
Clay, blue, sticky	4	547
Clay, blue, sandy	10	557
Sand, gray; clayey at top	5	562

Table 5.--Logs of wells in King George County, Virginia--Continued

Well 28, Dahlgren; Naval Proving Grounds

(Log modified from driller's record furnished by Washington Pump and Well Co.; correlations by A. Sinnott)

Altitude, 15 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Sand; clay	11	11
Sand, yellow, medium coarse	7	18
Gravel, yellow	10	28
Nanjemoy Formation (Eocene):		
Marl, sandy, black	104	132
Marl, light gray	17	149
Marlboro Clay Member:		
Clay, brown	18	167
Aquia Formation (Paleocene):		
Marl, sandy, black	23	190
Marl, black; shells	$11\frac{1}{2}$	$201\frac{1}{2}$
Rock, gray	$11\frac{1}{2}$	213
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Marl, glauconitic, green	79	292
Clay, reddish brown	22	314
Clay, yellow	74	388
Sand, blue-gray; clay	11	399
Clay, blue; tough	3	402
Clay, red; tough	6	408

Table 5.--Logs of wells in King George County, Virginia--Continued

Well 28, Dahlgren; Naval Proving Grounds--Continued

	Thickness (feet)	Depth (feet)
Mattaponi Formation--Continued		
Clay, yellow	91	499
Clay, sandy, brown	10	509
Sand, glauconite-quartz; water-bearing	12	521

Table 5.--Logs of wells in King George County, Virginia--Continued

Well 30, Dahlgren; Naval Proving Grounds

(Drilled by Virginia Machinery and Well Co.; sample descriptions by G. C. Tibbitts, Jr.; correlations by A. Sinnott)

Altitude, 19 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Clay, sandy, very light gray	1	1
Clay, sandy, white, mottled with yellow	13	14
Clay, sandy, light olive gray; very hard; with a few shell fragments	66	80
Gravel and boulders, with quartz sand	4	84
Nanjemoy Formation:		
Clay, sandy, light tan, with some glauconite; streaks of lighter clay	11	95
Sand and clay, olive gray, with glauconite; streaks of lighter clay	52	147
Marlboro Clay Member:		
Clay, sandy, grayish pink, with some glauconite and muscovite	15	162
Aquia Formation:		
Clay, sandy, dark gray, with glauconite	23	185
Clay, dark gray, with glauconite and shells	15	200
Clay, sandy, bluish-green, with abundant glauconite; some shell fragments	25	225
Sand, olive gray, glauconitic, with abundant quartz; clay and some shell fragments	25	250
Sand, fine, olive gray, glauconitic, with abundant quartz	20	270

Table 5.--Logs of wells in King George County, Virginia--Continued

Well 30, Dahlgren; Naval Proving Grounds--Continued

	Thickness (feet)	Depth (feet)
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Sand, fine, clayey, light yellow; abundant quartz	15	285
Clay, brown, with very fine quartz grains and trace of hematite from 292-300 feet	15	300
Clay, dark brown; abundant fine yellow quartz grains and traces of jasper, rose quartz, and glauconite	20	320
Clay, light brown and some light yellow; with coarse to fine clear, rose and milky quartz; some glauconite	3	323
Clay, brown, with abundant coarse sand; some glauconite	12	335
Clay, brown, with very fine quartz grains; trace of glauconite	30	365
Sand, gray, medium-to coarse-grained, with dark gray silt	15	380
Clay, light brown, with some fine sand	20	400
Clay, dark brown	35	435
Clay, light brown, with very fine sand	10	445
Clay, light brown, with fine sand	20	465
Clay, light brown, with a few sponge spicules	20	485
Clay, dark brown, with fine quartz sand and some muscovite; more sandy in the lower 35 feet	71	556
Silt, clayey, light brown, with very fine quartz and glauconite	30	586
Clay, light brown, sandy, with clear and yellow quartz	19	605
Sand, light gray, with some glauconite	23	628

Table 5.--Logs of wells in King George County, Virginia--Continued

Well 30, Dahlgren; Naval Proving Ground--Continued

	Thickness (feet)	Depth (feet)
Potomac(?) Group (Cretaceous):		
Silt, clayey, brown, with fine quartz sand	27	655
Sand, light gray, very fine	28	683
Silt, clayey, light brown, with some fine sand	11	694
Sand, light gray, very fine	21	715
Clay, sandy, grayish brown	15	730
Sand, nearly white, coarse; with small pebbles	3	733
Silt, sandy, light brown	7	740
Clay, dark brown, with grains of quartz and muscovite	10	765
Sand, silty, dark brown	15	780

Table 5.--Logs of wells in King George County, Virginia--Continued

Well 31, 1.8 mile west-southwest of Dahlgren; W. H. Washington

(Drilled by Leazer Well & Pump Co.; log modified from record by P. Prine, driller; correlations by A. Sinnott)

Altitude, 80 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Hard yellow clay	11	11
Iron stain; water-bearing sand	6	17
Yellow clay	15	32
Clay with large gravel	8	40
Chesapeake(?) Group (Miocene):		
Blue clay	10	50
Green clay	15	65
Organic matter mixed with green clay	20	85
Nanjemoy(?) Formation (Eocene):		
Soft silty clay with shells	5	90
Fine silty sand with shells	10	100
Soft limestone	7	107
Blue clay	43	150
Nanjemoy Formation (Eocene):		
Soft sticky blue clay and black fine sand	41	191
Lime rock	1	192
Soft sticky blue clay	20	212
Hard shell rock	2	214
Blue clay with shells	5	219

Table 5.--Logs of wells in King George County, Virginia--Continued

Well 31, 1.8 mile west-southwest of Dahlgren; W. H. Washington--Continued

	Thickness	Depth
Nanjemoy Formation--Continued		
Blue and red clay, mixed	10	229
Marlboro Clay Member:		
Light-red clay	16	245
Pre-Eocene deposits, undifferentiated:		
Undescribed (no samples)	475	720

Table 5.--Logs of wells in King George County, Virginia--Continued

Well 32, Dahlgren; Union Bethel Church ($6\frac{1}{2}$ miles southwest of Potomac River Bridge, on Route 301)

(Log modified from driller's record furnished by Reynolds & Norman; correlations by A. Sinnott)

Altitude, 160 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene) and Chesapeake Group (Miocene), undifferentiated:		
Clay, blue	130	130
Nanjemoy Formation (Eocene):		
Sand, blue	20	150
Clay, blue	103	253
Clay, tough; (Nanjemoy fossils at this depth)	2	255
Marlboro Clay Member:		
Clay, red	2	257
Aquia Formation (Paleocene):		
Clay, blue	68	325
Sand, blue	25	350
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Clay, tough	2	352
Clay, brown	18	370
Clay, white	20	390
Clay, tough	6	396
Clay, yellow, and sand	304	700
Clay, red	50	750
Potomac(?) Group:		
Clay, white	100	850
Sand, white	44	894

Table ~~15~~ 6.--Chemical analyses of ground waters from wells in King George County, Virginia
(Parts per million except specific conductance and pH)

Well number	4	7b	13	19	24	24
Location	Nr. Sealston	Fairview Beach	King George	SSW of Edge Hill	Port Conway	Port Conway
Depth (feet)	201	105	400	35	401	401
Geologic age	Late Cretaceous and Paleocene	Paleocene	Late Cretaceous and Paleocene	Pleistocene	Cretaceous	Cretaceous
Formation or Group	Mattaponi Formation	Aquia Formation	Mattaponi Formation	Columbia Group	Potomac Group	Potomac Group
Date	June 16, 1949	April 2, 1944	May 14, 1953	May 14, 1953	June, 1949	May 14, 1953
Silica (SiO_2)	30	--	19	--	35	--
Iron (Fe)	5.0	--	.04	--	.32	--
Calcium (Ca)	26	--	3.8	5.0	1.0	1.8
Magnesium (Mg)	7.4	--	2.5	1.2	1.4	.2
Sodium (Na)	} 12	--	78	--	} 54	--
Potassium (K)		--	8.4	--		--
Carbonate (CO_3)	0	--	0	0	0	0
Bicarbonate (HCO_3)	129	246	210	22	124	121
Sulfate (SO_4)	11	85	18	--	19	--
Chloride (Cl)	2.8	6	1.0	15	2.8	6.2
Fluoride (F)	.3	.2	.4	.1	.1	.2
Nitrate (NO_3)	.2	1.0	.9	4.2	.2	.4
Dissolved solids	154	--	230	--	170	--
Hardness as $CaCO_3$	95	270	20	17	8	5
Specific conductance (micromhos at 25°C)	238	--	370	101	245	234
pH	6.8	7.6	8.3	6.3	7.5	7.8

Westmoreland County I

Location and Development[1/] II

Westmoreland County lies along the south bank of the Potomac River, and is bordered on the west by King George County, and on the south and east by Richmond and Northumberland Counties. Across the Rappahannock River, on the south, lies part of Essex County. The area of Westmoreland County is 250 square miles, and its population in 1960 was 11,042.

Tomatoes are an important crop, and much hay is produced; crabs and oysters are shipped from the county in abundance. It is frequented by sportsmen and muskrat, raccoon, and rabbit are trapped for fur. Transportation is provided by several excellent State highways, the most important of which are Nos. 3 and 202. Water transportation is available along the Potomac River. There are, however, no railroads in the county.

The county seat is Montross, near the southern boundary. Other important towns include Kinsale, at the head of Yeocomico River off the Potomac River at the east end of the county, Colonial Beach in the northwest part of the county, Oak Grove, Potomac Mills, Templeman, and Mt. Holly. There are camp grounds at Westmoreland State Park and bathing beaches at Colonial Beach. In the northwest part of the county is the George Washington's Birthplace National Monument.

1/ For further information on the economic development of Westmoreland County, see Va. Div. of Planning, (1967), Economic Data Summary Westmoreland County.

Topography and Drainage

II

The total relief in Westmoreland County is about 175 feet. The area surrounding Mattox Creek in the northwestern part of the county is at an average elevation of about 40 feet above sea level; also a large part of the area between Nomini Bay and Yeocomico River is at a similar elevation. These areas have been ascribed to the Talbot terrace of Cooke (Wentworth, 1930). There are small areas at the east and west ends of the county bordering the Potomac and the Rappahannock, respectively, which have average elevations of about 20 feet and are referred to the Pamlico terrace of latest Pleistocene age. Both terraces have been somewhat dissected. Essentially all the remainder of the county is referred to the higher Sunderland terrace, which has been submaturely dissected in a dendritic drainage pattern by streams. Reaching nearly 150 feet high are the Nomini Cliffs, which have been cut by the Potomac River between Popes Creek and Currioman Bay along the north-central border of the county. (See Figure 5.)

A large part of east-central Westmoreland County is drained by Nomini Creek and its tributaries, and the eastern part of the county is drained by the Yeocomico River. The headwaters of Cat Point Creek, which flows to the Rappahannock River across Richmond County, drain a large area in the west-central part of Westmoreland County. Many smaller creeks serve to complete the drainage pattern of the county.

Figure 5. --Exposure of rocks of the Chesapeake group of Miocene age, overlain by sands of Pleistocene age, in Nomini Cliffs, south bank of Potomac River, Westmoreland County.

(Photograph, courtesy of the Virginia Chamber of Commerce.)

Geology and Ground-Water Conditions II

Basement Complex III

The basement bedrock of pre-Cretaceous age in Westmoreland County may be more than 2,000 feet below sea level (DeBuchananne, 1968, Sheet 1). So far as known, no wells have reached these rocks in the county.

Cretaceous System--Potomac Group III

The Potomac Group of sediments rests upon basement rock but have not been reached by wells in Westmoreland County.

There are without doubt excellent water-bearing sands among these deposits, and it is highly likely that ample water of very satisfactory quality is obtainable by means of wells drilled deep enough to reach them. The Potomac Group rests on the basement complex, and underlies the Mattaponi Formation; wells drilled deeper than about 750 feet below sea level should tap these water-bearing sands.

Ground water from the Potomac Group of sediments in this area would be expected to be a soft sodium bicarbonate type of good quality.

Cretaceous to Tertiary Systems--Mattaponi Formation III

As discussed previously in the section on the general geology of the Northern Neck, the two type wells for the Mattaponi Formation, of Late Cretaceous and Paleocene age (Cederstrom, 1957, p. 17), are in Westmoreland County. (See logs, wells 1b and 2a, at Colonial Beach and Washington's Birthplace, respectively.) The Mattaponi Formation is variable in its lithology within short distances; however, the characteristic mottled clays are widely persistent.

In Westmoreland County, the Mattaponi consists largely of clays of various colors, with clean water-bearing sands near the basal part of the section. Glauconite is commonly present.

Besides the two localities represented by the type wells, the Mattaponi Formation has been encountered near Oak Grove, Montross, Coles Point, Sandy Point, and at several other places where deeper wells have been drilled.

Water-Bearing Character IV

A number of the more productive wells in Westmoreland County have been drilled deep enough to obtain water from the Mattaponi Formation.

For example, one of two municipal wells at Colonial Beach (1a, Table 8), near the northwestern corner of the county along

the Potomac, was reported to have an artesian flow of 100 gpm (gallons per minute) in the late 1940's. It is pumped at more than 200 gpm. Another municipal well at this locality (1b), one of the type wells of the Mattaponi Formation, is reported to flow at 50 gpm and yields 400 gpm by pumping.

In the middle part of the county, another public-supply well (7) at Montross yields about 50 gpm from basal sand and gravel in the Mattaponi Formation, and two industrial wells (6, 8) yield respectively 75 and 46 gpm from lower sands of the Mattaponi. A large capacity industrial well (9) near Montross, drilled in 1966, yielded more than 800 gpm with a drawdown of 148 feet when test-pumped--illustrating the potential yield of the Mattaponi to larger wells.

Farther east, the sandy beds in the Mattaponi yielded 100 gpm by free flow in 1918 from about the lower hundred feet of a 727-foot well (44) about 2 miles south of Coles Point.

At the extreme eastern end of the county, a 594-foot well (62), at Sandy Point, taps the Mattaponi and was reported to flow at a rate of 37 gpm, and is pumped at a rate of 60 gpm with a 2-foot drawdown.

On the basis of the several moderately large-yield wells noted, it may be confidently stated that the Mattaponi Formation in Westmoreland County is a potentially good future source of ample ground-water supplies.

In addition to the wells noted above, small supplies are obtained by many other wells in the county for smaller industries or for domestic use. On low ground at altitudes of 3 feet or less, small artesian flows are obtained from a few wells. ~~For example,~~ in the east-central part of the county a 340-foot well (20), near Mount Holly, was reported to flow at a rate of 5 gpm at an altitude of about 3 feet--the water being delivered to a house on a nearby terrace by means of a hydraulic ram.

In Westmoreland County, water from the Mattaponi Formation is a soft bicarbonate type, high in sodium, in which bicarbonate ranges from little more than 200 ppm to more than 400 ppm. Chloride and sulfate are low and fluoride moderate, generally less than 1.5 ppm.

A well (6) at Montross was sampled in 1944, 1948, and 1953, but showed practically no change during that time. The water, like that from the western part of the county, is a soft sodium bicarbonate type, but fluoride exceeds the optimum concentration of 1.5 ppm, averaging about 2.4 ppm.

Tertiary System III

Aquia and Nanjemoy Formations IV

The Aquia Formation of Paleocene age, and the Nanjemoy Formation of early and middle Eocene age are characterized by glauconitic sands, clays, and marls. Where they can be readily distinguished, particularly in the western part of Westmoreland County, the Nanjemoy is several times thicker than the Aquia. A pink clay--the Marlboro Clay Member--lies at the base of the Nanjemoy and may be noted in certain well logs. (See logs for wells 1b, 2a, and 73).

The Aquia and Nanjemoy Formations become thinner downdip toward the eastern part of the county.

In Westmoreland County the Aquia and Nanjemoy Formations are not commonly developed by wells. In the western part of the county, where the Chickahominy is absent, the lack of persistent water-bearing sands in the Aquia and Nanjemoy require deeper drilling in order to reach the sands in the Mattaponi.

The very few primarily domestic wells (55, 68, 70, 71) that probably tap the Aquia and Nanjemoy Formations in Westmoreland County have low yields, as far as can be determined.

Samples were collected for analysis from two of these wells (68, 71). The waters are both soft and high in sodium and bicarbonate, similar in chemical character to those obtained from the Mattaponi Formation. It seems likely that in other parts of Westmoreland County ground water in the Aquia and Nanjemoy will be found to be essentially similar in quality to that from the Mattaponi Formation.

Chickahominy Formation IV

Foraminifera diagnostic of the Chickahominy Formation of late Eocene (Jackson) age have been recognized in drill cuttings from several wells in eastern Westmoreland County. (See Table 8, logs for wells 37a, 44, 65.) The formation is about 70 feet thick near Coles Point, and thins westward, having been eroded by the transgression of the early Miocene seas; it disappears in a featheredge just east of Montross. (See section A-A' in Plate 1.)

The Chickahominy consists of clay and shell beds at Kinsale, but it is sandy in character near Coles Point.

Water-Bearing Character V

Despite the fact that the Chickahominy Formation underlies only about the eastern half of Westmoreland County, it is nevertheless tapped by a number of wells for water supplies. Where sandy beds are present, as in the area south of Coles Point and approaching Hague, (40-43, 45, 49, 51, 54, 56, and 58) small supplies are obtained. Of these wells, one (54) had been flowing for 35 years in 1946.

Still farther south, in the southeast part of the county at Kinsale, a well (65) drilled for public supply, 280 feet deep and 8 inches in diameter, yielded 130 gpm on test with a drawdown of 25 feet, but is normally pumped at a rate of 60 gpm, and thus the Chickahominy here provides an adequate although moderate supply.

A few other wells tapping the Chickahominy in the Mt. Holly area (13, 21, 23, 24, 28) and in Coles Point proper (35, 36, 37a) mostly yield small natural flows up to about 10 gpm. These wells are all small-diameter jetted wells, primarily for low-demand domestic use. It is likely that moderate supplies, perhaps up to 100 gpm, might be obtained from Chickahominy sands in many places where wells are equipped with screens and properly developed.

A domestic well (67) along the Potomac at the east end of the county developed in the Chickahominy, yields a very slightly hard sodium bicarbonate water, in which bicarbonate is 350 ppm. The public supply well at Kinsale (65) yields a similar water but bicarbonate is less than 200 ppm. In both wells other constituents are low. Bicarbonate is 309 ppm in a well at Coles Point (45) but, a few miles to the west near Mount Holly, well 16 yields water with only 153 ppm.

Chesapeake Group IV

The Chesapeake Group of Miocene age unconformably overlies the Eocene sediments and dips more gently. The formations in this group are not differentiated in this report, chiefly because they are for the most part difficult to distinguish one from another from drill cuttings.

The Chesapeake Group ranges in thickness from 20 to 30 feet at Colonial Beach in the western part of the county to more than 200 feet at the eastern extremity near Northumberland County. The deposits consist chiefly of gray and blue clay, diatomaceous clay, sand, and shell marl. They are well exposed in the Nomini Cliffs along the Potomac. (See ~~Figure~~ fig. 5.)

Water-Bearing Character V

The Chesapeake Group in Westmoreland County, despite its thickness toward the east, is tapped by very few wells of low yield and thus is of little importance as a source of ground water.

Quaternary System--Columbia Group III

The Columbia Group of Pleistocene age forms a surface mantle over virtually the entire county, in a few places reaching a maximum thickness of perhaps 50 feet. These rocks are chiefly yellowish sand, clay, and gravel.

Water-Bearing Character IV

Most of the small domestic supplies in the rural parts of Westmoreland County are obtained ~~water~~ by means of dug and driven wells ~~from~~ in the Columbia Group. The small volume of water required by such users is readily obtainable from these deposits, although the quality of the water is likely to be inferior to the water obtained from the deeper strata.

In the southeastern part of the county, near Oldhams, a 45-foot dug well (69) for a cannery is pumped at 13 gpm--the largest yield on which records are available on wells in the Columbia Group.

Two springs in the western part of the county--one at Washington's Birthplace (2b) and the other at the Robert E. Lee Memorial, (3) obtain water from the Columbia Group. The latter spring flows at a rate of 3 gpm.

Doubtless, larger supplies could be obtained in these deposits as has been successfully done on the Eastern Shore, by pumping several shallow wells as a unit, in favorable localities

in the county. This procedure would utilize to a greater degree the maximum potential of these relatively shallow deposits.

The many shallow dug wells throughout the county which derive their water from the Columbia Group probably yield ground water of generally satisfactory quality. However, iron and hardness are locally troublesome, and the hazards of organic pollution are much greater than for wells developed from deeper water-bearing zones. Dug wells should be adequately protected against contamination from surface drainage.

Analyses were made of water from the springs at both Washington's Birthplace (2b) and at the Robert E. Lee home at Stratford (3). Each derives its water from the Columbia Group.

The water from Washington's Birthplace is moderately hard (105 ppm) and nitrate is significantly high at 8.4 ppm, suggesting the possibility of pollution. Water from the spring at the Robert E. Lee Home at Stratford, east of Westmoreland County State Park, was sampled for complete analysis in June, 1948, and found to yield water of very low mineralization (3, Table 9). Like the spring at Washington's Birthplace, the relatively high concentration of nitrate--9.6 parts per million--points to probable pollution from surface drainage. An earlier analysis of water from this spring, as of 1935, showed similar concentrations of the constituents, and the nitrate concentration even then was high enough (5 ppm) to arouse a suspicion of organic pollution.

In summary, the chemical quality of ground water in

Westmoreland County is of generally very good quality for most ordinary purposes. Iron is likely to be a problem, however, among users of wells tapping the Columbia Group, as is nitrate.

Summary of Ground-Water Conditions II

The Potomac Group in Westmoreland County is believed to contain a large untapped reserve of water of good quality for future increasing water needs.

The Mattaponi Formation that overlies it has the largest artesian flows in the county--more than 50 gpm being reported in places. Yields of 400 gpm by pumping are readily obtainable, and in recent years more than 800 gpm was obtained by an industrial well on test. Ground water from the Mattaponi is of the soft sodium bicarbonate type; fluoride is generally low, but in places may reach more than 2 ppm. Small yields of soft sodium bicarbonate water are obtained from a few wells in the overlying Aquia and Nanjemoy Formations.

In roughly the eastern half of Westmoreland County, the Chickahominy is present in the subsurface and has been tapped for small to moderate supplies by many wells. Yields of more than 100 gpm can be obtained from properly constructed wells. In quality, the water is soft, high in bicarbonate and sodium; chloride and fluoride are low.

The Chesapeake Group is not of economic importance in the county as a source of ground water. The surficial Columbia Group provides small supplies for many homes and small farms with water of generally good quality.

Well Records and Chemical Analyses II

Records of wells, available logs, and chemical analyses of water samples in Westmoreland County are given in Tables 7, 8, and 9 on the pages that follow. Locations of wells listed in Tables 7 through 9 are given in Figure 6 preceding the tables.

Table 7.—Records of wells in Westmoreland County, Virginia

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
67	4.1 mi. ENE of Hague	Maurice A. Thorne		1951	20	J	273		Late Eocene	Chickahominy Fm	(-)		D	See analysis, Table 9.	67
68	1.2 mi. S of Machodoc	T. M. Arnest, Jr.		1914	15	D	366		Eocene	Nanjemoy Fm	(+)		D,S	See analysis, Table 9. Flows about 3 gpm.	68
69	2.1 mi. WSW of Oldhams	Belmont Canning Co.			130	Dug	45		Pleistocene	Columbia Group	-125	13	I	Canning factory. Two similar wells in vicinity.	69
70	Leedstown	G. W. Grigsby	H. Lyons		10	J	214		Paleocene and Eocene	Aquia(?) and Nanjemoy Fms				Black sand at 214 ft.	70
71	Do.	S. S. Hall			10		160		Eocene	Nanjemoy Fm				See analysis, Table 9. Black sand at 160 ft beneath streak of red clay.	71
72	Do.	Leedstown			10		500	3	Late Cretaceous and Paleocene	Mattaponi Fm	(+)			See analysis, Table 9. Flows 3 gpm.	72
73	1.8 mi. SSW of Oak Grove	E. T. Hynson	Mitchell's Well and Pump Co.	1943	180	D	530	4¼	do	do	-168	9		See log, Table 8; analysis, Table 9. Drawdown 61 ft when pumping 9 gpm.	73
74	2.3 mi. SSW of Oak Grove	Slocum	do	1940	170	D	708		do	do	(+)			See log, Table 8.	74

Table 7.—Records of wells in Westmoreland County, Virginia

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
41	2 mi. SW of Coles Point	Mrs. Ficklen			1	J	300	1½	Late Eocene	Chickahominy(?)Fm	(+)		D,S	Flows 5–10 gpm. Another similar well nearby.	41
42	2.5 mi. SSW of Coles Point	Harden Daiger			20	J	220	1¼	Late Eocene ~~Miocene~~	Chickahominy Fm ~~Chesapeake Group~~	(−)		D,S	See analysis, Table 9.	42
43	2 mi. SE of Coles Point	Smith	John W. Wilson		10	J	239	1½	Late Eocene ~~Miocene~~	Chickahominy Fm ~~Chesapeake(?)Group~~	(−)		D	Pumps 18 gpm.	43
44	2 mi. S of Coles Point		G. Pfeiffer, Jr.	1918	10	D	727	8–6	Late Cretaceous and Paleocene	Mattaponi Fm	(+)			See log, Table 8. Flowed 100 gpm in 1918.	44
45	Do.	William Barnes	John W. Wilson	1945	10	J	240	1½	Late Eocene ~~Miocene~~	Chickahominy Fm ~~Chesapeake(?)Group~~	(−)		D	See analysis, Table 9. Temp., 58°F.	45
49	2.4 mi. SSW of Coles Point	Carl Hubbard			2	J	220	1½	do	do ~~Chesapeake Group~~	(−)		D,S		49
51	2.6 mi. SSW of Coles Point	B. Tilman			3	J	220	1½	do	do	(+)		D,S	Flows 10 gpm. No decline in water level during dry years.	51
54	1.3 mi. NNE of Hague	G. M. Thompson			13	J	240	1½	Late Eocene	Chickahominy Fm	(+)		D,S	Flowing for 35 years. Some iron stain.	54
55	1 mi. NE of Hague	Strongs	C. Jones		16	J	350	2	Eocene	Nanjemoy Fm.	−6		D,I	Stopped flowing in 1945.	55
56	1.4 mi. NE of Hague	H. L. Barnes	John W. Wilson		14	J	270	2	Late Eocene	Chickahominy Fm	−2		D,S	No iron stain.	56
57	1.4 mi. ENE of Hague	E. L. Mozingo	do		15	J	400	2	Late Cretaceous and Paleocene	Mattaponi Fm	(+)		D,S	Flows ¾ gpm. No iron stain.	57
58	1.6 mi. ENE of Hague	I. T. Short	do	1924	18	J	260+	2	Late Eocene	Chickahominy Fm	(−)		D,S	Pumps some sand. Water causes slight brown stain.	58
62	Sandy Point	T. Brooks	Mitchell's Well and Pump Co.	1946	11	D	594	6–4¼	Late Cretaceous and Paleocene	Mattaponi Fm	(+)	60		See analyses, Table 9. Flows about 30 gpm. When pumped, yields 60 gpm with 2-ft drawdown.	62
63	Do.	do	John W. Wilson		3		497		do	do	(−)			Stopped flowing in about 1945.	63
64	1.4 mi. S of Sandy Point	S. P. Collier	do		3		470		do	do	(+)			Flows 1 gpm.	64
65	Kinsale	Sydnor Hydrodynamics, Inc.	Sydnor Hydrodynamics, Inc.	1946	70	D	280	8	Late Eocene	Chickahominy Fm	−53		PS	See log, Table 8; analyses, Table 9. Temp., 62°F. Pumps 66 gpm with 25-ft drawdown. Has yielded 130 gpm on test.	65
66	0.7 mi. SSE of Hague	C. C. Cole	Arthur Cole		35	J	456		Late Cretaceous and Paleocene	Mattaponi Fm	(+)		I	See analysis, Table 9. Temp., 62°F. Supplies cannery. Black sand at 250 ft.	66

Table 7.—Records of wells in Westmoreland County, Virginia

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
16	0.7 mi. W of Mt. Holly	W. B. Davis			2	J	130	2	Late Eocene ~~Miocene~~	Chickahominy Fm ~~Chesapeake Group~~	(+)		D	See analyses, Table 9. Temp., 62½°F. In 1948, flowed 4 gpm.	16
18	0.7 mi. ENE of Mt. Holly	T. S. Hall	John W. Wilson		3	J	375	1½	Late Cretaceous and Paleocene	Mattaponi Fm	(+)		D,S	Equipped with hydraulic ram. Tide affects flow. Another similar well nearby.	18
20	0.5 mi. N of Mt. Holly	Mrs. J. B. Hall			3	J	340	2	do	do	(+)		D	Formerly used by fish factory. Ram delivers water to house on terrace.	20
21	0.9 mi. NNE of Mt. Holly	J. F. Farwell	John W. Wilson		4	J	200	1½	Late Eocene	Chickahominy Fm (?)	(−)		D		21
23	1.3 mi. NE of Mt. Holly	J. B. Dall			1	J	200	1½	do	do	(+)		D,S	Flows ½ gpm.	23
24	1.3 mi. NNE of Mt. Holly	M. R. Dean	John W. Wilson		3	J	230	2½	Late Eocene	Chickahominy Fm	(+)		D,I	Flows 2 gpm. Used by oyster packing plant. Another similar well nearby.	24
27	1.4 mi. NE of Mt. Holly	do	do		2	J	330		Late Cretaceous and Paleocene	Mattaponi Fm	(+)		D, S	Flows 1 gpm.	27
28	1.6 mi. NE of Mt. Holly	Bushfield Farm	Parks	1946	1	J	255	1½	Late Eocene	Chickahominy Fm	(+)		D	Flows 5 gpm.	28
33	3.5 mi. W of Coles Point	Mrs. May B. Woods	John W. Wilson		2	J	362	1½	Late Cretaceous and Paleocene	Mattaponi Fm	(+)		D	See analysis, Table 9. Temp., 66°F. Flows 1 gpm.	33
34	2.6 mi. W of Coles Point	R. D. McFaden			2	J	168	1½	Miocene	Chesapeake Group	(−)		D, S		34 ok
35	Coles Point	Fred Torrence	John W. Wilson	1946	2	J	231	1½	Late Eocene	Chickahominy Fm	(−)		D	Pumps 6 gpm.	35
36	Do.	Edward Godman	do	1945	5	J	240	1½	do	do	(−)		D	Pumps 4 gpm.	36
37a	Do.	W. P. Campbell	A. L. Wilson	1950	23	J	231	1½	do	do	−12		D	See log, Table 8.	37a
37b	Do.	R. Campbell	John W. Wilson	1932	2	J	380	1½	Late Cretaceous and Paleocene	Mattaponi Fm	(+)	32	D	Flows 10 gpm. Another similar well nearby.	37b
38	Near Coles Point	G. H. McDaniel			1	J	200	1½	Miocene	Chesapeake Group (?)	(+)		D, S	Flows ¼ gpm.	38
39	2 mi. SSW of Coles Point	L. H. Linton	John W. Wilson		1	J	375	2	Late Cretaceous and Paleocene	Mattaponi Fm	(+)		D, S	Flows 2 gpm. Four similar wells nearby.	39
40	2 mi. SE of Coles Point	Britton	do	1946	10	J	242	1½	Late Eocene ~~Miocene~~	Chickahominy Fm ~~Chesapeake (?) Group~~	(−)	5	D	Three similar wells nearby.	40

W 87

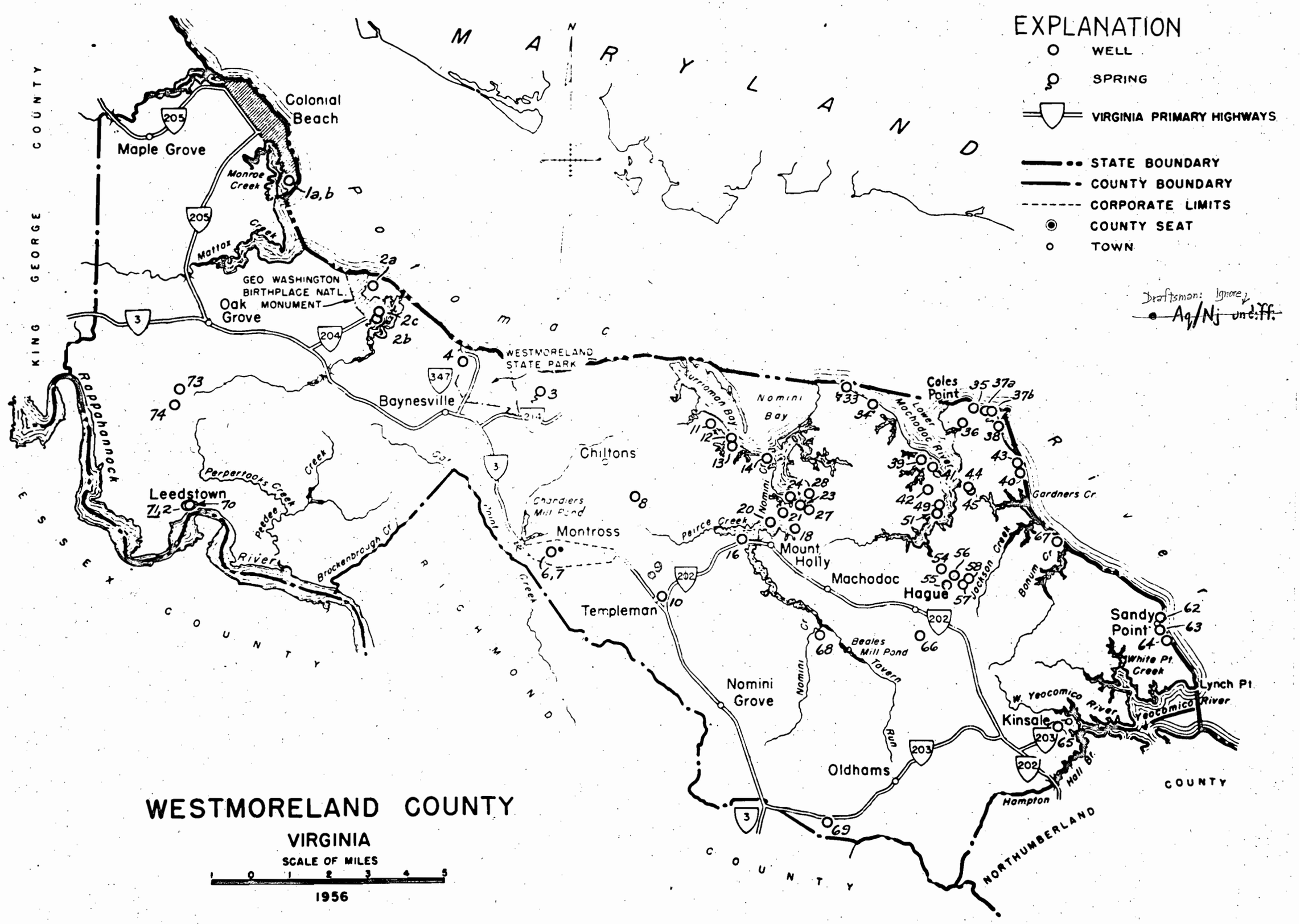
Table 7.—Records of wells in Westmoreland County, Virginia

Type of well: D, drilled; J, jetted
Use of water: PS, public supply; D, domestic; I, industrial; S, stock

gpm, gallons per minute; Fm, formation
Temp., temperature (degrees Fahrenheit)

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
1a	Colonial Beach	Town of Colonial Beach	Miller		8		585	6	Late Cretaceous and Paleocene	Mattaponi Fm	(+)	225	PS	See analysis, Table 9. Flows 100 gpm.	1a
1b	Do.	do	Virginia Machinery and Well Co.		8		634+	8	do	do	(+)	400	PS	Water from sand below 634 feet. Flows 50 gpm.	1b
2a	Near George Washington Birthplace National Monument	J. H. Muse	Mitchell's Well and Pump Co.	1945	19	D	420		do	do	−4½	15	D		2a
2b	George Washington Birthplace National Monument	U.S. Dept. of Interior			20		Spring		Pleistocene	Columbia Group				See analysis, Table 9.	2b
2c	Do.	do			20	D	380		Late Cretaceous and Paleocene	Mattaponi Fm	(−)	20		See analysis, Table 9.	2c
3	0.5 mi. E of Westmoreland State Park	R. E. Lee Memorial Foundation, Inc.			25		Spring		Pleistocene	Columbia Group			D	See analysis, Table 9. Flows 3 gpm.	3
4	Westmoreland State Park	State Department of Conservation and Development	Virginia Machinery and Well Co.	1945	100	D	631		Late Cretaceous and Paleocene	Mattaponi Fm	−58	72	D	See log, Table 8. Drawdown 104 ft after 45 hrs pumping at 72 gpm.	4
6	Montross	Coca Cola Bottling Co.	Mitchell's Well and Pump Co.	1936	145	D	648	6	do	do	(−)	75	I	See log, Table 8; analysis, Table 9. Drawdown 60 ft after 38 hrs pumping at 75 gpm. Casing to 628 ft.	6
7	Do.	Town of Montross		1936	145	D	560	6	do	do	−130	50±	PS	See log, Table 8.	7
8	2.5 mi. ENE of Montross	Stratford Packing Co.	B. Williams	1943	142	D	455	6	do	do	−146	46	I	See log, Table 8. Drawdown 104 ft after 18 hrs pumping at 46 gpm.	8
9	2 mi. SE of Montross	Scovill	Sydnor Hydrodynamics, Inc.	1966	140 ±	D	817	20-8	do	do	−141		I	Tested at 844 gpm for 28 hrs; drawdown 148 ft	9
10	Templeman	J. F. Johnson			125	Dug	30		Pleistocene	Columbia Group	−5	5	I	Water level declines during dry years.	10
11	3.5 mi. NW of Mt. Holly	E. Hastings			3	J	360	1½	Late Cretaceous and Paleocene	Mattaponi Fm	(+)		D,S	In 1946, flowed 1/3 gpm.	11
12	3 mi. NW of Mt. Holly	Littlefield			1	J	360	1½	do	do	(+)			Not in use in 1946. Flowed 1/3 gpm.	12
13	2.7 mi. NW of Mt. Holly	C. Hennage	C. Lyons		2	J	199	1½	Late Eocene	Chickahominy(?)Fm	(+)		I	In 1946, flowed 2 gpm at low tide. Oyster packing plant.	13
14	2.2 mi. N of Mt. Holly	A. Reed			2	J	340	1½	Late Cretaceous and Paleocene	Mattaponi Fm	(+)		D,S	In 1946, flowed 5 gpm. Another similar well nearby.	14

112



(Base, Courtesy of the Virginia Division of Planning)

Table 8.--Logs of wells in Westmoreland County, Virginia

Well 1b, Municipality of Colonial Beach

(Log in part from driller's record furnished by Virginia Machinery & Well Co., Inc.; sample descriptions and correlations by D. J. Cederstrom, 1957, p. 17-18)

Altitude, 20 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Clay, yellow	30	30
Chesapeake Group (Miocene):		
Clay, gray, compact	42	72
Nanjemoy Formation (Eocene):		
Sand, yellow, clayey	6	78
Gravel	6	84
Boulders, fine sand, gravel	11	95
Clay, black, glauconitic	99	194
Marlboro (?) Clay Member:		
Clay, pink	3	197
Aquia Formation (Paleocene):		
Marl, dark-olive-green, glauconitic, sandy	28	225
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Clay, black, hard	10	235
Sand, black	15	250
Sand, grayish-green, clayey, glauconitic; Foraminifera	25	275

Table 8.--Logs of wells in Westmoreland County, Virginia--continued

Well 1b, Municipality of Colonial Beach--continued

	Thickness (feet)	Depth (feet)
Mattaponi Formation (Upper Cretaceous and Paleocene): (cont.)		
Clay, dark-olive-green, sandy; Foraminifera	20	295
Sand, dark-gray, running, clayey; Foraminifera	25	320
Clay, mottled, yellowish, red-to-brown, gray; Foraminifers at base	54	374
Sand, fine gray; water under good head	26	400
Clay, pale-green, silty	10	410
Clay, dark-gray	7	417
Clay, dark-gray, lumps in gray sand	8	425
Clay, dark-gray, and sand	25	450
Clay, tough, gray and brown	110	560
Clay, light-gray	4	564
Clay, red	6	570
Clay, light-brown	10	580
Clay, dark-purplish-brown	10	590
Clay, bright-red	10	600
Clay, light-gray	20	620
Clay, dark-gray	14	634
Sand, water-bearing	20	654

Table 8.--Logs of wells in Westmoreland County, Virginia--continued

Well 2a, George Washington Birthplace National Monument

(Log in part from driller's record furnished by Mitchell's Well & Pump Co., with sample descriptions and correlations by D. J. Cederstrom, 1957, p. 18)

Altitude, 20 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Clay, yellow, and sand	20	20
Chesapeake Group (Miocene):		
Marl, gray, sandy	60	80
Nanjemoy Formation (Eocene):		
Clay, black glauconitic	46	126
Clay, light-grayish-green, glauconitic; Foraminifera	93	219
Marlboro (?) Clay Member:		
Clay, dull-pink	5	224
Aquia Formation (Paleocene):		
Sand, glauconitic	6	230
Marl, vivid-green, glauconitic; Foraminifera	22	252
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Sand, slightly marly, glauconitic; Foraminifera	4	256
Marl, vivid-green, glauconitic; Foraminifera	34	290
Rock	$\frac{1}{2}$	$290\frac{1}{2}$
Sand, slightly marly, dark-green, glauconitic; Foraminifera	20	$310\frac{1}{2}$

Table 8.--Logs of wells in Westmoreland County, Virginia--continued

Well 2a, George Washington Birthplace National Monument--continued

	Thickness (feet)	Depth (feet)
Mattaponi Formation (Upper Cretaceous and Paleocene): (cont.)		
Rock	½	311
Sand, slightly marly, dark-green, glauconitic; Foraminifera	37	348
Clay, dark-yellowish-brown	38	386
Sand, fine, gray; water	10	396

Table 8.--Logs of wells in Westmoreland County, Virginia--Continued

Well 4, Westmoreland State Park; Virginia Department of Conservation and Economic Development

(Log from driller's record furnished by Virginia Machinery & Well Co.; correlations by A. Sinnott and D. J. Cederstrom

Altitude, 80± feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene) and Chesapeake Group (Miocene), undifferentiated:		
Clay, yellow	2	2
Clay, gray	38	40
Clay, olive-green	100	140
Nanjemoy Formation (Eocene):		
Clay, gray; black sand, shell traces	20	160
Clay, gray, and gray sandstone	20	180
Clay, dark gray, little sand	25	205
Clay, tough, dark gray; sand	65	270
Aquia(?) Formation (Paleocene):		
Clay, tough, dark	30	300
Clay, brown	20	320
Mattaponi(?) Formation (Upper Cretaceous and Paleocene):		
Clay, black; sand	60	380
Clay, light green, traces of black sand	50	430
Clay, dark green; sand	8	438
Clay, tough, brown	32	470
Clay, tough, gray; Foraminifera	10	480

(more)

Table 8.--Logs of wells in Westmoreland County, Virginia--Continued

Well 4, Westmoreland State Park; Virginia Department of Conservation and Economic Development--Continued

	Thickness (feet)	Depth (feet)
Mattaponi(?) Formation--Continued		
Clay, dark brown	50	530
Clay, gray and brown	20	550
Clay, dark red	10	560
Clay, dark brown	20	580
Clay, light brown	25	605
Clay, gray	12	617
Sand; water-bearing	12	629
Clay, tough	3	632

Table 8.--Logs of wells in Westmoreland County, Virginia--Continued

Well 6, Montross; Coca Cola Bottling Company

(Log from driller's record furnished by Mitchell's Well & Pump Co.; correlations by A. Sinnott)

Altitude, 145 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Sand and gravel	46	46
Chesapeake Group (Miocene)		
Clay, blue	214	260
Unclassified:		
Undescribed (no samples)	224	484
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Rock	3	487
Clay, blue	43	530
Clay	6	536
Clay, and sand; shell marl at 571 feet	37	573
Clay, yellow	16	589
Clay, blue	14	603
Sand	42	645
Gravel	3	648

Table 8.--Logs of wells in Westmoreland County, Virginia--Continued

Well 7, Montross; Town of Montross

(Log from driller's record furnished by Town; correlations by A. Sinnott)

Altitude 145 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Sand, yellow	40	40
Chesapeake Group (Miocene) and Nanjemoy and Aquia Formations (Eocene and Paleocene, respectively), undifferentiated:		
Clay, blue	330	370
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Clay, yellow	50	420
Sand, black, and mud, mixed	40	460
Sand, green, and mud	80	540
Clay, white	5	545
Sand, white	15	560

Table 8.--Logs of wells in Westmoreland County, Virginia--Continued

Well 8, 3.6 miles east-northeast of Montross; Stratford Packing Co.

(Log by R. Williams, driller; correlations by A. Sinnott)

Altitude, 142 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Clay, yellow	35	35
Chesapeake Group (Miocene):		
Marl, blue	235	270
Nanjemoy and Aquia Formations (Eocene and Paleocene), undifferentiated:		
Clay, black	25	295
Nanjemoy, Aquia, and Mattaponi Formations (Eocene Paleocene, and Upper Cretaceous and Paleocene), undifferentiated:		
Clay, blue	130	425
Clay, pink	15	440
Sand, very fine, black	10	450
Sand, fine, and clay, mixed	5	455

Table 8.--Logs of wells in Westmoreland County, Virginia--Continued

Well 37a, Coles Point; W. P. Campbell

(Sample descriptions by E. G. Otton, from Md. Dept. Geology, Mines and Water Resources, Bull. 11, p. 186-87; see Ferguson, 1953)

Altitude, 23 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Sand, fine, angular, grayish-orange, quartz fine, clear angular, pale-yellow; feldspar, dull, fine, pink, and white; glauconite, green, very fine and rare	10	10
Sand, angular, fine to medium, light olive-gray; quartz, clear and gray, fine to medium, angular to subangular; glauconite, green, oblate, rare; feldspar, white, fragments; a few coarse chlorite and biotite fragments; grains of gray flint	11	21
Sand, medium, angular, yellowish gray, as above, but coarser, with coarse, angular, violet and pink quartz and fragments of brown limestone	10	31
Chesapeake Group (Miocene):		
Sand, fine, light olive-gray; mostly fine and medium, clear, angular quartz grains; glauconite rare, fine, oblate, green; feldspar, fine, rare; gray dull flint	11	42
Sand, very clayey, greenish-gray; fine to medium, clear, angular quartz; fine mica; black phosphate fragments; a few ostracods and pelecypods	11	53
Sample questionable	10	63
Clay, silty, soft, pale-olive; some clear, subangular, fine and medium quartz, black and brown phosphatic fragments and a few grains, green, glauconite; a few small Foraminifera	10	73
Clay, silty, pale-olive, a few small foraminifera; fish teeth and sponge spicules	11	84
Clay, silty, pale-olive; fine, clear and gray angular quartz and a few small Foraminifera	11	95

(more)

36

P (cont'd)

Table 8.--Logs of wells in Westmoreland County, Virginia--Continued

Well 37a, Coles Point; W. P. Campbell--Continued

	Thickness (feet)	Depth (feet)
Chesapeake Group--Continued		
Clay, silty, pale-olive; small amount of coarse to fine, clear and white angular quartz; a few Foraminifera and fish teeth	10	105
Clay, silty, pale-olive; some quartz as above and a few small Foraminifera; phosphatic material common	10	115
Clay, silty, pale-olive; similar to above	21	136
Clay, silty, grayish-olive	11	147
Clay, silty, yellowish-gray to grayish-olive	11	158
Clay, silty, mostly yellowish-gray, similar to above; sponge spicules very abundant; small Foraminifera ~~frequent~~ common	10	168
Clay, sandy, grayish-olive to pale-olive; mostly clear, angular, fine quartz; some fine black phosphatic material; sponge spicules and shell fragments common	10	178
Clay, very sandy, grayish-olive; similar to above; some coarse subrounded clear quartz grains; light-green fine glauconite more common; several small black phosphatic pebbles	11	189
Chickahominy Formation(?) (Upper Eocene):		
Sand, slightly clayey, mottled greenish-gray; quartz, fine to medium, clear, angular, glauconite, common, light-green to green, fine, oblate to irregular; pyrite, microgranular, rare	10	199
Sand, medium, mottled greenish-gray; similar to above	11	210
Sand, light-gray, clean; mostly clear, subangular, medium to coarse quartz; fine black glauconite; shell fragments and Foraminifera common	10	220
Sand, clean, light-gray; similar to above, with a slight increase in amount of glauconite	11	231

37

Table 8.—Logs of wells in Westmoreland County, Virginia—Continued

Well 44, 2 miles south of Coles Point

(Log by G. Pfeiffer, driller; correlations by A. Sinnott and D. J. Cederstrom)

Altitude, 10± feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Clay, shells	12	12
Clay	10	22
Chesapeake Group (Miocene):		
Marl	38	60
Sand, dark	10	70
Sand, and gravel	12	82
Sand, mud, and marl	48	130
Clay, brown	60	190
Chickahominy Formation (Upper Eocene):		
Shells, cemented	1	191
Sand, dark	6	197
Shells, cemented	1	198
Sand, dark green	62	260
Sand, dark; slightly water-bearing	10	270
Nanjemoy and Aquia Formations (Eocene and Paleocene), undifferentiated:		
Clay, dark brown	48	318
Sand, light; slightly water-bearing	8	326
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Clay, mixed	74	400
Clay, dark yellow	13	413
Undescribed (penetrates one or more water-bearing sands; screens set from 622 to 722 feet)	314	727

Table 8.--Logs of wells in Westmoreland County, Virginia--Continued

Well 65, Kinsale; Sydnor Hydrodynamics, Inc.

(Log from driller's record furnished by owner: correlations by A. Sinnott)

Altitude, 70 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Sand, brown, and clay	20	20
Sand, dark blue	12	32
Chesapeake Group (Miocene):		
Clay, blue	186	218
Clay, olive drab	39	257
Clay, olive drab, with fine sand and shells	5	262
Chickahominy Formation (Upper Eocene):		
Clay, olive drab, with thin streak of rock at base	2	264
Clay, gray	5	269
Shells, indurated; water-bearing	11	280

Table 8.--Logs of wells in Westmoreland County, Virginia--Continued

Well 73, 1.8 miles south-southwest of Oak Grove; E. T. Hynson

(Drilled by Mitchell's Well & Pump Co.; Foraminifera determined by J. A. Cushman; lithology, study of washed residues, and correlations by D. J. Cederstrom; modified after Va. Geological Survey Circular 3)

Altitude, 180 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Sand, clayey, yellow-orange	45	45
Chesapeake Group (Miocene):		
Sand, medium-yellow	30	75
Clay, yellow	10	85
Clay, dark-gray, silty	105	190
Nanjemoy and Aquia Formations (Eocene and Paleocene), undifferentiated:		
Clay, dark-colored, silty, trace of glauconite	50	240
Clay	40	280
Clay, gray, with scant quartz and glauconite sand; Aquia(?) Foraminifera	60	340
Clay, pink, tough; residue contains quartz and glauconite sand; glauconite is green and brown; slightly pyritic; Aquia(?) Foraminifera	15	355
Sand, fine, gray-green glauconite, and quartz; glauconite brown, mottled and green; phosphate pebbles common; Aquia(?) Foraminifera	35	390

Table 8.--Logs of wells in Westmoreland County, Virginia--Continued

Well 73, 1.8 miles south-southwest of Oak Grove; E. T. Hynson--Continued

	Thickness (feet)	Depth (feet)
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Clay, dark-colored, glauconitic; glauconite is green; Aquia(?) Foraminifera (washed down?)	70	460
Sand, green, glauconite and quartz, scant clay; few indeterminate Foraminifera	15	475
Clay, pink, tough; residue contains phosphate pebbles, quartz sand, less green glauconite sand	15	490
Clay, pink, tough; residue contains quartz sand, less glauconite sand	15	505
Clay, red, tough, mottled; residue contains quartz sand, red iron oxide nodules, a little green glauconite sand	10	515
Clay, red, tough, mottled; residue contains iron oxide nodules and much mica	5	520
Clay, gray, tough, slightly sandy	10	530

Table 8.--Logs of wells in Westmoreland County, Virginia--Continued

Well 74, 2.3 miles south-southwest of Oak Grove; Wirtland Estate

(Drilled by Mitchell's Well & Pump Co.; Foraminifera determined by J. A. Cushman; lithology, study of washed residues, and correlations by D. J. Cederstrom; modified after Va. Geological Survey Circular 3)

Altitude, 170 feet

	Thickness (feet)	Depth (feet)
Columbia Group		
Clay, red	8	8
Chesapeake Group (Miocene):		
Clay, yellow	71	79
Clay, gray	91	170
Nanjemoy and Aquia Formations (Eocene and Paleocene), undifferentiated:		
Clay, gray	92	262
Clay, gray, with a trace of glauconite	93	355
Sand, quartzose, glauconitic	32	387
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Sand, quartzose, glauconitic	97	484
Clay, yellow, glauconitic; Foraminifera	84	568
Clay, yellow-brown, slightly sandy, trace of glauconite; Foraminifera indeterminate	92	660
Sand, white, quartz, water-bearing; Foraminifera indeterminate	48	708

Table 9.--Chemical analyses of ground waters from wells in Westmoreland County, Virginia--Continued
(Parts per million, except specific conductance and pH)

Well number	1a	2b	2c	E of 3	E of 3	E of 3
Location	Colonial Beach	Geo. Washington Birthplace Nat'l Monument	Geo. Washington Birthplace Nat'l Monument	Westmoreland State Park	Westmoreland State Park	Westmoreland State Park
Depth (feet)	585	(spring)	380	(spring)	(spring)	(spring)
Geologic age	Late Cretaceous and Paleocene	Pleistocene	Late Cretaceous and Paleocene	Pleistocene	Pleistocene	Pleistocene
Formation or Group	Mattapani Formation	Columbia Group	Mattapani Formation	Columbia Group	Columbia Group	Columbia Group
Date	Dec., 1943	Sept., 1944	Oct. 12, 1933	Aug. 27, 1935	June 7, 1948	May 20, 1953
Silica (SiO_2)	---	---	12	8.7	8.7	---
Iron (Fe)	---	---	.08	.02	.10	---
Calcium (Ca)	---	---	3.4	1.8	2.2	1.7
Magnesium (Mg)	---	---	2.3	1.5	1.9	1.1
Sodium (Na)	---	---	143	2.4	3.0 calc.	---
Potassium (K)	---	---	8.7	1.1		---
Carbonate (CO_3)	2	0	---	0	0	0
Bicarbonate (HCO_3)	241	110	400	5	6	6
Sulfate (SO_4)	14	15	8.0	2.6	1.6	---
Chloride (Cl)	1	4	2.5	3.9	3.8	4.3
Fluoride (F)	1.5	.2	1.3	---	.1	.0
Nitrate (NO_3)	.2	8.4	.1	5.0	9.6	6.2
Dissolved solids	---	---	381	32	44	---
Hardness as $CaCO_3$	6	105	18	11	13	9
Specific conductance (micromhos at 25°C)	---	---	---	---	74.5	42.6
pH	8.2	6.4	---	---	5.5	5.8

Table 9.--Chemical analyses of ground waters from wells in Westmoreland County, Virginia--Continued
(Parts per million, except specific conductance and pH)

Well number	6	6	6	16	16	16
Location	Montross	Montross	Montross	W of Mount Holly	W of Mount Holly	W of Mount Holly
Depth (feet)	648	648	648	130	130	130
Geologic age	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	~~Miocene~~ Late Eocene	~~Miocene~~ Late Eocene	~~Miocene~~ Late Eocene
Formation or Group	Mattaponi Formation	Mattaponi Formation	Mattaponi Formation	Chickahominy Fm ~~Chesapeake Group~~	Chickahominy Fm ~~Chesapeake Group~~	Chickahominy Fm ~~Chesapeake Group~~
Date	Jan. 1, 1944	June 9, 1948	May 20, 1953	Aug. 16, 1946	June 7, 1948	May 20, 1953
Silica (SiO_2)	18	17	19	---	---	---
Iron (Fe)	.06	.09	.04	.04	---	---
Calcium (Ca)	.8	.8	1.6	---	---	10
Magnesium (Mg)	.8	.5	.4	---	---	3.7
Sodium (Na)	} 130 (calc.)	130 (calc.)	{ 130	---	---	---
Potassium (K)			3.9	---	---	---
Carbonate (CO_3)	~~2.0~~	0	14	~~5.9~~ 6	---	0
Bicarbonate (HCO_3)	320	326	299	153	157	161
Sulfate (SO_4)	10	8.3	7.5	11	10	---
Chloride (Cl)	2.8	3.5	2.6	1	1	1.3
Fluoride (F)	2.6	2.2	2.4	---	.4	.5
Nitrate (NO_3)	.4	.3	2.3	.5	.5	.9
Dissolved solids	326	330	328	---	---	---
Hardness as $CaCO_3$	5.5	4	6	45	45	40
Specific conductance (micromhos at 25°C)	---	534	529	---	290	276
pH	8.1	8.0	8.5	---	---	8.2

Table 9.--Chemical analyses of ground waters from wells in Westmoreland County, Virginia
(Parts per million, except specific conductance and pH)

Well number	33	42	45	62	62	65
Location	W of Coles Point	SSW of Coles Point	S of Coles Point	Sandy Point	Sandy Point	Kinsale
Depth (feet)	362	220	240	594	594	280
Geologic age	Late Cretaceous and Paleocene	[redacted] Late Eocene	[redacted] Late Eocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Late Eocene
Formation or Group	Mattaponi Formation	Chickahominy Fm [redacted]	Chickahominy Fm [redacted]	Mattaponi Formation	Mattaponi Formation	Chickahominy Formation
Date	June 7, 1948	Aug. 15, 1946	June 8, 1948	May, 1946	June 8, 1948	May, 1946
Silica (SiO_2)	---	---	---	12	---	45
Iron (Fe)	---	0.29	---	.09	---	.05
Calcium (Ca)	---	---	---	2.0	---	14
Magnesium (Mg)	---	---	---	1.7	---	5.8
Sodium (Na)	---	---	---	} 158	---	49
Potassium	---	---	---			
Carbonate (CO_3)	---	18	---	23	11	0
Bicarbonate (HCO_3)	327	294	309	347	364	182
Sulfate (SO_4)	7	7	1	17	19	11
Chloride (Cl)	4	1	4	10	3	1.8
Fluoride (F)	1.1	---	.7	.6	.7	.5
Nitrate (NO_3)	.4	.1	.6	.1	.5	.1
Dissolved solids	---	---	---	396	---	212
Hardness as $CaCO_3$	24	33	36	12	15	59
Specific conductance (micromhos at 25°C)	522	---	484	---	621	---
pH	---	---	---	8.5	---	7.8

Table 9.--Chemical analyses of ground waters from wells in Westmoreland County, Virginia--Continued
(Parts per million, except specific conductance and pH)

Well number	65	66	67	68	71	72	73
Location	Kinsale	SSE of Hague	ENE of Hague	S of Machodoc	Leedstown	Leedstown	SSW of Oak Grove
Depth (feet)	280	456	273	366	160	500	520
Geologic age	Late Eocene	Late Cretaceous + Paleocene	Late Eocene	Eocene	Eocene	Late Cretaceous + Paleocene	Late Cretaceous + Paleocene
Formation or Group	Chickahominy Formation	Mattaponi Formation	Chickahominy Formation	Nanjemoy Formation	Nanjemoy Formation	Mattaponi Formation	Mattaponi Formation
Date	May 20, 1953	June 7, 1948	Sept. 14, 1951	Aug. 15, 1946	Oct. 14, 1944	Oct. 14, 1944	Oct. 12, 1944
Silica (SiO_2)	---	---	---	---	11	11	---
Iron (Fe)	---	---	---	.12	.33	.03	---
Calcium (Ca)	13	---	---	---	5.4	2.2	---
Magnesium (Mg)	5.9	---	---	---	4.0	1.8	---
Sodium (Na)	---	---	---	---	154	171	---
Potassium (K)	---	---	---	---	12	9.0	---
Carbonate (CO_3)	0	---	---	13	15	25	6 ~~5.9~~
Bicarbonate (HCO_3)	191	223	256	403	417	422	268
Sulfate (SO_4)	---	1	19	4	11	11	7
Chloride (Cl)	1.0	1	28	1	3.5	2.0	1
Fluoride (F)	.5	.7	.8	---	1.7	1.7	1.6
Nitrate (NO_3)	1.0	.5	.1	.6	.0	.0	.2
Dissolved solids	---	---	---	---	421	444	---
Hardness as $CaCO_3$	57	51	50	24	30	13	6
Specific conductance (micromhos at 25°C)	315	359	494	---	---	---	---
pH	8.2	---	7.9	---	8.1	8.4	8.0

R 136-165

Heading Rank

RICHMOND COUNTY (I)

LOCATION AND DEVELOPMENT[1/] (II)

Richmond County lies in the upper part of the Northern Neck peninsula on the north side of the Rappahannock River. It is bordered on the north by Westmoreland and Northumberland counties, and on the southeast by Lancaster county. Essex county lies across the Rappahannock to the southwest. The total land area is 192 square miles; the total relief is about 174 feet with the highest point of land at the extreme northwestern part of the county. The population of Richmond County in 1960 was 6,375.

Agriculture is the chief occupation. The most important crops are corn, soybean, small grains, and tomatoes. Livestock is becoming important. Timber and sea food is also important in the county. There is a large garment factory in Warsaw, and other industries including packaging sea food and canning tomatoes.

The county seat is Warsaw in the central part of the county. Among the other towns, Lyells, Emmerton, and Farnham are on Route 30 and Luttrellville is on U. S. Route 360.

[1/] For further information on the economic development of Richmond County, see Va. Div. of Planning, (1967), Economic Data Summary, Richmond County.

TOPOGRAPHY AND DRAINAGE

The highest part of Richmond County is a little more than 170 feet above sea level in the extreme northwestern part of the county.

The Pamlico terrace, of late Pleistocene age, is prominently developed along the north bank of the Rappahannock, from the vicinity of Cat Point Creek southeastward. Its average altitude here is about 25 feet above sea level. The remainder of the county is a higher terrace with a maximum altitude of about 170 feet above sea level, and is referred to the Sunderland terrace of earlier Pleistocene age. This higher terrace is submaturely dissected in a dendritic drainage pattern.

Along the mouths of larger creeks there are broad marshy lowlands which are largely flooded by each tide.

The entire southern boundary of Richmond County is the north bank of the Rappahannock River, one of the streams that originates in the Piedmont province. The entire area of Richmond County is within the Rappahannock drainage basin; the southeastern third of the inland boundary, separating Richmond and Northumberland Counties, is taken along the drainage divide between the Rappahannock and Potomac rivers.

Several smaller streams drain roughly southward into the Rappahannock as tributaries. Among those are Cat Point Creek, in the northwestern part of the county, Totuskey Creek in the middle of the county, Farnham and Lancaster Creeks at the southeastern border forming the boundary between Richmond and Lancaster Counties.

Geology and Ground-Water Conditions II

The surface of Richmond County is almost entirely capped by Pleistocene deposits of the Columbia Group. The marsh lands, bottoms of creeks and beaches along the Rappahannock River compose the Holocene (Recent) deposits.

Underlying these surficial deposits are the Chesapeake Group. Exposures of Miocene rocks are poor, and most data on their local characteristics and those of the underlying older Tertiary and Cretaceous deposits, are known only from drill cuttings.

Basement Complex III

The basement bedrock, possibly consisting chiefly of granite and metamorphic rocks, has not been reached by wells in Richmond County, so far as known. The top of the basement may range from about 2,500 to about 2,700 feet below sea level (DeBuchananne, 1968, Sheet 1). Depth to bedrock at West Point and Mathews suggests that it may be somewhat less.

Cretaceous System--Potomac Group

The Potomac Group of Cretaceous Age consists of sands and clays of continental and deltaic origin resting on the basement bedrock.

According to the available records no wells as yet have been drilled to tap the water-bearing sands in the Potomac Group. However, it is likely that the productive water-bearing sands and gravels in this group found elsewhere in the Coastal Plain, occur also beneath the Northern Neck. These deposits, therefore, should be the target for deep test drilling should the need arise for additional large sources of ground water.

The quality of ground water to be expected from wells that may reach the Potomac deposits is likely to be excellent--a soft sodium bicarbonate type. However, fluoride may be a problem, based on its typical higher concentration from water derived from the deeper Coastal Plain sediments.

Cretaceous to Tertiary Systems--Mattaponi Formation III

The Mattaponi Formation of Late Cretaceous and Paleocene Ages consists of glauconitic clay of various colors, sandy clay and glauconitic sand. The characteristic mottled clays are apparently absent, according to drillers' records.

Water-Bearing Character IV

As elsewhere in the Northern Neck the Mattaponi Formation provides many wells with ample supplies of ground water.

Two wells (43, 44) at Jones Landing, on the Rappahannock south of Newland in the western part of the county, are each 350 feet deep, and each flowed at least ~~one~~ 1 gpm as of 1946. Well 43 formerly supplied water to a small cannery.

Among the larger-yield wells in Richmond County is an 8-inch municipal well (38a) drilled in Warsaw in 1949 to a depth of 653 feet; the principal water-bearing bed is sand in the Mattaponi from 622 to 638 feet. The well yields 211 gpm with a drawdown of 90 feet. Another municipal well (38b), 6 inches in diameter, was drilled in 1962 to 682 feet, and was tested at 503 gpm for 24 hours; the drawdown at this rate was 156 feet.

The water level in a 385-foot well (41) at Naylors Point is reported to have been 32 feet above the surface--[redacted] about 38 feet above sea level--in 1918. In 1948, however, the flow was less than a gallon a minute, probably due in part to gradual clogging of the well and in part to the general decline in artesian pressure in this area, as elsewhere in the Virginia Coastal Plain.

At Emmerton, near the eastern part of the county, a $4\frac{1}{2}$-inch well (4) drilled to a depth of 553 feet below the surface, provided ample water for a cannery, although the actual yield is not available.

A 622-foot well (6) near Downings taps sand and shells of the Mattaponi Formation from 400 to 408 feet below the surface. However, below the gray mud and yellow clay, from 408 to 488 feet, there are 134 feet of undescribed material--probably all of it in the Mattaponi; this part of the well presumably yields most of the water. In a short production test, this well, which is 4 inches in diameter, yielded 25 gpm with a 13-foot drawdown.

Wells 8 and 9, $2\frac{1}{2}$ miles southwest of Downings, were put down to depths of 609 and 615 feet, respectively, tapping the Mattaponi; both are flowing wells, and reported to yield more than 10 gpm in 1946.

At Simonson, in the southeast corner of the county, a 516-foot well (11), tapping the upper part of the Cretaceous beds, was reported flowing in 1946.

A well at a former tomato factory at Naylors Wharf (41), on the Rappahannock, in the western part of the county, was sampled in 1918, 1941, and 1953. (See Table 12.) The water is moderately mineralized, ~~very~~ soft, ~~and of the~~ and high in sodium and bicarbonate ~~type~~. Chloride ranges from 2 to 3.8 ppm, and fluoride a little more than 2 ppm. The dissolved solids in 1918 was 506 ppm, and the electrical conductivity as of 1953 shows that the dissolved solids concentration had not changed materially, nor had individual constituents, during the 35-year period.

Another well water, (43, Table 12) about 5 miles upstream from Naylors, also is moderately mineralized, and is a very soft sodium bicarbonate type ~~water~~; the fluoride content is about 2 ppm. The well supplies water at a public landing on the river.

A 622-foot well (6, Table 12) at Downings, in the southeastern part of the county, has a dissolved-solids content of 309 ppm, and chloride, 2.8 ppm. The fluoride concentration in water from this well is 1.8 ppm--a little higher than the recommended maximum of 1.5 ppm for domestic use. Like the other analyses from Mattaponi waters, it is a soft sodium bicarbonate type.

Tertiary System III

Aquia and Nanjemoy Formations

The Aquia and Nanjemoy Formations have not been differentiated in Richmond County. The formations consist of glauconitic sand and glauconitic sandy clay or marl.

In Richmond County, the Aquia and Nanjemoy together occur from about 100 to 230 feet below sea level in the western part, and from about 220 to 330 feet below sea level in the eastern part.

Two wells at Sharps (20, 21) reached 325 feet below the surface and may obtain water from the Nanjemoy Formation. These wells were reported to flow at about 20 feet above the surface (about 30 feet above sea level).

Chickahominy Formation IV

The Chickahominy Formation of late Eocene age is well developed in the eastern part of Richmond County, where it is more than 50 feet thick, but becomes thinner westward and probably disappears in a featheredge in the western part of the county. (See section B-B', Plate 1.)

The Chickahominy consists typically of glauconitic sandy clay and glauconitic sand. Shells and sand are reported in a well (6) at Downings, from 400 to 408 feet. Thin indurated layers are present below 310 feet in well 7 near Simonson, along with shells and black sand.

In the western part of the county, at Cat Point Creek, glauconitic sands in the Chickahominy Formation provide the principal sources of ground water. (See well 40, Table 11.)

A municipal well at Warsaw (39) obtained water from the Chickahominy but use of the well was discontinued in about 1949, probably because its yield was insufficient compared to another deeper municipal well (38a) drilled about that time which taps the Mattaponi.

In the central part of the county, two wells (2, 3) three miles southeast of Warsaw at Totuskey Bridge, reaching about 180 feet below the surface, were flowing wells when put down shortly after the turn of the century; the latter was flowing at 15 gpm in 1906, and 5 gpm in 1948.

Layers of water-bearing black sand occur at Simonson Point in southeastern part of Richmond County. Wells 7, 10-14 and 16-18 end in sands at the top of the Chickahominy Formation.

Well 7 flowed at a rate of about 10 gpm in 1948. The flow is utilized in operating a hydraulic ram.

Among the wells in the Sharps area, six (19, 22-26) tap the Chickahominy Formation. One of these (22) was reported to flow at a rate of 52 gpm in 1894. Well 23, jetted to 212 feet, flowed with an artesian pressure 16 feet above the surface in 1890, and well 24, jetted to 230 feet, had an artesian pressure of 9 feet above the surface in earlier years.

With regard to water quality, the Warsaw well (37) was sampled in 1948. The water is only moderately mineralized, and is a fairly soft sodium bicarbonate type. Well 3 southeast of Warsaw at Totuskey Bridge, yields a similar moderately soft water, of very low chloride content (1 to 2 ppm).

At Garlands Mill Pond, east of Warsaw in the central part of the county, a sample taken in 1918 (1, Table 12) showed a chloride concentration of 18 ppm and a hardness of 116 ppm. Both of these constituents are somewhat higher than might be expected and suggests that leakage from Miocene beds is taking place. Well 30 at Tidewater in the southeastern part of the county is 285 feet deep and furnishes soft sodium bicarbonate water from the Chickahominy, but iron is high--0.75 ppm--and the water is reported to be turbid. Hardness is also somewhat high, 76 ppm.

Chesapeake Group

The Chesapeake Group of Miocene age unconformably overlies the Eocene deposits and has a more gentle dip. Exposures of the Miocene deposits are poor, and most information on their lithology is based on drill cuttings. The formations composing the group have not been differentiated in this report. They consist chiefly of clays, including diatomaceous clays, and sandy clays with thin beds of sand and shells. They reach a thickness of over 200 feet at Warsaw (38a, Table 11) and occur from about 25 to 125 feet below sea level

in the west and from about 100 to 275 feet below sea level in the eastern part of the county.

Water-Bearing Character V

Sandy beds in the Chesapeake Group furnish small supplies to a few domestic or farm wells in Richmond County. Tarpleys Point, well 15 was jetted to a depth of 167 feet and seemingly ends in basal Miocene beds. It had a flow of over 5 gpm.

Quaternary System--Columbia Group

The Columbia Group of Pleistocene age in Richmond County consists chiefly of yellow sands and clays, and may reach a maximum thickness of more than 50 feet in the upland parts of the county. At Simonson Point, pebbles with peat are reported in the driller's record (7, Table 11).

Many small-yield wells for domestic use are dug into the surface mantle of the Columbia Group. More recently, some of the shallow wells in these deposits have been driven or jetted, providing greater sanitary protection. Most are less than about 50 feet in depth, and generally are adequate to supply the relatively small demands made on them.

Chemical analyses have been made of water from the shallow wells tapping the Columbia Group at Farnham (5, Table 12), near Sharps (28), and near Naylors (42). The first two have very soft water, 7 and 20 ppm of hardness, respectively; the well near Naylors, however, yields very hard water with 210 ppm. Chloride is high (100 ppm) in water from the Farnham well and even higher (168 ppm) in that from the Naylors well. The Farnham well yields a low nitrate water, but Naylors well water contains extremely high nitrate--123 ppm--which would be very hazardous for infant feeding formulas.

A large untapped reserve of ground water of good quality is believed to be present in the sands of the Potomac Group particularly in the eastern part of the county where the Potomac Group is thicker.

Overlying this group is the Mattaponi Formation. Yields range up to 500 gpm or more from properly constructed wells 6 or more inches in diameter. Fluoride may be a minor problem locally.

The Nanjemoy and Aquia Formations are of minor importance in Richmond County, although small supplies of water of satisfactory quality may be developed locally.

The Chickahominy Formation provides small but adequate supplies of fair to medium quality to many wells in central and eastern Richmond County. Larger supplies may be obtained from the Chickahominy in the eastern part of the county.

The Chesapeake Group of formations appear to contain few aquifers. A great many rural homes are supplied with water from the Columbia group. Although generally soft and excellent for domestic use, shallow well water may be easily polluted, as suggested by the high nitrate content in some samples.

Well Records and Chemical Analyses II

Records of wells, available logs, and chemical analyses of water samples in Richmond County are given in Tables 10, 11, and 12 on the pages that follow. Locations of wells listed in Tables 10 through 12 are given in Figure 7 preceding the tables.

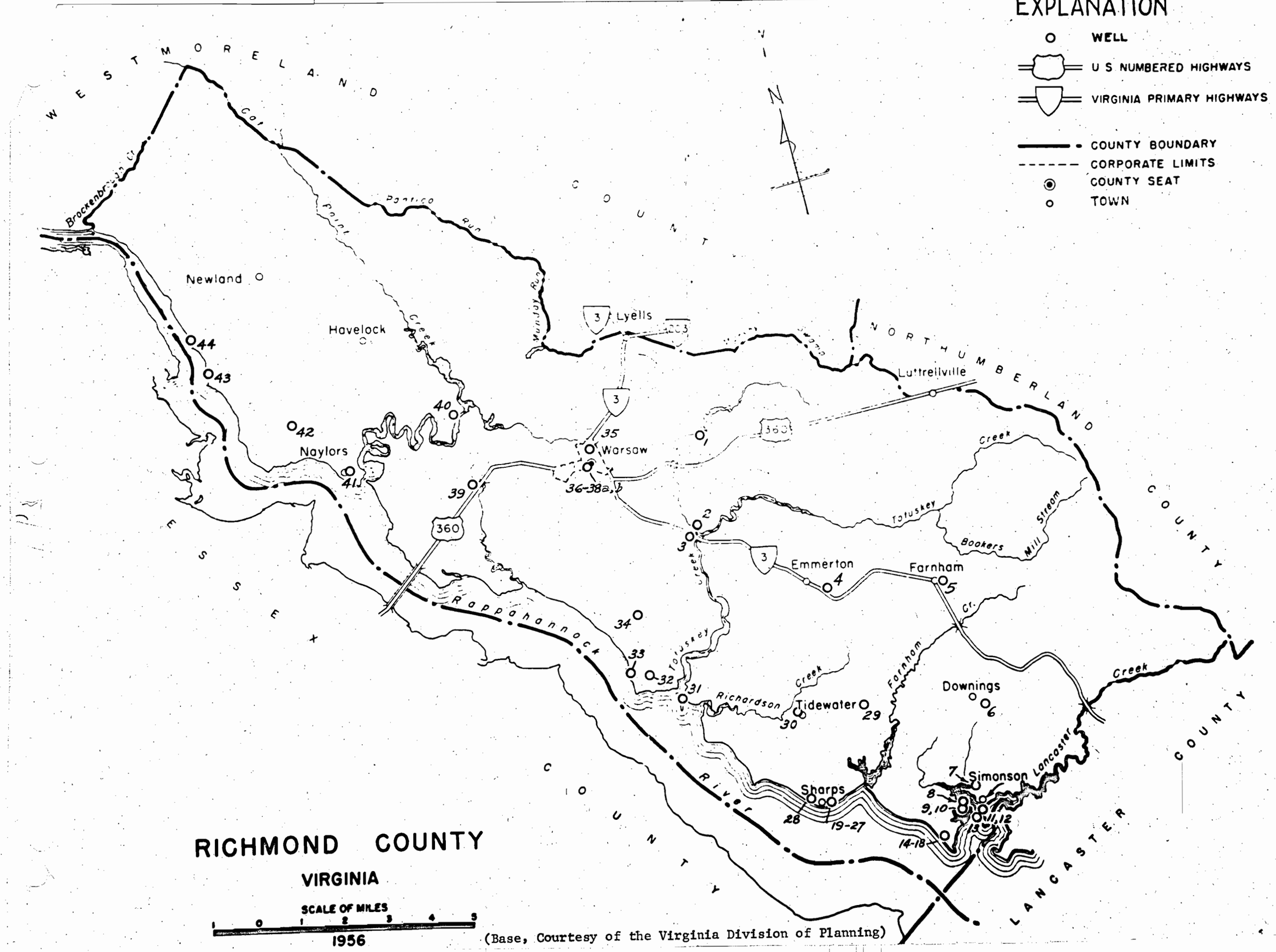

EXPLANATION
WELL
U S NUMBERED HIGHWAYS
VIRGINIA PRIMARY HIGHWAYS
COUNTY BOUNDARY
CORPORATE LIMITS
COUNTY SEAT
TOWN
N
WESTMORELAND COUNTY
ESSEX COUNTY
NORTHUMBERLAND COUNTY
LANCASTER COUNTY
Brockenbrough Cr.
Cat Point Creek
Pantico Run
Mundy Run
Newland
Havelock
Naylors
Lyells
Warsaw
Emmerton
Farnham
Luttrellville
Tidewater
Sharps
Downings
Simonson
Rappahannock River
Totuskey Creek
Richardson Creek
Farnham Cr.
Bookers Mill Stream
Lancaster Creek
3
360
203
RICHMOND COUNTY
VIRGINIA
SCALE OF MILES
1 0 1 2 3 4 5
1956
(Base, Courtesy of the Virginia Division of Planning)

Table 10.—Records of wells in Richmond County, Virginia

Type of well: J, jetted; D, drilled; Dv, driven
Use of water: D, domestic; I, industrial; S, stock; PS, public supply

gpm, gallons per minute
Temp., temperature (degrees Fahrenheit)
Fm, formation

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
1	2.7 mi. E of Warsaw	E. W. Garland			11	J	188	2	Late Eocene	Chickahominy Fm			D	See log, Table 11; analysis, Table 12. In 1899, flow reported 20 gpm, and water level 36 ft above surface.	1
2	3 mi. SE of Warsaw, at Totuskey Bridge	M. D. Kalbach			8	J	181	1½	do	do			D	In 1906, flow reported 2 gpm, and water level 20 ft above surface.	2
3	Do.	G. M. Snyder			3	J	180	1½	do	do			D	See analyses, Table 12. Temp. 61°F. In 1906 flow reported 15 gpm, and water level 20 ft above surface. Flowed 4 gpm in 1948.	3
4	0.5 mi. SE of Emmerton	Hammock Cannery	Mitchell's Well and Pump Co.	1945	102	D	553	4½	Late Cretaceous and Paleocene	Mattaponi Fm	-70		I	See log, Table 11; analysis, Table 12.	4
5	Farnham	L. M. Simonson		Prior to 1918	114	Dug	44		Pleistocene	Columbia Group	(-)		D	See analysis, Table 12.	5
6	Downings	J. W. Welch	Mitchell's Well and Pump Co.	1942	75	J	622	6-4	Late Cretaceous and Paleocene	Mattaponi(?)Fm	-70	15	I	See log, Table 11; analyses, Table 12. Drawdown 13 ft after 6¼ hrs pumping at 14 gpm. Canning factory.	6
7	0.5 mi. N of Simonson	F. C. Packet			5	J	310+	1½	Late Eocene	Chickahominy Fm	(+)			Flows 10 gpm. Hydrogen sulfide odor reported.	7
8	0.5 mi. W of Simonson	John Oakley	J. W. Wilson	1925	10	J	609	1½	Late Cretaceous and Paleocene	Mattaponi Fm	(+)		S	Flows 18 gpm.	8
9	Do.	do	do	1940	10	J	615	1½	do	do	(+)		D,S	Flows 11 gpm.	9
10	Do.	do	I. Rude	1900	10	J	275	1½	Late Eocene	Chickahominy Fm	(+)		D,S	Flows 11 gpm.	10
11	Simonson	H. G. Oakley			5	J	516	1½	Late Cretaceous and Paleocene	Mattaponi Fm	(+)		D,S		11
12	Do.	W. M. Simonson	E. Lewis		3	J	245	1½	Late Miocene Eocene	Chesapeake(?)Group Chickahominy Fm	(+)		D,S	Hydrogen sulfide odor reported. Iron-free.	12
13	0.5 mi. SW of Simonson	J. W. Welch	Hale		1	J	180	1½	Miocene do	Chesapeake-Group do	(+)			Flowed 5 gpm. Now abandoned.	13
14	1.3 mi. SW of Simonson	W. P. Handley			7	J	240	1½	do	do			D	Hydrogen sulfide odor reported.	14

Table 10.—Records of wells in Richmond County, Virginia

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
31	2.8 mi. WNW of Tidewater	L. Dean			1	J	180	1½	Late Eocene ~~Miocene~~	Chickahominy Fm ~~Chesapeake Group~~	(+)		D,S	Supplies two houses.	31
32	5.2 mi. S of Warsaw	G. Delano			1	J	180	1½	do	do	(+)		S	Flows 5 gpm.	32
33	5 mi. S of Warsaw	A. W. Delano			1	J	180	1½	do	do			D	See analysis, Table 12. Two similar wells in vicinity.	33
34	3.7 mi. S of Warsaw	R. O. Delano			30	J	82	1½	Pleistocene	Columbia Group	-16		D,S		34
35	Warsaw	Warsaw Cleaners			145	Dug	36		do	do	- 7			Pumps about 15 gpm. Water level declines during dry years.	35
36	Do.	Rice			143	Dug	40		do	do	(-)			See analysis, Table 12.	36
37	Do.	Town of Warsaw	Mitchell's Well and Pump Co.	1936	143	J	385	4	Late Eocene	Chickahominy Fm.	(-)		D,PS	See analysis, Table 12. Temp., 64° F. Not used since about ~~1940;~~ 1949; probably insufficient yield.	37
38a	Do.	Town of Warsaw	do	1949	143	D	653	8	Late Cretaceous and Paleocene	Mattaponi Fm	(-)	211	PS	See log, Table 11; ~~analysis, Table 12.~~ Drawdown ~~90~~ 99 ft after 7 hrs pumping at 211 gpm.	38a
38b	Do	Town of Warsaw	Sydnor Hydrodynamics, Inc.	1962	143 ±	D	682	8-6	do	do.	(-)		PS	Drawdown 156 ft after 24 hrs pumping at 503 gpm.	38b
39	2.8 mi. W of Warsaw	A. Stephens	Reynolds & Norman	1945	20	J	177	3	Late Miocene Eocene	Chickahominy Fm ~~Chesapeake Group~~	-17	3		See ~~log, Table 11.~~ Cased to 147 ft. Drawdown about 3 ft after pumping 3 hrs at 3 gpm.	39
40	3.5 mi. NW of Warsaw	Vernon Frazier	do	1945	10	J	148	2	do	do	(+)		D	See log, Table 11. Flows 2 gpm.	40
41	Naylors	L. Jenkins; formerly Wadington & Holme		Prior to 1918	6		385	1½	Late Cretaceous and Paleocene	Mattaponi Fm	(+)			See analyses, Table 12. Temp. 64½° F. In 1918 water level reported 32 ft above surface. Flowed ¼ gpm. In 1953. Abandoned tomato factory; well no longer used.	41
42	1.6 mi. NW of Naylors	G. Bowen		1943	20	Dv	22	1½	Pleistocene	Columbia Group	(-)			See analysis, Table 12. Reported iron taste; stains utensils.	42
43	2.5 mi. SW of Newland	G. W. Oliff	H. Lyons		1	J	350	2	Late Cretaceous and Paleocene	Mattaponi Fm	(+)			See analyses, Table 12. Temp., 62° F. Flows about 1 gpm. Abandoned cannery; now public landing.	43
44	2.2 mi. SW of Newland	W. A. Tory	do		3	J	350	1½	do	do	(+)		D,S	Flows 1 gpm.	44

Table 10.—Records of wells in Richmond County, Virginia

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
15	1.3 mi. SW of Simonson	R. T. Coutts		1938	1	J	167	1½	Late Miocene Eocene	Chickahominy Fm Chesapeake Group	(+)			Flows 8 gpm; supplies 4 cottages. Hydrogen sulfide odor reported.	15
16	About a mile SW of Simonson	Dr. Wingfield	Reynolds & Norman	1947	5	J	240	2	do	do	(−)		D	See log, Table 11. Cased to 216 ft.	16
17	Do.	U. L. Johnson	do	1947	5	J	235		do	do	(−)		D	See log, Table 11. Cased to 214 ft. Flows a little during high tide.	17
18	Do.	J. R. Self	do	1947	5	J	240		do	do	(−)		D	See log, Table 11. Cased to 209 ft. Does not flow.	18
19	Sharps	P. Y. Barber			15	J	240	1½	do	do	(+)			In 1899, water level reported 12 ft above surface.	19
20	Do.	A. T. Davis			10		325		Eocene	Nanjemoy Fm	(+)			Water level reported 20 ft above surface in earlier years.	20
21	Do.	F. Downing			10		325		do	do	(+)			Water level reported 20 ft above surface in earlier years.	21
22	Do.	J. M. McCarty			10	J	240	2	Late Eocene	Chickahominy Fm	(+)	52		In 1894, flow reported 52 gpm, and water level 26 ft above surface.	22
23	Do.	D. W. Sharp			4	J	212	1½	do	do	(+)			In 1890, water level reported 16 ft above surface.	23
24	Do.	E. Sharp			3	J	230	1½	do	do	(+)			Cased to 188 ft. Water level reported 9 ft above surface in earlier years.	24
25	Do.	G. L. Smith & Bro.			3	J	245	2	do	do	(+)			In 1903, flow reported 4 gpm.	25
26	Do.	J. B. Smith			15	J	255	1½	do	do	(+)			In 1888, water level reported 14 ft above surface.	26
27	Do.	Hotel		1907 ?	10	J	440	1½	Late Cretaceous and Paleocene	Mattaponi Fm					27
28	0.3 mi. WNW of Sharps	F. Norfolk			1	J	29	2	Pleistocene	Columbia Group	(+)		I	See analysis, Table 12. Flows 5 gpm.	28
29	1.5 mi. E of Tidewater	W. S. Hale			32	J	400+	1½	Late Cretaceous and Paleocene	Mattaponi Fm	(−)		D,S		29
30	Tidewater	J. L. Saunders	H. Lyons		25	J	285	1½	Late Eocene	Chickahominy Fm	-16		D,S	See analysis, Table 12. Water turbid; causes iron stain.	30

Table 11.--Logs of wells in Richmond County, Virginia

Well 1, 2.7 miles east of Warsaw; E. W. Garland

(Log from Bulletin 5, Virginia Geological Survey; correlations by D. J. Cederstrom)

Altitude, 11 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Sand	8	8
Columbia and Chesapeake Groups (Pleistocene and Miocene), undifferentiated:		
Marl, blue	157	165
Chickahominy (?) Formation (Upper Eocene):		
Rock (sandstone ?)	2	167
Marl, blue	17	184
Rock (sandstone ?)	3	187
Sand, quartz; glauconitic; water-bearing	1	188

Table 11.--Logs of wells in Richmond County, Virginia--Continued

Well 4, Emmerton; Hammock Cannery

(Log from driller's record furnished by Mitchell's Well & Pump Co.; correlations by A. Sinnott and D. J. Cederstrom)

Altitude, 100 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Undescribed (no sample)	36	36
Sand and mud	44	80
Chesapeake Group (Miocene):		
Mud, blue	100	180
Mud, yellow	10	190
Clay, light colored	65	255
Chickahominy(?) Formation (Upper Eocene):		
Mud, green	45	300
Nanjemoy and Aquia Formations (Eocene and Paleocene), undifferentiated:		
Mud, black, and sand	20	320
Mud, green	10	330
Sand, black	40	370
Mud and sand, hard	23	393
Mattaponi(?) Formation (Upper Cretaceous and Paleocene):		
Sand, black, and mud	17	410
Mud, gray	10	420
Mud and black sand	10	430

Table 11.--Logs of wells in Richmond County, Virginia--Continued

Well 4, Emmerton; Hammock Cannery--Continued

	Thickness (feet)	Depth (feet)
Mattaponi(?) Formation--Continued		
Sand, black, soft, and mud	6	436
Sand, black, and mud	4	440
Clay, hard, and black sand	10	450
Mud and sand, dark	10	460
Mud, pink	8	468
Mud, light-colored, and sand	22	490
Sand, black and white, mixed	10	500
Undescribed (no sample)	10	510
Sand, black	5	515
Mud and black sand	20	535
Mud and sand	15	550
Sand, white and black, mixed	3	553

Table 11.--Logs of wells in Richmond County, Virginia--Continued

Well 6, Downings; J. W. Welch

(Log from driller's record furnished by Mitchell's Well & Pump Co.; residue descriptions by D. J. Cederstrom; correlations by A. Sinnott)

Altitude, ~~35~~ 95 feet

	Thickness (feet)	Depth (feet)
Columbia and Chesapeake Groups (Pleistocene and Miocene):		
Undescribed (no samples)	195	195
Chesapeake Group (Miocene):		
Mud, blue	105	300
Chickahominy, Nanjemoy, and Aquia Formations, undifferentiated (Upper Eocene, Eocene, and Paleocene):		
Sand, brown	50	350
Mud, sandy, blue	50	400
Sand, glauconitic, and shells	8	408
Mattaponi(?) Formation (Upper Cretaceous and Paleocene):		
Mud, clay; glauconitic	52	460
Clay, yellow, glauconitic	28	488
Undescribed (no samples)	134	622

Table 11.--Logs of wells in Richmond County, Virginia--Continued

Well 16, about a mile southwest of Simonson; Dr. Wingfield

(Log from driller's record furnished by Reynolds & Norman; correlations by D. J. Cederstrom)

Altitude, 5± feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Subsoil	16	16
Chesapeake Group (Miocene):		
Clay, blue	174	190
Shells and sand	2	192
Chickahominy Formation (Upper Eocene):		
Sand, black	3	195
Clay, tough	21	216
Clay, tough; water-bearing sand	24	240

Table 11.--Logs of wells in Richmond County, Virginia--Continued

Well 17, about a mile southwest of Simonson; U. L. Johnson

(Log from driller's record furnished by Reynolds & Norman; correlations by D. J. Cederstrom)

Altitude, 5± feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Subsoil	22	22
Chesapeake Group (Miocene):		
Clay, blue	168	190
Sand and shells	3	193
Chickahominy Formation (Upper Eocene):		
Clay, tough; water-bearing sand below 214 feet	55	248

Table 11.--Logs of wells in Richmond County, Virginia--Continued

Well 18, about a mile southwest of Simonson; J. R. Self

(Log from driller's record furnished by Reynolds & Norman; correlations by D. J. Cederstrom)

Altitude, about 5 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Subsoil	18	18
Chesapeake Group (Miocene):		
Clay, blue	174	192
Chickahominy Formation (Upper Eocene):		
Sand and shells	2	194
Sand, black	6	200
Clay, tough; water-bearing sand below 209 feet	40	240

Table 11.--Logs of wells in Richmond County, Virginia

Well 38a, Warsaw; Town of Warsaw

(Log from driller's record furnished by Mitchell's Well and Pump Company; correlations by A. Sinnott)

Altitude, 143 feet

	Thickness (feet)	Depth (feet)
Columbia Group		
Top soil	5	5
Clay, sandy red	22	27
Sand, with a little clay	31	58
Chesapeake Group:		
Clay, blue	72	130
Clay, blue; shells	45	175
Mud, blue	91	266
Mud, blue; shells	5	271
Shells	14	285
Chickahominy(?) Formation (Upper Eocene):		
Rock	2	287
Mud and sand	3	290
Nanjemoy and Aquia Formations, undifferentiated (Eocene and Paleocene):		
Sand, black	60	350
Mud, blue; sand	42	392
Mattaponi Formation(?) (Upper Cretaceous and Paleocene):		
Clay, blue; sand	138	530
Clay, blue	30	560

Table 11.--Logs of wells in Richmond County, Virginia--continued

Well 38[a], Warsaw; Town of Warsaw--continued

	Thickness (feet)	Depth (feet)
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Sand and mud	62	622
Sand, water-bearing	16	638
Mud, gray	15	653

Table 11.--Logs of wells in Richmond County, Virginia--Continued

Well 40, Cat Point Creek; Frazier

(Log from driller's record furnished by Reynolds & Norman; correlations by A. Sinnott and D. J. Cederstrom)

Altitude, about 15 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Soil and fine material	18	18
Chesapeake Group (Miocene):		
"Fuller's earth," blue	94	112
Sand, white	1	113
"Fuller's earth," blue	17	130
Chickahominy(?) Formation (Upper Eocene):		
Sand, black; Foraminifera	1	131
Clay, medium hard	14	145
Sand, black and white	3	148

Table 12.--Chemical analyses of ground waters from wells in Richmond County, Virginia
(Parts per million, except specific conductance and pH)

Well number	1	3	3	5	6	6
Location	E of Warsaw	SE of Warsaw	SE of Warsaw	Farnham	Downings	Downings
Depth (feet)	188	180	180	44	622	622
Geologic age	Late Eocene	Late Eocene	Late Eocene	Pleistocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene
Formation or Group	Chickahominy Formation	Chickahominy Formation	Chickahominy Formation	Columbia Group	Mattaponi (?) Formation	Mattaponi (?) Formation
Date	July 9, 1918	June 9, 1948	May 15, 1953	July 9, 1918	June 9, 1948	May 15, 1953
Silica (SiO_2)	59	---	---	---	16	---
Iron (Fe)	.60	---	---	---	.38	---
Calcium (Ca)	4.0	---	9.1	1.2	7.6	9.0
Magnesium (Mg)	3.8	---	3.8	1.0	.9	.6
Sodium (Na)	} 131	---	---	} 110	114 (calc.)	{ ---
Potassium (K)		---	---			---
Carbonate (CO_3)	86	---	0	17	14	13
Bicarbonate (HCO_3)	156	222	225	83	281	231
Sulfate (SO_4)	13	4	---	7.1	8.6	---
Chloride (Cl)	18	2	1.0	100	2.8	3.0
Fluoride (F)	---	.6	.7	---	1.8	1.2
Nitrate (NO_3)	tr.	.5	.9	2.0	.2	.5
Dissolved solids	400	---	---	315	309	---
Hardness as $CaCO_3$	116	42	38	7	23	25
Specific conductance (micromhos at 25°C)	---	355	353	---	501	417
pH	---	---	8.3	---	8.5	8.6

Table 12.--Chemical analyses of ground waters from wells in Richmond County, Virginia--Continued
(Parts per million, except specific conductance and pH)

Well number	28	30	33	36	37	38a	41	41
Location	WNW of Sharps	Tidewater	S of Warsaw	Warsaw	Warsaw	Warsaw	Naylors	Naylors
Depth (feet)	29	285	180	40	385	653	385	385
Geologic age	Pleistocene	Late Eocene	~~Miocene~~ Late Eocene	Pleistocene	Late Eocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene
Formation or Group	Columbia Group	Chickahominy Formation	~~Chesapeake Group~~ Chickahominy Formation	Columbia Group	Chickahominy Formation	Mattaponi Formation	Mattaponi Formation	Mattaponi Formation
Date	Nov., 1946	Sept. 3, 1946	July 8, 1918	July 12, 1918	June 9, 1948	May 15, 1953	July 10, 1918	Feb. 27, 1941
Silica (SiO_2)	---	---	49	11	46	17	21	---
Iron (Fe)	.06	.75	tr.	1.1	.59	.02	.06	---
Calcium (Ca)	---	---	2.2	40	16	1.6	2.0	---
Magnesium (Mg)	---	---	3.9	14	5.1	.3	2.0	---
Sodium (Na)	---	---	} 106	113	45 (calc.)	{ 118	} 212	{ ---
Potassium (K)	---	---				3.5		---
Carbonate (CO_3)	~~5.9~~ 6	---	60	0	0	10	94	---
Bicarbonate (HCO_3)	265	206	173	212	176	285	335	430
Sulfate (SO_4)	9	5	6.8	32	12	6.7	12	5
Chloride (Cl)	3	3	2.0	81	1.0	3.0	3.7	2
Fluoride (F)	---	---	---	---	.5	2.2	---	2.2
Nitrate (NO_3)	.6	.5	tr.	108	.3	.7	.33	---
Dissolved solids	---	---	314	490	217	297	506	---
Hardness as $CaCO_3$	20	78	21	157	61	5	13	12
Specific conductance (micromhos at 25°C)	---	---	---	---	320	482	---	---
pH	---	---	---	---	8.0	8.4	---	---

Table 12.--Chemical analyses of ground waters from wells in Richmond County, Virginia--Continued
(Parts per million, except specific conductance and pH)

Well number	41	42	43
Location	Naylors	NW of Naylors	SW of Newland
Depth (feet)	385	22	350
Geologic age	Late Cretaceous and Paleocene	Pleistocene	Late Cretaceous and Paleocene
Formation or Group	Mattaponi Formation	Columbia Group	Mattaponi Formation
Date	May 15, 1953	Aug. 29, 1946	May 15, 1953
Silica (SiO_2)	---	---	---
Iron (Fe)	---	.05	---
Calcium (Ca)	2.2	---	3.2
Magnesium (Mg)	1.7	---	1.5
Sodium (Na)	---	---	---
Potassium (K)	---	---	---
Carbonate (CO_3)	17	---	14
Bicarbonate (HCO_3)	434	20	389
Sulfate (SO_4)	---	58	---
Chloride (Cl)	3.8	168	2.5
Fluoride (F)	2.0	---	2.0
Nitrate (NO_3)	.9	123	.2
Dissolved solids	---	---	---
Hardness as $CaCO_3$	12	210	14
Specific conductance (micromhos at 25°C)	728	---	654
pH	8.5	---	8.4

Northumberland County I

Location and Development[1] II

Orginally comprising the entire Northern Neck, Northumberland County is now restricted to the northeastern part, bounded on the northeast by the Potomac River and Chesapeake Bay, and on the southwest by Richmond and Lancaster Counties. Its area is 189 square miles, and in 1960 its population was 10,185.

Tomatoes are an important product, as well as potatoes and grain crops. Poultry farming, fishing, and oyster processing are important industries.

Because ~~Since~~ there are no railroads, transportation is provided by water, and by State Highways 200 and 201 and by Federal Highway 360.

Heathsville, near the middle of the county, is the county seat. The largest town is Reedville, the center of the county's industrial activities including fish and fish-oil factories, canneries and mills. Other important towns include Fairfield, Lottsburg, Callao, Edwardsville, and Avalon. Along the northern shore of the county there are sandy stretches of beaches and cliffs, providing scenery and recreation.

1/ For further information on the eoconomic development of Northumberland County, see Va. Div. of Planning, (1965), Economic Data Summary, Northumberland County.

The total relief in Northumberland County is about 151 feet, from sea level to the highest elevation along the drainage divide at the boundary between Northumberland and Richmond Counties.

Bordering the county on the north and east is the Pamlico terrace of late Pleistocene age--a lowland 2 to 4 miles in width whose elevation ranges between 10 and 25 feet above sea level. Over the remainder of the county, the interstream divides are predominantly about 100 feet above sea level, and represent the dissected Wicomico terrace, of earlier Pleistocene age.

The northwestern part of Northumberland County is drained by Yeocomico River, which empites into the Potomac River. A considerable area in the northwestern part is drained by Coan River and Glebe Creek, and Little Wicomico River Drains part of the eastern end of the County. Great Wicomico River drains the larger part of southeastern Northumberland County toward Ingram Bay, bordering Chesapeake Bay.

Geology and Ground-Water Conditions II

Practically the entire area of Northumberland County is mantled by the Columbia Group of deposits of Pleistocene age. These are well exposed along many road cuts and along the banks of stream. Minor deposits of Holocene ~~(Recent)~~ age are present locally as beach deposits, lagoon deposits and stream alluvium.

Underlying these surface deposits, the Chesapeake Group of Miocene age is exposed along the banks of the major inlets, and is known also from samples collected while drilling wells. Rocks older than the Miocene do not crop out at the surface in the county, and thus are known only from drill cuttings.

Basement Complex III

The consolidated rocks which form the basement underlying the Coastal Plain sediments are ~~probably~~ may lie more than 2,000 feet below sea level in Northumberland County (DeBuchananne, 1968, Sheet 1). Nothing is known of their character, as no deep boring has been made in this area.

The Potomac Group of Cretaceous age in Northumberland County rests unconformably on the basement rock. The deposits of this Group are continental in origin and consist of alternating arkosic quartz sands and clays with minor beds of gravel. The Potomac Group probably lies at depths of ~~about 600 to 1,100~~ on the order of 1,000 feet below the surface in eastern Northumberland County. ~~(DeBuchananne, 1968, Sheet 1).~~

None of the wells listed in Table 13 is believed to have been drilled deep enough to tap sands in the Potomac Group. However, the extensive sands noted from many wells in the Coastal Plain, particularly in southeastern Virginia, suggest that the Potomac Group is a large, virtually untapped potential source of ground water in the Northern Neck peninsula. Any future program of deep test drilling would necessarily ~~should~~ include exploration of these deep sands. Moreover, not only their permeability but also the chemical character of the ground water contained in them should be investigated.

The Mattaponi Formation of Late Cretaceous and Paleocene age has been penetrated by many wells in Northumberland County. Its lithology, as indicated by drill cuttings, consists typically of clays of various colors, glauconitic clays, and glauconitic sands. White quartz sands are common in the basal part of the formation and these are commonly water-bearing. The characteristic mottled clays of the Mattaponi appear to be somewhat less prevalent than in the western part of the Northern Neck, but they are better developed in this county than in Lancaster County immediately to the south.

The Mattaponi is presumably more than 300 feet thick at Fairport (68, Table 14) in the eastern part of Northumberland County, and at least 268 feet 9 miles south of Byrdton (90). Other wells in the county for which records are available are believed to penetrate at least 200 feet of the Mattaponi Formation.

In the eastern end of Northumberland County, several wells in Reedville, Fairport, and Fleeton, have reached the Mattaponi Formation of Paleocene and Late Cretaceous age. At or near Reedville, wells 54 a & b, 55c and 56-63 inclusive, all drilled prior to 1920 and several of them before 1910, were initially flowing wells with flows ranging from 30 to 50 gpm when completed. In 1918 (?), well 64, 3 inches in diameter and 659 feet deep, flowed at a rate of 110 gpm, the highest rate of artesian flow on record in the county.

Information on more recent yields is available only for well 56, the municipal well in Reedville. In 1918 the flow from this well was 50 gpm but in June, 1948, it was only about 17. This appears to be characteristic of the decline of artesian pressure in flowing well areas in most of the Coastal Plain of Virginia.

Near Fairport and Fleeton, about 2 miles, respectively, south of Reedville, several other wells also yield water from the Mattaponi. (See Table 13, wells 67-77, inclusive.) Several of these also were drilled prior to 1920. Wells in this group had rates of flow ranging between 10 and 75 gallons per minute. Well 75, drilled in 1946, had an initial flow of 12 gpm; 2 years later ~~the~~, the flow was reported ~~at~~ to be $4\frac{1}{2}$ gpm.

Two wells (Mattaponi 85, 86) about 6 miles south of Fleeton at Ditchley, each 580 feet deep and $4\frac{1}{2}$ inches in diameter, were reported to flow 150 gpm each, in 1912 and 1911, respectively.

At the extreme southeastern end of the County, an 8-inch well (90) near Brydton, drilled to a depth of 810 feet, had a reported initial flow in 1943 of 15 gpm from 74 feet of white sand in the Mattaponi Formation. Another well (87) in the same locality, 637 feet deep, flowed in 1918 at 100 gpm.

About 3½ miles northwest of Fairport, well 80, drilled to a depth of 590 feet tapping the Mattaponi in 1945, was reported to have a natural flow of 2 gpm at the rather high altitude of 15 feet above sea level.

About 3 miles east of Burgess, on the south side of Little Wicomico River, a 4-inch well (43a), drilled in 1946 to a depth of 740 feet, was reported to have an initial flow of 75 ~~gallons per minute~~.

In the northern part of the county, a 572-foot well (20) south of Walnut Point, at Lake, drilled to a depth of 572 feet, taps white sand in the Mattaponi and had a natural flow of 27 gpm when it was drilled in 1941. A 550-foot well (13) at Lewisetta flowed 25 gpm in 1918, and a 590-foot well at Lodge (6), 4½ miles west of Lewisetta, had only a very small flow in 1918, probably only because it is located ~~in~~ on a 20-foot terrace.

Admittedly, some diminution of flow may be due to partial sanding of unscreened wells.

Although the artesian pressures in sands of the Mattaponi are doubtless considerably lower than 50 years ago, nevertheless, from properly developed wells of moderate diameter situated on low ground, relatively high natural flows may still be obtained. When these aquifers are tapped by properly constructed large diameter wells, yields up to 1 mgd or more

may be expected. The Mattaponi is extensively tapped elsewhere in the Northern Neck, and remains a large potential ground water resource which will be of vital importance to future municipal and industrial expansion in this part of the Coastal Plain.

Wells in the vicinity of Reedville (54b, 55c, 56, 58, 63) and near Fleeton (73, 75, 77) and south to Ditchley (85) commonly yield water from the Mattaponi that is somewhat more mineralized than water from higher horizons. In particular, the bicarbonate is higher and ranges from about 350 to 550 ppm. Chloride is low, ranging from 7 ppm (wells 55c and 77) to 14 ppm (56). A well near Fleeton (78) yields water containing 20 ppm of chloride. The sample from Burgess (45c) is shown to have a chloride content of 110 ppm. It is thought that the sample is not a true sample, perhaps due to leakage alongside the casing, inasmuch as nearby deeper well waters (54b) are low in chloride and the boundary of the high chloride zone lies in southeastern Lancaster County. Fluoride ranges from 1.6 ppm (56) to 2.4 ppm (75, 85).

Several wells were sampled more than once, with 5 to 30 years between samplings.

In summary, wherever sampled and analyzed, water from wells tapping the Mattaponi Formation in Northumberland County is found to be moderately mineralized and of the soft sodium bicarbonate type. Mineralization is somewhat lower in the western and central parts of the county, but the general character of the water is similar to that from the eastern part. The quality of the water appears to change little with time.

Tertiary System III

Aquia and Nanjemoy Formations IV

In Northumberland County the Aquia Formation, of Paleocene age, probably is absent, except perhaps in the extreme northwestern part near the Westmoreland County line.

The Nanjemoy Formation, stratigraphically younger than the Aquia, is of early and middle Eocene age, and may occur in the subsurface throughout Northumberland County. As elsewhere on the Northern Neck, the Nanjemoy consists of black glauconitic sand and green, brown, and blue clays. It is probably less than 100 feet thick in the county. There are no wells among the records currently available that are known to tap the Nanjemoy in the county.

Chickahominy ~~Chickamoniny~~ Formation IV

The Chickahominy Formation, of late Eocene eage, occurs in the subsurface throughout the county, and consists of glauconitic black sand, calcareous sand, clay, and thin limestone and sandstone beds. It is believed to be a little more than 100 feet thick at Byrdton (90, Table 14), but elsewhere it generally ranges from about 50 to 70 feet in thickness.

Water-Bearing Character

The Chickahominy Formation has been found generally to be a dependable source of water for domestic use. For larger supplies, wells are commonly sunk deeper, to reach the excellent water-bearing sands that occur in the Mattaponi Formation already discussed.

In the northwestern part of the County, well 7 drilled in 1908 to a depth of 325 feet, was reported to have a natural flow of 6 gpm in 1918. Near Lewisetta a 310-foot well (16a) flowed $3\frac{1}{2}$ ~~gallons a minute~~ gpm in 1918. A natural flow of 16 gpm is reported from a 317-foot 2-inch well (14) at Lewisetta in the same year.

In central and eastern Northumberland County at Lake, south of Walnut Point, a 360-foot well (19) has a flow of 3 gpm, but during the oyster season is pumped at a rate of 10 gpm. Well 23, about 3 miles north of Heathsville on low ground about at sea level, flowed at a rate of $7\frac{1}{2}$ gpm in about 1918. Small initial flows are also reported from wells 21, 29, 45c from the Chickahominy.

In the eastern part of the county, at Fairport, among the many wells tapping the deeper Mattaponi Formation, two obtain water from the Chickahominy: well 65, 393 feet deep, flows at 2 gpm, and a 405-foot well (66), jetted down in 1912, flows at $\frac{1}{2}$ gpm.

About 5 miles south of Fairport, two other wells tap the Chickahominy. Well 84 at Hardings, near Ditchley, 372 feet deep and 1 inch in diameter, flowed at a rate of 1 gpm in 1918. A 370-foot well (88) drilled in 1953 near Byrdton flowed 3/4 gpm, and when equipped with a pump produced 40 gpm.

Quality of Water V

Several samples were collected from wells tapping the Chickahominy Formation. Like the Mattaponi Formation, the Chickahominy yields soft sodium bicarbonate water of low to moderate mineralization.

An analysis from a public supply well (2) at Callao shows that the water is fairly soft--62 ppm of hardness--and contains less than 200 ppm of dissolved solids. Nitrate and chloride are low at 1.5 ppm, and other constituents are low.

A comprehensive analysis of water from well 11 at Lewisetta, sampled in 1918, shows that it is a soft sodium bicarbonate water. Most constituents are low (dissolved solids, 311 ppm), but iron is a little high--0.67 ppm.

Two analyses are available of water from well 17 at Walnut Point. (See Table 15.) Little change is noted in the 30-year period between samples; the water is a soft sodium bicarbonate type, and of low mineralization (dissolved solids, 271 ppm).

Water from well 27, near the Potomac River southwest of Walnut Point, was sampled in 1918. The comprehensive analysis shows that the water is a soft (hardness, 26 ppm) sodium bicarbonate water of generally good quality; the dissolved solids content is 424 ppm.

The quality of the ground water in the Chickahominy Formation is thus of generally excellent character from most uses including domestic and small public supplies.

Chesapeake Group IV

The Chesapeake Group of Miocene age unconformably overlies the Chickahominy Formation in Northumberland County. It lies near the surface but is covered by the relatively thin Pleistocene deposits.

Outcrops of the Miocene strata may be seen along several creeks in the county. However, the lithologic character of the Chesapeake Group is known best from drill cuttings. The deposits consist mostly of clay, diatomaceous earth, sandy clay, and fine sand, and a few thin beds of limestone and shells.

The Chesapeake ranges in thickness from about 250 to more than 350 feet. It is thickest in the easternmost part of the county.

Water-Bearing Character

It is not entirely certain that the Chesapeake Group in Northumberland County contains water bearing beds. A few wells mentioned in the following paragraphs end in basal Miocene strata or in uppermost beds of the Chickahominy Formation. A better age determination of the aquifer drawn upon by these wells cannot be made on the basis of the data at hand.

Two domestic wells on low ground near Walnut Point (24, 26) in the upper part of the county had very small flows of less than 1 gpm in 1918; a third (25) in this area flowed at $1\frac{1}{2}$ gpm at that time. Well 34, 2 miles south of these wells, flowed at 4 gpm, also in 1918.

Quality of Water V

Very few chemical analyses have been made of ground water from the Chesapeake Group. The quality is generally reported as satisfactory, but one well yields water with hydrogen sulfide odor (45a) and at least one well water (82) is reported to be high in iron. Water from the Miocene would be expected to be somewhat hard.

Water from well 24, near Walnut Point is soft (hardness, 40 ppm), and the bicarbonate is fairly high (260 ppm). It is not appreciably different from samples taken from wells ending in the Chickahominy Formation.

Quaternary System--Columbia Group III

The surficial deposits of Northumberland County form the Columbia Group of Pleistocene age. They consist chiefly of sands and gravels, and are characteristically yellowish in color, contrasting with the underlying grayish Miocene rocks. These beds are overlain locally by minor beach and channel deposits of Holocene (~~Recent~~) age.

Water-Bearing Character IV

Many dug wells tap the surficial deposits for small domestic supplies in the county. Yields are probably small everywhere. The normal result of deficient precipitation is particularly noticeable in shallow wells because the level declines during dry years as reported by many well owners. Some wells become completely dry when the water table recedes below the bottom of the well. Deepening such wells usually restores them to service.

One well (36) was used as a public well in the town of Healthsville, and another (50) for a poultry farm, watering 1,000 chickens. However, the yields of these wells is thought to be only moderate.

Iron content is likely to be troublesome to users of shallow well water. Exceptions occur, however; for example, well 41 along the Potomac northeast of Avalon reportedly delivers water that is soft and iron-free. Well 47 yields iron-free water also, according to the owner.

A few chemical analyses have been made of water from the Columbia Group; all were collected in 1918 by the U.S. Geological Survey. Near Lewisetta, water from well 10, sampled in 1918, is slightly hard (82 ppm), with 54 ppm of chloride, and other constituents, including iron, low. Northeast of Healthsville, well 33 yielded water high in nitrate (21 ppm) suggesting organic pollution. The water is otherwise of good quality, soft (36 ppm of hardness), and of very low mineralization (dissolved solids, 156 ppm), but iron (0.23 ppm) may require aeration. The chloride concentration is 28 ppm, and because the well is nearly 3 miles inland and unlikely to gain chloride from brackish tidewater from the Potomac, it probably derives chloride from the source of pollution.

The old public well at Heathsville (36) was sampled in 1918 and the analysis suggests even greater pollution, with a high nitrate content of 52 ppm and chloride, 40 ppm. Hardness (91 ppm) may be due to contact with underlying Miocene marls. Well 37b, a mile south of Avalon, yielded water similar to that from the Heathsville well--very high nitrate (60 ppm) and high chloride (41 ppm), indicating organic pollution. Other constituents are low. Both analyses

indicate water that is unsuitable for infant feeding formulas. (See references given earlier in this report in discussion of nitrate as a constituent in ground water.)

Two dug wells (55a, b) at Reedville in the eastern part of the county produced water with only a trace of nitrate. Water from well 55a, 14 feet deep, had a very high chloride concentration of 380 ppm, probably from invasion of brackish tidewater into the permeable Columbia deposits, although infiltration of wind-borne salt spray from brackish bay water may be a factor.

Summary of Ground-Water Conditions

Although no wells are known to tap the Potomac Group in Northumberland County as yet, the sands of this Group are believed to contain large reserve supplies of ground water, of generally good quality, for possible future needs.

The Mattaponi Formation is about 200 feet thick in the county, and is a good source of moderate supplies. The artesian flow was good in earlier years--in places more than 50 gpm--but it has declined. Wells 8 inches or more in diameter and properly constructed and developed probably would yield several hundred gallons per minute. The water is generally soft, and high in sodium and bicarbonate.

Small supplies are obtained from the Nanjemoy Formation in the county, although it is not of great importance as a source of supply. The quality is generally good.

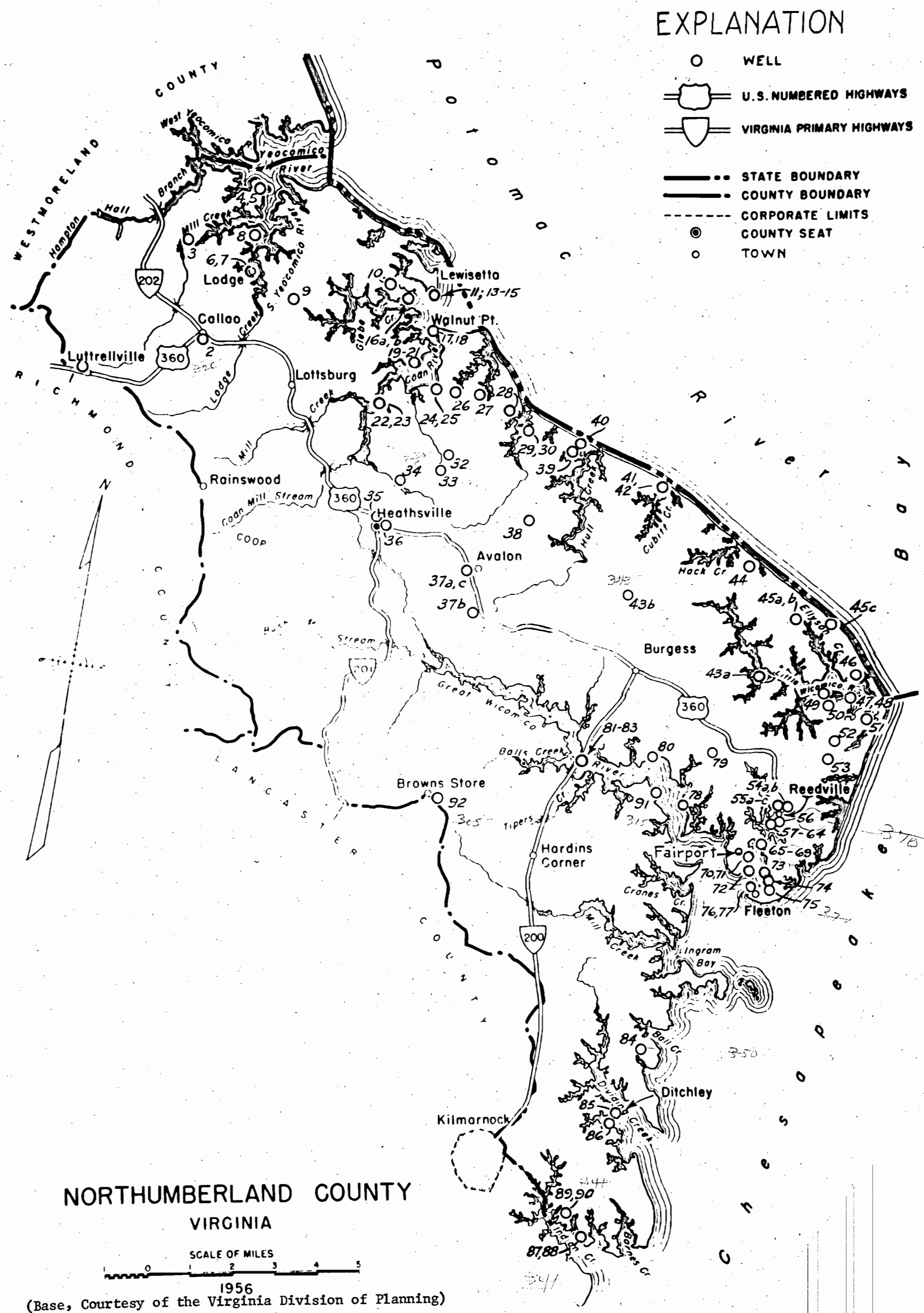
The Chickahominy Formation supplies a number of wells in Northumberland County, providing small to moderate supplies. Larger yields very likely could be obtained from wells of larger diameter. The ground water from the Chickahominy is of the soft sodium bicarbonate type.

The Chesapeake Group may provides small supplies to a few wells, but is not economically important as a source; the water is likely to be hard, especially in the upper part of the Group.

The surficial deposits of the Columbia Group are utilized for many small domestic and farm supplies by means of dug wells and a few driven wells. Iron may be troublesome, and pollution from surface drainage should be guarded against by proper construction.

Well Records and Chemical Analyses II

Records of wells, available logs, and chemical analyses of water samples in Northumberland County are given in Tables 13, 14, and 15 on the pages that follow. Locations of wells listed in Tables 13 through 15 are given in Figure 8 preceding the tables.



NORTHUMBERLAND COUNTY

VIRGINIA

SCALE OF MILES

1 0 1 2 3 4 5

1956

(Base, Courtesy of the Virginia Division of Planning)

Table 13.—Records of wells in Northumberland County, Virginia

Type of well: D, drilled; J, jetted; B, bored; Dv, driven
Use of water: PS, public supply; D, domestic; I, industrial; S, stock

gpm, gallons per minute; Fm, Formation; ppm, parts per million
Temp., temperature (degrees Fahrenheit)

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
1	Luttrellville	J. E. Winstead			144	Dug	22		Pleistocene	Columbia Group					1
2	Callao	Sydnor Hydrodynamics, Inc.	Sydnor Hydrodynamics, Inc.	1945	101	D	356		Late Eocene	Chickahominy Fm.	-87	22	PS	See log, Table 14; analysis, Table 15. Temp., 63½°. Drawdown, 4 ft when bailing 22 gpm.	2
3	1.7 mi WNW of Lodge	L. B. Northern		Prior to 1918	5	J	252	2	do	do				Water level reported ½ ft above surface in 1918.	3
4	1.9 mi. NNW of Lodge	Lovis Courtney	John W. Wilson		3	J	432		Late Cretaceous and Paleocene	Mattaponi (?) Fm			D,I	Used for washing oysters.	4
5	Do.	Warren Courtney	do	1939	3	J	310		Late Eocene	Chickahominy Fm					5
6	Lodge	M. T. Dawson			20	J	590	2	Late Cretaceous and Paleocene	Mattaponi Fm	(-)			Weak flow in 1918.	6
7	Do.	Dawson and Callahan		1908	5	J	325	2	Late Eocene	Chickahominy Fm	(+)			In 1918, flow reported 6 gpm, and water level 3 ft above surface.	7
8	0.9 mi. NNW of Lodge	C. H. Howell	A. L. Wilson	1950	17	J	284	1½	do	do	-12	16	D	See log, Table 14. Drawdown 7 ft after 4 hrs. pumping at 11 gpm.	8
9	1.2 mi. ESE of Lodge	Garner Bros.			21	Dug	22		Pleistocene	Columbia Group	- 7				9
10	1 mi. W of Lewisetta				11	Dug	22		do	do	(-)			See analysis, Table 15.	10
11	Lewisetta	Lewisetta Packing Co.			5		325	1½	Late Eocene	Chickahominy Fm	(+)			See analysis, Table 15. Several other wells in this vicinity are of same depth. Flow reported 3 gpm in 1918.	11
13	Do.	do		Prior to 1918	5	J	550	2	Late Cretaceous and Paleocene	Mattaponi Fm				See analysis, Table 15. In 1918, flow reported 25 gpm and water level 12 ft above surface.	13
14	Do.	C. R. Lewis and Co.			3	J	317	2	Late Eocene	Chickahominy Fm	(+)			In 1918(?), reported flow 16 gpm.	14
15	Do.	Garner Bros.		Prior to 1912	2		700		Late Cretaceous and Paleocene	Mattaponi Fm	(+)			In 1910, reported flow 17 gpm.	15
16a	0.6 mi. WSW of Lewisetta	S. Cowart		Prior to 1918	10	J	310	1½	Late Eocene	Chickahominy(?)Fm				In 1918, flow reported 3½ gpm, and water level 8 ft above surface.	16a
16b	Do.	J. L. Dobins		Prior to 1918	8	J	288	2	Miocene	Chesapeake(?)Group				In 1918, flow reported 2 gpm, and water level 6 ft above surface.	16b

Table 13.—Records of wells in Northumberland County, Virginia

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
17	Walnut Point	J. A. Lewis, store		Prior to 1918	1		340		Late Eocene Miocene	Chickahominy Fm. Chesapeake Group	(−)		D	See analysis, Table 15. Temp., 63° F. Shark teeth at 340 ft.	17
18	Do.	J. A. Lewis, residence		Prior to 1918	1		605		Late Cretaceous and Paleocene	Mattaponi Fm	(+)		D	See analysis, Table 15. Chief aquifer, black sand from 400–408 ft.	18
19	1 mi. SSW of Walnut Point	Headly	John W. Wilson		4	J	360		Late Eocene	Chickahominy Fm	(+)	10	D,I	Used for washing oysters.	19
20	Do.	J. H. Darling	Reynolds & Norman	1941	15	J	572	3		Mattaponi Fm	(+)			Flowed 27 gpm in 1941. Black sand and marl at about 300 feet; taps white sand at 572 feet.	20
21	Do.	Mrs. J. W. Cowart			1	J	360	1½	Late Eocene	Chickahominy Fm	(+)		D,S	Reported flow, 1/3 gpm. Reported iron-free.	21
22	2.1 mi. E of Lottsburg	T. H. Fallin			3	J	318	1½	do	do	(+)			Reported flow, 3/4 gpm. in about 1918 (?).	22
23	Do.	do			1	J	310	1½	do	do	(+)			Reported flow, 7½ gpm. in about 1918 (?).	23
24	1.3 mi. SSE of Walnut Point	do		Prior to 1906?	5	J	260	1½	Miocene	Chesapeake Group	(+)			See analysis, Table 15. In 1918, flow reported 3/4 gpm, and water level 12 feet above surface.	24
25	Do.	do			2	J	270	1½	do	do	(+)		D	In 1918, flow reported 1½ gpm, and water level 10 feet above surface. Temp., 67° in 1948.	25
26	1.4 mi. SSE of Walnut Point	do			3	J	290	1½	do	do	(+)		D	In 1918, flow reported 3/4 gpm.	26
27	1.7 mi. SE of Walnut Point	A. H. Clark		1910	12	J	407	1½	Late Eocene	Chickahominy Fm	(−)		D	See analysis, Table 15. Adequate during dry years.	27
28	2.4 mi. SE of Walnut Point	C. F. Howard			12	D	400+		do	do	(−)		D	Reported iron-free, and soft.	28
29	4.2 mi. NE of Heathsville	E. W. Bray	A. G. Hainey	1926	2	D	404	2	do	do	(+)		D,S	See analysis, Table 15. Temp., 63° F. in 1948. In about 1926, flow reported 1/3 gpm.	29
30	Do.	G. B. Bray	do	1926	2	B	400	2	do	do	(+)		D,S	Reported iron-free. In about 1926, flow reported ½ to 1/3 gpm.	30
32	2.3 mi. NE of Heathsville	B. Fletcher			115	Dug	42		Pleistocene	Columbia Group	(−)		D,S	Water level declines in dry years; reported to contain some iron.	32
33	2 mi. NE of Heathsville	J. H. Sisson			114	Dug	27		do	do	−27		D	See analysis, Table 15.	33
34	1.2 mi. NNE of Heathsville	W. C. Snow			6	J	265	2	Miocene	Chesapeake Group	(+)			In 1918, flow reported 4 gpm.	34
35	Heathsville	Sydnor Hydrodynamics, Inc.	Sydnor Hydrodynamics, Inc.	1946	100	D	448	8	Late Eocene	Chickahominy Fm	−87	50	PS	See log, Table 14. Screen set at 414 to 440 ft. Drawdown, 70 ft after pumping 50 gpm for 24 hours.	35

Table 13.—Records of wells in Northumberland County, Virginia

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
36	Heathsville	Public Supply Well			102	Dug	50		Pleistocene	Columbia Group	-40			See analysis, Table ~~3~~ 15. High nitrate.	36
37a	Avalon	J. A. Lewis			105	D	605	1½	Late Cretaceous and Paleocene	Mattaponi Fm	(-)			See analysis, Table ~~3~~ 15.	37a
37b	1 mi. S of Avalon	W. N. Bentley		Prior to 1918	115	Dug	30		Pleistocene	Columbia Group	-26		D	See analysis, Table ~~3~~ 15. In 1918, water level reported 26 ft below surface.	37b
37c	Avalon	(At Post Office)			105	Dug	43		do	do	(-)		D,S	Adequate during dry years; reported to contain a little iron.	37c
38	1.6 mi. NNE of Avalon	O. H. Crowther			90	Dug	53		do	do	(-)			Water level declines in dry years. Reported to contain some iron.	38
39	3.5 mi. NNE of Avalon	Jedson Hall			1	Dv	300+		Late Miocene Eocene	Chickahominy Fm. Chesapeake Group	(+)		D,S	Flows up to ½ gpm. No lack of water in dry years.	39
40	3.8 mi. NNE of Avalon	T. H. Gile			15	Dug	15		Pleistocene	Columbia Group	(-)		D,S		40
41	4.8 mi. NE of Avalon	Redford			10	Dv	22		do	do	(-)		D	Some decline in water level in dry years. Reported soft and iron-free.	41
42	Do.	C. F. Bowles			2		595		Late Cretaceous and Paleocene	Mattaponi Fm	(+)			Taps black sand at about 595 feet; also, black and gray sand with "rock" at about 360 ft.	42
43a	3 mi. E of Burgess	Elliott & Brooks	W. S. Reynolds	1946	4	J	740		do	do	(+)	75	I	See log, Table ~~2~~ 14.	43a
43b	1.8 mi. NNW of Burgess	R. W. Edwards			82	Dug	34		Pleistocene	Columbia Group	(-)		D,S	Water level declines during dry years. Reported hard, contains iron.	43b
44	3.6 mi. NNE of Burgess	T. H. Swann			15	Dug	16		do	do	(-)		D,S	Water level declines during dry years.	44
45a	4 mi. NE of Burgess	A. W. Noble	Mitchell's Well and Pump Co.		15		385		Late Miocene Eocene	Chickahominy Fm. Chesapeake Group	(-)		D	Sulfide odor reported.	45a
45b	Do.	F. W. Herndle	do		15		425		Late Eocene	Chickahominy Fm	(-)		D		45b
45c	4.6 mi. ENE of Burgess	F. J. Spilling	John W. Wilson	1940-41	11		500	3	Late Eocene	Chickahominy(?)Fm	(+)		D	See analysis, Table ~~3~~ 15. Flowed ½ gpm in 1946.	45c
46	5.2 mi. ENE of Burgess	Moses Cockrell			10	Dug	16		Pleistocene	Columbia Group	(-)		D	Water level declines during dry years.	46
47	3.2 mi. NNE of Reedville	E. S. Gough			1	Dv	14	1½	do	do	(-)		D,I	Reported iron-free. Used for washing oysters. Many other dug wells in vicinity.	47

Late Cretaceous and Paleocene

Mattaponi Fm

Table 13.—Records of wells in Northumberland County, Virginia

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
48	3.2 mi. NNE of Reedville	Mrs. A. A. Page			9	Dug	20		Pleistocene	Columbia Group	(−)		D	Reported to contain iron.	48
49	3.0 mi. N of Reedville	C. O. Hancock			2	Dv	12+	2	do	do	(−)		D		49
50	2.8 mi. N of Reedville	H. G. Williams			11	Dug	15		do	do	(−)		D,S	Used for 1,000 chickens. Water level declines during dry years. Reported high in iron.	50
51	3 mi. NNE of Reedville	Robert Jett			11	Dv	18		do	do	(−)		D		51
52	2.1 mi. NNE of Reedville	J. H. Youngquist			12	Dug	15		do	do	(−)		D,S	Water level declines during dry years. Reported to contain iron.	52
53	1.7 mi. NNE of Reedville	P. Lee			11	Dug	10		do	do	-5		D,S	Reported to contain iron.	53
54a	Reedville	Albert Morris			8	J	724	2	Late Cretaceous and Paleocene	Mattaponi Fm			D	In 1918, flow reported 40 gpm, and water level 38 ft above surface.	54a
54b	Do.	William Blunden		Prior to 1908	8	J	680	2	do	do			D	See analysis, Table ~~3~~ 15. In 1918, flow reported 25 gpm, and water level 8 ft above surface.	54b
55a	Do.	V. McFarland			10	Dug	14		Pleistocene	Columbia Group	-12		D	See analysis, Table ~~3~~ 15.	55a
55b	Do.	S. C. Butler			10	Dug	18		do	do				See analysis, Table ~~3~~ 15.	55b
55c	Do.	Mrs. R. B. Moore			5	J	740	2	Late Cretaceous and Paleocene	Mattaponi Fm	(+)		D	See analysis, Table ~~3~~ 15. In 1918, flow reported 75 gpm.	55c
56	Do.	Blunden & Hinton		1918	1	J	685	3	do	do	(+)		PS,I	See log, Table ~~2~~ 14; analysis, Table ~~3~~ 15. In 1918 flow reported 50 gpm; in 1948, flowed 17½ gpm.	56
57	Do.	McNeal & Edwards			5	J	682	2	do	do	(+)		I	In 1918, flow reported 30 gpm, and water level 25 ft above surface.	57
58	Do.	McGill & McNeal Co.	R. H. Milligan	1902	3	J	680	3	do	do	(+)		I	See analysis, Table ~~3~~ 15. In 1910, flow reported 50 gpm, and water level 38 ft above surface.	58
59	Do.	G. N. Reed			1	J	680	2½	do	do	(+)			In 1918, flow reported 35 gpm.	59
60	Do.	Jas. C. Fisher		1904	5	J	698	2	do	do	(+)			In 1918, flow reported 45 gpm.	60
61	Do.	Edwards, Reed, & Co.	R. H. Milligan	1902	5	J	685	2	do	do	(+)		I	In 1918, flow reported 32 gpm; in 1910, water level reported 25 feet above surface.	61
62	Do.	Paine & Snow Co.			3	J	683	2	do	do	(+)		I	In 1910, flow reported 45 gpm; in 1918(?) flow reported 40 gpm.	62

Table 13.—Records of wells in Northumberland County, Virginia

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
63	Reedville	Taylor & Reed Co.			3	J	680	3	Late Cretaceous and Paleocene	Mattaponi Fm	(+)		I	See analysis, Table 15. In 1918, flow reported 45 gpm, and water level 33 ft above surface.	63
64	Do.	Edwards Fish Hatchery			3	J	659	3	do	do	(+)		I	In 1918(?), flow reported 110 gpm.	64
65	Fairport	Morris Fisher Co.			5	J	393	1½	Late Eocene	Chickahominy Fm	(+)		I	Flows 2 gpm.	65
66	Do.	do		1912	5	J	405	1½	do	do	(+)		I	Flows ½ gpm. Chloride reported 20 ppm.	66
67	Do.	do			5	J	680	3	Late Cretaceous and Paleocene	Mattaponi Fm	(+)		D	In 1918, flow reported 20 gpm. Chloride reported 8 ppm.	67
68	Do.	McNeal & Dodson	Mitchell's Well and Pump Co.	1940	5	D	870	3	do	do	(+)		I	See log, Table 14. Flows 15 gpm.	68
69	Do.	do			3		680	3	do	do	(+)		I	Chloride reported 6 ppm.	69
70	Do.	McGill & McNeal Co.		1903	3	J	690	2	do	do	(+)		I	In 1918, flow reported 50 gpm, and water level 35 ft above surface.	70
71	Do.				1		662		do	do	(+)			In 1918, flow reported 75 gpm, and water level 30 ft above surface.	71
72	0.5 mi. S of Fairport	C. E. Davis and P. King Co.			1		634	3	do	do	(+)			In 1918, flow reported 60 gpm.	72
73	0.5 mi. N of Fleeton	Douglas Co. (Fish Factory)			1		740	3	do	do	(+)			See analysis, Table 15. In 1918, flow reported 75 gpm.	73
74	0.4 mi. NNW of Fleeton	Mrs. Otis Douglas			8		660	2	do	do	(+)		D	In 1918, flow reported 35 gpm; in 1946, flow reported 10 gpm. Furnishes water to several homes.	74
75	0.4 mi. NE of Fleeton	T. C. Slaughter	Reynolds & Norman	1946	8	J	711	3-2	do	do	(+)		D,S	See log, Table 14; analysis, Table 15. Temp., 72°F. In 1946, flow reported 12 gpm; in 1948, flow reported 4½ gpm.	75
76	Fleeton	Fleeton Development Co.	R. H. Milligan	1904	3	J	746	2	do	do	(+)			In 1918, flow reported 40 gpm, and water level 35 ft above surface.	76
77	Do.	Town well			5	J	690	2	do	do	(+)			See analysis, Table 15. In 1918, flow reported 10 gpm.	77
78	3.5 mi. SE of Burgess	J. H. Smith			1		680		do	do					78

Table 1.—Records of wells in Northumberland County, Virginia

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
79	2.8 mi. ESE of Burgess	Cobbs Dairy			21	Dug	20		Pleistocene	Columbia Group	-15		D,S	Water level declines during dry years.	79
80	2.1 mi. SE of Burgess	Lilian Lumber Co.	Virginia Machinery and Well Co.	1945	15	D	590		Late Cretaceous and Paleocene	Mattaponi Fm	(+)	39	I	Flows 2 gpm. Drawdown 50 ft when pumping 39 gpm. Water foams in boiler.	80
81	2.5 mi. SSW of Burgess	Mason Booth			3		375		Miocene	Chesapeake Group	(+)		D,I,S	Flows 1½ gpm. Water-bearing sand at 318 ft.	81
82	Do.	Earl Cockrell			3	J	320	1½	do	do	(+)		D	Flows 1½ gpm. No decline of water level during dry years. Reported to contain iron.	82
83	Do.	Mrs. W. H. Booth	J. M. Buress		4		625	2	Late Cretaceous and Paleocene	Mattaponi Fm	(+)		PS	See analysis, Table ~~3~~ 15.	83
84	1.6 mi. W of Ditchley	S. A. Whittaker			6		372	1	Late Eocene	Chickahominy Fm	(+)			See log, Table ~~2~~ 14. Flow reported 1 gpm in 1918. Chloride reported 5.5 ppm.	84
85	Ditchley	Mrs. E. I. DuPont			2		580	4½	Late Cretaceous and Paleocene	Mattaponi Fm	+16		D	See analysis, Table ~~3~~ 15. Temp., 70°F. In 1912, flow reported 150 gpm, and water level 16 ft above surface.	85
86	0.3 mi. S of Ditchley	Virginia Fish Co.			3		580	4½	do	do	+16			In 1911, flow reported 150 gpm, and water level 16 ft above surface.	86
87	3 mi. ESE of Kilmarnock	Western Chemical Co.			1		637	8	do	do			I	In 1918, flow reported 100 gpm. Chloride reported 10 ppm.	87
88	Do.	Luther George	J. P. Prine	1953	1	D	370	2	Late Eocene	Chickahominy Fm	(+)	40±		Flows 3/4 gpm. Hydrogen sulfide odor.	88
89	2 mi. ESE of Kilmarnock, at Byrdton	Col. Mark A. Dawson			5	Dug	14		Pleistocene	Columbia Group	-8		D		89
90	Do.	do	Mitchell's Well and Pump Co.	1943	5	D	810	8	Late Cretaceous and Paleocene	Mattaponi Fm	(+)		D	In 1943, flow reported 15 gpm. ~~Water-bearing white sand from 705 to 779 ft.~~	90
91	3 mi. SSE of Burgess	J. L. Sisson	Reynolds & Norman	1942	5	J	707	3	do	do			D	See log, Table ~~2~~ 14.	91
92	Browns Store	J. D. Hinton	W. S. Reynolds	1950	103	J	690	4-3	do	do			D	See log, Table ~~2~~ 14.	92

Table 14.--Logs of wells in Northumberland County, Virginia

Well 2, Callao; Sydnor Hydrodynamics, Inc.

(Drilled by owner; log modified from driller's record; correlations by A. Sinnott)

Altitude, 101 feet

	Thickness (feet)	Depth (feet)
~~Top soil~~	~~1~~	~~1~~
Columbia Group (Pleistocene):		
Clay, yellow	18	18
Clay, sandy, yellow	38	56
Chesapeake Group (Miocene):		
Clay, blue	252	308
Clay, blue, with fine sand and shells	12	320
Clay, blue	7	327
Chickahominy Formation (upper Eocene):		
Clay, blue, with streaks of "rock"	22	349
"Rock" (probably sandstone)	7	356

Table 14.--Logs of wells in Northumberland County, Virginia--Continued

Well 8, 0.9 mile north-northwest of Lodge; C. H. Howell

(Sample descriptions by E. G. Otton, from Md. Dept. Geology, Mines and Water Resources, Bull. 11, p. 187-8; see Ferguson, 1953)

Altitude, 17 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Sand, clean, medium, grayish-orange; mostly subangular and angular, clear, white, pale-gray and pale-yellow quartz; some limonite and feldspar fragments	10	10
Sand, and clay, pale yellowish-brown; sand medium to coarse, dull vari-colored, subangular quartz; limonite fragments and a few rounded black glauconite grains	11	21
Sand, medium, grayish-orange; mostly medium, dull, subangular, white, yellow and iron-stained quartz grains	10	31
Sand, medium, grayish-orange; similar to above	11	42
Clay, sandy, pale yellowish-brown to light olive-gray; medium to coarse, angular gray, pale-yellow, violet and clear quartz; vivianite; a few shells and brown plant fragments	10	52
Chesapeake(?) Group (Miocene):		
Clay, sandy, olive-gray; quartz as above; several pieces vivianite; coarse pelecypod fragments; black, soft plant fragments and a few pieces of reddish limonite	11	63
Clay, sandy, olive-gray; pale-violet and dull-gray subangular, medium quartz grains; vivianite; a few carbonized plant fragments and a few shell fragments	10	73
Clay, sandy, olive-gray; similar to above	11	84
Clay, slightly sandy, light olive-gray; small amount of medium to coarse quartz, as above; a few pieces of shell and vivianite; grains of dull gray-black flint	11	95
Clay, slightly sandy, light olive-gray; similar to above, except mostly medium to coarse quartz grains and a few coarse shell fragments	10	105
Sand, fine, clean, yellowish-gray; angular clear, pale-yellow and green quartz and fine to very fine irregular glauconite; well-sorted	10	115

Table 14.--Logs of wells in Northumberland County, Virginia--Continued

Well 8, 0.9 mile north-northwest of Lodge; C. H. Howell--Continued

	Thickness (feet)	Depth (feet)
Clay, silty and sandy, light olive-gray; coarse, subrounded gray-green quartz pieces of chert and jasper; vivianite; pieces of indurated brown silt; coarse pelecypod and shell fragments and a few Foraminifera	11	126
Clay, very sandy, light olive-gray; Foraminifera identified as Miocene Calvert	10	136
Clay, sandy, light olive-gray	22	158
Sand, fine, clayey, light olive-gray; fine to medium, subangular, clear, gray and pale-green quartz grains; abundant phosphate fragments; Foraminifera and shell fragments	10	168
Clay, slightly sandy, light olive-gray; similar to above	11	179
Clay, sandy, light olive-gray; fine to coarse, mostly clear and gray, some yellow-green and dull quartz grains; shell fragments; a few sponge spicules and bone fragments	10	189
Clay, slightly sandy, light olive-gray; similar to above	32	221
Sand, medium, light olive-gray; clear and gray subangular quartz grains; shell fragments and phosphate plates	10	231
Sand, medium, mottled light olive-gray; similar to above; shell fragments more common	11	242
Chickahominy Formation (Upper Eocene):		
Sand, calcareous, medium, light-gray; fine to medium, clear, pale-yellow and gray quartz; medium, irregular to botryoidal green and light green glauconite; fragments gray calcareous rock and abundant shell fragments	10	252
Sand, medium, calcareous, light-gray; similar to above; some pyrite	11	263
Sand, medium, light-gray; similar to above, but much more calcareous rock fragments	10	273
Sand, medium, light-gray; similar to above, but contains some brown, medium oblate glauconite	11	284

Table 14.--Logs of wells in Northumberland County, Virginia--Continued

Well 43a, 3 miles east of Burgess; Elliott & Brooks

(Drilled by W. S. Reynolds; descriptions and correlations by D. J. Cederstrom)

Altitude, 4 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Clay, sandy	42	42
Chesapeake Group (Miocene):		
Clay, blue	33	75
Sand, and shells	1	76
Clay, blue	114	190
Limestone	10	200
Clay, greenish blue	135	335
Clay, brown, hard	12	347
Chickahominy Formation (Upper Eocene and Nanjemoy(?) Formation (Eocene), undifferentiated:		
Limestone, white sand, and shells	1	348
Clay, light brown, grading to greenish brown and light brown	34	382
Limestone	5	387
Sand, black	2	389
Clay, brown	41	430
Limestone and black sand	4	434
Clay, compact	66	500
Sand, black	1/2	500½

Table 14.--Logs of wells in Northumberland County, Virginia--Continued

Well 43a, 3 miles east of Burgess; Elliott & Brooks--Continued

	Thickness (feet)	Depth (feet)
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Clay, mottled	179½	680
Sand, white	60	740

Table 14.--Logs of wells in Northumberland County, Virginia--Continued

Well 56, Reedville; Blunden & Hinton

(Log from owner; correlations chiefly by D. J. Cederstrom)

Altitude, about 1 foot

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Sand and gravel	42	42
Chesapeake Group (Miocene):		
Clay, blue	12	54
Clay, blue, with white pebbles and peat	3	57
Marl, blue, sandy dark-colored shells in several places	313	370
Shells, cemented	1	371
Sand, fish bones, and shells; water-bearing (sulfide odor)	30	401
Chickahominy(?) Formation (Upper Eocene):		
Clay, yellow, with hard "crusts"	19	420
Clay, sandy, yellow	60	480
Nanjemoy(?) Formation (Eocene):		
Sand, dark	1	481
Clay, brown, changing downward through red, yellow, purple, etc.	79	560
Clay, green	10	570
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Sandstone, white	1	571
Sand; water-bearing (small flow)	10	581
Clay, black, with fossil wood	5	586
Sand, clean; water-bearing	12	598

(more)

Table 14.--Logs of wells in Northumberland County, Virginia--Continued

Well 56, Reedville; Blunden & Hinton--Continued

	Thickness (feet)	Depth (feet)
Mattaponi Formation--Continued		
Clay, red and brown	20	618
Clay, white	3	621
Clay, red	19	640
Clay, white (and sand?); water-bearing	45	685

Table 14.—Logs of wells in Northumberland County, Virginia—Continued

Well 68, Fairport; McNeal and Dodson

(Log from driller's record furnished by Mitchell's Well & Pump Co.; correlations by D. J. Cederstrom)

Altitude, 5± feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Clay, yellow, and sand	35	35
Chesapeake Group (Miocene)		
Clay, gray	115	150
Clay, blue, sand shells	130	280
Clay, blue	70	350
Sand and rock	50	400
Chickahominy Formation (Upper Eocene):		
Clay, gray	20	420
Sand, black, rock, and shells	20	440
Sand, black, rock, and shells	40	480
Nanjemoy Formation (Eocene):		
Sand, black, and blue clay	40	520
Sand, black	20	540
Sand, black, and blue clay	30	570
Mattaponi Formation (Upper Cretaceous and Paleocene:		
Clay, blue, very hard	30	600
Sand, black, hard	10	610
Sand, green, and clay	10	620
Clay, black, hard	10	630

Table 14.--Logs of wells in Northumberland County, Virginia--Continued

Well 68, Fairport; McNeal and Dodson--Continued

	Thickness (feet)	Depth (feet)
Mattaponi Formation--Continued		
Sand, yellow	5	635
Sandstone, hard	5	640
Sand, black and white	20	660
Sand, white	65	725
Clay, light gray, hard	5	730
Sand, fine, white	5	735
Clay, red	25	760
Clay, red and blue	80	840
Clay, red	10	850
Sand	15	865
Clay	5	870

Table 14.--Logs of wells in Northumberland County, Virginia--Continued

Well 75, Fleeton; T. C. Slaughter

(Log from driller's record furnished by Reynolds & Norman; correlations by D. J. Cederstrom)

Altitude, about 8 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Clay, sandy	35	35
Chesapeake Group (Miocene):		
Clay, blue	340	375
Chickahominy Formation (Upper Eocene):		
Sand, white	1	376
Rock (sandstone?)	1/2	377-1/2
Clay, blue	2-1/2	380
Sand, white	1	381
Clay, hard, brown	38	419
Rock (sandstone?)	21	440
Clay, hard, blue; thin streak of rock	36	476
Nanjemoy Formation (Eocene):		
Clay, hard	9	485
Sand, black	1/2	485-1/2
Clay, hard	59-1/2	545
Mattaponi(?) Formation (Upper Cretaceous and Paleocene):		
Clay, light blue	51	596
Clay, hard	74	670
Sand, white; water-bearing	41	711

Table 14.--Logs of wells in Northumberland County, Virginia--Continued

Well 84, 1.6 miles north of Ditchley; S. A. Whittaker

(Log from owner; correlations by D. J. Cederstrom)

Altitude, 6± feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Clay, soil and loam	5	5
Sand	4	9
Chesapeake Group (Miocene):		
Clay, bluish black	3	12
Marl, light-colored	5	17
Clay, sandy, blue	10	27
Clay, yellow; some sand at 33-56 feet	29	56
Marl, light-colored	3	59
Clay, sandy, green	274	333
Clay, hard, yellow	23	356
Chickahominy Formation (Upper Eocene):		
Shell rock and sandy beds, hard; water bearing at 372 feet	16	372
Sand and clay, black	41	413

Table 14.--Logs of wells in Northumberland County, Virginia--Continued

Well 88, Byrdton; Luther George

(Log by J. P. Prine, driller; correlations by D. J. Cederstrom)

Altitude, 1± foot

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Clay, red	8	8
Sand, iron-stained; water-bearing	4	12
Chesapeake Group (Miocene):		
Sand, blue; shells; clay binder	3	15
Clay, blue	30	45
Clay, blue, and shells	40	85
Sand, very fine, blue; mixed with blue clay to 90 ft.	25	110
Clay, blue	170	280
Clay, blue, and shells	62	342
Chickahominy Formation (Upper Eocene):		
Rock, hard lime	1	343
Sand; water-bearing	27	370

Table 14.--Logs of wells in Northumberland County, Virginia--Continued

Well 90, Byrdton; Col. M. A. Dawson, Estate East Richlands

(Drilled by Mitchell's Well & Pump Co.; sample descriptions and correlations by D. J. Cederstrom)

Altitude, 5± feet

	Thickness (feet)	Depth (feet)
Soil	2	2
Columbia Group (Pleistocene):		
Clay, yellow	13	15
Chesapeake Group (Miocene):		
Clay, blue	58	73
Marl, blue	29	102
Clay, blue	90	192
Clay, sandy, blue	28	220
Clay, blue	125	345
Chickahominy Formation (Upper Eocene):		
Rock	½	345½
Sand, and shells	46½	392
Sandstone	18	410
Sand, black, glauconitic	20	430
Rock	2	432
Sand, black, glauconitic, and shells	13	445
Sand, black	4	449
Sand, black; shells	10	459
Sand, gray	7	466
Rock	8	474
Sand, black; glauconitic	6	480
Sand, marly; glauconitic	20	500

Table 14.--Logs of wells in Northumberland County, Virginia--Continued

Well 90, Byrdton; Col. M. A. Dawson, Estate East Richlands--Continued

	Thickness (feet)	Depth (feet)
Nanjemoy Formation (Eocene):		
Sand, black; glauconitic	30	530
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Clay, blue	29	559
Sand, black; glauconitic	2	561
Rock	1	562
Clay, green	7	569
Clay, blue; glauconitic	66	635
Clay, blue	16	651
Clay, blue, glauconitic	5	656
Sand, white; trace of glauconite	12	668
Clay, sandy, brown	10	678
Clay, blue; glauconitic	5	683
Sandstone	22	705
Sand, white; coarse at 729 feet; water-bearing	74	779
Clay, sandy, black	19	798
Sandstone	12	810

Table 14.--Logs of wells in Northumberland County, Virginia--Continued

Well 91, 3 miles south-southeast of Burgess; J. L. Sisson

(Log from driller's record furnished by Reynolds & Norman; correlations by A. Sinnott and D. J. Cederstrom)

Altitude, about 5 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Sand and clay, yellow	34	34
Chesapeake Group (Miocene):		
Clay, blue	146	180
Sand	½	180½
Clay, green	119½	300
Clay, brown	20	320
Chickahominy Formation (Upper Eocene) and Nanjemoy Formation (Eocene), undifferentiated:		
Sand, and shells	1½	321½
Clay, brown	63½	385
Sand, black	½	385½
Clay, hard, greenish brown	114½	500
Clay, hard	62	562
Sand, black	1	563
Clay, hard	27	590
Sand, black and white	2	592
Mattaponi(?) Formation (Upper Cretaceous and Paleocene):		
Clay, pink, grading to green and light brown	73	665
Clay, pink, grading to white	15	680
Sand and clay, white, mixed	27	707

Table 14.--Logs of wells in Northumberland County, Virginia--Continued

Well 92, Browns Store; J. D. Hinton

(Log furnished by W. S. Reynolds, driller; correlations by A. Sinnott and D. J. Cederstrom)

Altitude, 103 feet

	Thickness (feet)	Depth (feet)
Undescribed	85	85
Chesapeake Group (Miocene):		
Clay, hard	47	132
Clay, gray	20	152
Clay, light gray	128	280
Clay, hard	94	374
Clay, brown	10	384
Clay, hard	23	407
Chickahominy Formation (Upper Eocene) and Nanjemoy Formation (Eocene), undifferentiated:		
Clay, brown	61	468
Clay, blue	57	525
Clay, white	60	585
Mattaponi(?) Formation (Upper Cretaceous and Paleocene):		
Clay, blue	25	610
Clay, red	10	620
Sand, white	30	650
Undescribed	40	690

15

Table 3.--Chemical analyses of ground waters from wells in Northumberland County, Virginia
(Parts per million, except specific conductance and pH)

Well number	2	10	11	13	13
Location	Callao	W of Lewisetta	Lewisetta	Lewisetta	Lewisetta
Depth (feet)	356	22	325	550	550
Geologic age	Late Eocene	Pleistocene	Late Eocene	Late Cretaceous-Paleocene	Late Cretaceous and Paleocene
Formation or Group	Chickahominy Formation	Columbia Group	Chickahominy Formation	Mattaponi Formation	Mattaponi Formation
Date	May 15, 1953	July 5, 1918	July 5, 1918	July 5, 1918	Feb. 27, 1941
Silica (SiO_2)	36	15	31	24	---
Iron (Fe)	.05	.02	.67	.10	---
Calcium (Ca)	15	20	5	2.1	---
Magnesium (Mg)	6.3	7.8	6.7	1.7	---
Sodium (Na)	41	} 53	107	177	---
Potassium (K)	12				
Carbonate (CO_3)	0	0	60	85	---
Bicarbonate (HCO_3)	191	80	180	283	378
Sulfate (SO_4)	.8	45	7.6	18	15
Chloride (Cl)	1.5	54	3.5	3.9	3
Fluoride (F)	.5	---	---	---	.9
Nitrate (NO_3)	1.5	2.9	1.9	.61	---
Dissolved solids	192	254	311	459	---
Hardness as $CaCO_3$)	62	82	40	12	9
Specific conductance (micromhos at 25°C)	301	---	---	---	---
pH	8.2	---	---	---	---

208

15

Table ~~3~~.--Chemical analyses of ground waters from wells in Northumberland County, Virginia--Continued
(Parts per million, except specific conductance and pH)

Well number	17	17	18	24	27	29	29
Location	Walnut Point	Walnut Point	Walnut Point	Walnut Point	SE of Walnut Point	NE of Heathsville	NE of Heathsville
Depth (feet)	340	340	605	260	407	404	404
Geologic age	~~Miocene~~ Late Eocene	~~Miocene~~ Late Eocene	Late Cretaceous and Paleocene	Miocene	Late Eocene	Late ~~Eocene~~ Cretaceous and Paleocene	Late ~~Eocene~~ Cretaceous and Paleocene
Formation or Group	~~Chesapeake~~ Chickahominy Formation ~~Group~~	~~Chesapeake~~ Chickahominy Formation ~~Group~~	Mattaponi Formation	Chesapeake Group	Chickahominy Formation	~~Chickahominy~~ Mattaponi Formation	~~Chickahominy~~ Mattaponi Formation
Date	July 3, 1918	June 8, 1948	July 3, 1918	1906	July 2, 1918	June 8, 1948	May 15, 1953
Silica (SiO_2)	30	---	---	---	32	---	---
Iron (Fe)	.10	---	---	---	.08	---	---
Calcium (Ca)	5.6	---	---	---	4.8	---	3.8
Magnesium (Mg)	6.1	---	---	---	3.3	---	2.5
Sodium (Na)	} 90	---	---	---	} 153	---	---
Potassium (K)		---	---	---		---	---
Carbonate (CO_3)	27	---	125	---	62	---	5
Bicarbonate (HCO_3)	209	243	217	260	308	369	386
Sulfate (SO_4)	8	4	31	0	3.7	1	---
Chloride (Cl)	2.7	1	4	6.7	4.2	2	3.8
Fluoride (F)	---	.7	---	---	---	1.1	1.2
Nitrate (NO_3)	1.2	1.2	.5	---	1.5	1.2	1.4
Dissolved solids	271	---	471	---	424	---	---
Hardness as $CaCO_3$	39	48	---	40	26	30	20
Specific conductance (micromhos at 25°C)	---	388	---	---	---	567	602
pH	---	---	---	---	---	---	8.4

Table 15.--Chemical analyses of ground waters from wells in Northumberland County, Virginia--Continued
(Parts per million, except specific conductance and pH)

Well number	33	36	37a	37a	37b	45c	54b
Location	NE of Heathsville	Heathsville	Avalon	Avalon	Horse Head	ENE of Burgess	Reedville
Depth (feet)	27	50	605	605	30	500	680
Geologic age	Pleistocene	Pleistocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Pleistocene	Late ~~Eocene~~ Cretaceous and Paleocene	Late Cretaceous and Paleocene
Formation or Group	Columbia Group	Columbia Group	Mattaponi Formation	Mattaponi Formation	Columbia Group	Mattaponi Formation (?)	Mattaponi Formation
Date	July 2, 1918	July 2, 1918	June 8, 1948	May 15, 1953	July 1, 1918	1946	July 1, 1918
Silica (SiO_2)	12	---	14	---	---	---	37
Iron (Fe)	.23	---	.16	---	tr.	---	tr.
Calcium (Ca)	2.6	20	1.4	1.6	4.8	---	2.4
Magnesium (Mg)	7.1	10	.8	1.0	3.6	---	3.0
Sodium (Na) / Potassium (K)	45	60	146 (calc.)	---	65	---	230
Carbonate (CO_3)	17	---	4.9	11	24	---	115
Bicarbonate (HCO_3)	41	149	356	347	20	542	318
Sulfate (SO_4)	3.5	.5	17	---	5.4	1	37
Chloride (Cl)	28	40	2.8	2.8	41	110	8
Fluoride (F)	---	---	1.0	1.1	---	---	---
Nitrate (NO_3)	21	52	.6	.7	60	.1	.8
Dissolved solids	156	273	366	---	305	---	594
Hardness as $CaCO_3$	36	91	7	8	27	33	18
Specific conductance (micromhos at 25°C)	---	---	608	592	---	---	---
pH	---	---	8.3	8.5	---	7.9	---

Table ~~3~~ 15.--Chemical analyses of ground waters from wells in Northumberland County, Virginia--Continued
(Parts per million, except specific conductance and pH)

Well number	55a	55b	55c	55c	55c	56	56
Location	Reedville	Reedville	Reedville	Reedville	Reedville	Reedville	Reedville
Depth (feet)	14	18	740	740	740	785	785
Geologic age	Pleistocene	Pleistocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene
Formation or Group	Columbia Group	Columbia Group	Mattaponi Formation	Mattaponi Formation	Mattaponi Formation	Mattaponi Formation	Mattaponi Formation
Date	July 1, 1918	July 1, 1918	July 1, 1918	Feb. 27, 1941	May 15, 1953	Oct. 22, 1932	Feb. 16, 1938
Silica (SiO_2)	43	34	---	---	---	14.0	---
Iron (Fe)	---	2.9	---	---	---	3.4	---
Calcium (Ca)	18	4.0	---	---	0.8	2.2	8.0
Magnesium (Mg)	11	2.2	---	---	.5	5.3	1.5
Sodium (Na) Potassium (K)	256	49	---	---	---	164.0	---
Carbonate (CO_3)	0.0	0.0	120	---	0	14.4	14.4
Bicarbonate (HCO_3)	95	55	278	412	405	~~402.6~~ 403	432
Sulfate (SO_4)	31	13	34	20	---	32.2	40.2
Chloride (Cl)	380	42	10	7	8.9	14.0	8
Fluoride (F)	---	---	---	1.8	1.6	---	---
Nitrate (NO_3)	tr.	tr.	4.3	---	.8	.2	---
Dissolved solids	775	171	551	---	---	472.4	---
Hardness as $CaCO_3$	90	19	---	6	4	27.2	26.1
Specific conductance (micromhos at 25°C)	---	---	---	---	697	---	---
pH	---	---	---	---	8.3	---	---

Table 15.--Chemical analyses of ground waters from wells in Northumberland County, Virginia--Continued
(Parts per million, except specific conductance and pH)

Well number	56	56	58	63	73	73	75
Location	Reedville	Reedville	Reedville	Reedville	N of Fleeton	N of Fleeton	N of Fleeton
Depth (feet)	~~705~~ 685	~~705~~ 685	680	680	740	740	711
Geologic age	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene
Formation or Group	Mattaponi Formation	Mattaponi Formation	Mattaponi Formation	Mattaponi Formation	Mattaponi Formation	Mattaponi Formation	Mattaponi Formation
Date	June 8, 1948	May 15, 1953	July 2, 1918	July 1, 1918	July 2, 1918	Feb. 27, 1941	June 8, 1948
Silica (SiO_2)	---	---	25	24	22	---	15
Iron (Fe)	---	---	.40	.09	.04	---	.05
Calcium (Ca)	---	1.0	2	1.9	1.6	---	.7
Magnesium (Mg)	---	.5	1.3	1.2	2.3	---	.4
Sodium (Na)	---	---	} 201	199	202	~~[illegible]~~ as	185
Potassium (K)	---	---				~~[illegible]~~ as	
Carbonate (CO_3)	---	0	98	75	72	---	4 ~~3.9~~
Bicarbonate (HCO_3)	416	411	288	356	348	407	415
Sulfate (SO_4)	32	---	35	35	35	22	32
Chloride (Cl)	11	11	8	8.7	10	8	13
Fluoride (F)	1.6	1.6	---	---.6 ~~.59~~	---.6 ~~.56~~	2.2	2.4
Nitrate (NO_3)	.6	.9	.6			---	.5
Dissolved solids	---	---	525	526	506	---	455
Hardness as $CaCO_3$	~~416~~ 12	4	10	10	13	6	3
Specific conductance (micromhos at 25°C)	714	710	---	---	---	---	742
pH	---	8.3	---	---	---	---	8.3

Table 15.--Chemical analyses of ground waters from wells in Northumberland County, Virginia--Continued
(Parts per million, except specific conductance and pH)

Well number	75	77	77	78	83	83	85	85
Location	N of Fleeton	Fleeton	Fleeton	Fleeton	SSW of Burgess	SSW of Burgess	Ditchley	Ditchley
Depth (feet)	711	690	690	680	625	625	580	580
Geologic age	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene
Formation or Group	Mattaponi Formation	Mattaponi Formation	Mattaponi Formation	Mattaponi Formation	Mattaponi Formation	Mattaponi Formation	Mattaponi Formation	Mattaponi Formation
Date	May 15, 1953	July 2, 1918	Feb. 27, 1941	July 2, 1918	June 8, 1948	May 15, 1953	June 19, 1948	May 15, 1953
Silica (SiO_2)	---	26	---	22	---	---	---	---
Iron (Fe)	---	.06	---	---	---	---	---	---
Calcium (Ca)	0.8	1.5	---	---	---	1.8	---	1.0
Magnesium (Mg)	.5	1.7	---	---	---	.6	---	1.0
Sodium (Na)	---	} 194	---	---	---	---	---	---
Potassium (K)	---							
Carbonate (CO_3)	8	86	---	149	12	11	---	0
Bicarbonate (HCO_3)	406	303	429	559	452	448	452	557
Sulfate (SO_4)	---	35	23	6.3	22	---	34	---
Chloride (Cl)	11	9.5	7	20	3	4.6	8	9.2
Fluoride (F)	2.0	---	2.1	---	2.2	2.0	2.2	2.4
Nitrate (NO_3)	.8	.60	---	1.0	.6	1.0	.6	.8
Dissolved solids	---	524	---	851	---	---	---	---
Hardness as $CaCO_3$	4	11	9	---	15	7	12	6
Specific conductance (micromhos at 25°C)	722	---	---	---	768	761	780	779
pH	8.4	---	---	---	---	8.4	---	8.2

LANCASTER COUNTY

LOCATION AND DEVELOPMENT [1]

Lancaster County occupies the extreme southeastern end of the Northern Neck peninsula, on the north side of the Rappahannock River and the west side of Chesapeake Bay. It is bounded on the north by Northumberland and Richmond Counties. The area of Lancaster County is about 142 square miles, and its population in 1960 was 9,174.

The principal ~~industries~~ occupations in Lancaster County are agriculture, fishing ~~eries~~, and food processing. Tomatoes, raised in many parts of the Northern Neck, are processed at two canneries in Lancaster County. Poultry and some livestock are also produced. Fish, crabs, and oysters, which are processed in numerous plants in the county, have been important sources of income for many years.

Although there are no railroads, several Virginia primary highways traverse the county. Good water transportation is afforded by the numerous tidal inlets along the Rappahannock River.

Among the principal towns in Lancaster County are Lancaster, the county seat, in the north-central part. Irvington, where extensive shipping is carried on, is in the southeastern part of the county; Kilmarnock, in the eastern part, is near the Northumberland County line.

---

[1] For further information on the economic development of Lancaster County see Va. Div. of Planning, (1964) Economic Data Summary, Lancaster County.

TOPOGRAPHY AND DRAINAGE

The total relief ~~of~~ in Lancaster County is about 130 feet, the highest point being in the northern border of the county along the Potomac-Rappahannock drainage divide.

There is a low terrace bordering Rappahannock River and Chesapeake Bay, which is here correlated with the Pamlico terrace of Cooke (1931). Its average elevation is about 25 feet above sea level. This terrace has been subdivided locally by Wentworth (1930) into the Princess Anne and Dismal Swamp terraces, whose average elevations are about 15 and 25 feet above sea level, respectively. A small remnant of the Wicomico terrace, is present near the eastern end of the county between the Pamlico terrace and the Eastern Branch of Corotoman River. Adjacent to this remnant on the southwest is part of the Talbot terrace, with a maximum elevation of about 50 feet above sea level. The Sunderland terrace occupies the remainder of the county. Except for the Pamlico, each of these terraces has been well-dissected.

Insert Cooke 1931 in reference, p. 267

Check sp. Corotoman

The southern boundary of the county is along the Rappahannock River, whose drainage area extends west-northwestward across the northern Coastal Plain and across the Piedmont nearly to the Blue Ridge. Numerous creeks and tidal inlets, tributary to the tidewater portion of the Rappahannock, drain the southwestern half of the county. The largest of these is the Corotoman River, in the middle of the county, whose eastern and western branches extend across the entire county to the drainage divide on which the boundary between Lancaster and Northumberland counties is largely drawn. Four other small creeks drain into Fleets Bay, which borders Chesapeake Bay at the eastern end of the county. The shoreline of submergence has been modified somewhat by the tidal streams, and small spits have been formed on Poplar Neck and Fleets Island in Fleets Bay.

Basement Complex III

The basement bedrock complex probably lies on the order of 2,700 feet below sea level in Lancaster County according to DeBuchananne, (1968, Sheet 1). So far as known, no deep drilling has ever been undertaken to reach the bedrock surface. However, bedrock lies a little more than 2,300 feet below sea level in Mathews County to the south (Cederstrom, 1945, p. 49).

Cretaceous System--Potomac Group III

The continental sediments of the Potomac Group of Cretaceous age rest upon basement bedrock. No wells are believed have been drilled as yet to tap aquifers in the Potomac Group in Lancaster County, perhaps largely because adequate supplies at shallower depth can be more easily obtained from sandy layers in the overlying Mattaponi Formation. Farther south in the Virginia Coastal Plain they provide abundant supplies of ground water, and it may be expected that large additional reserves in these deposits remain virtually untapped in Lancaster County.

Although no chemical analyses of water from the Potomac are available, these sands where tapped elsewhere have been found to furnish water of generally excellent quality, except for possibly high fluoride content. Near the southernmost part of Lancaster County, chloride also may present a problem, and any wells drilled to tap the Potomac sands should be carefully monitored for possible progressive increase in chloride concentration in the water pumped.

Cretaceous to Tertiary Systems--Mattaponi Formation III

The Mattaponi Formation of Late Cretaceous and Paleocene age has been reached by many wells, and it lithologic character in this area is fairly well known. Typically, the formation consists of glauconitic clays and silts of various colors. Commonly, fine to coarse sand beds are present low in the section, as noted by Cederstrom (1957, p. 20) for the West Point area in King William County, about 20 miles to the southwest. The mottled clays that occur widely in the western part of the Northern Neck are apparently not as prevalent in Lancaster County, However, they are present at Kilmarnock, where 28 feet of mottled light brown clay is present below 645 feet. (See log, well 9, Table 17.)

The Mattaponi is probably at least 200 feet thick everywhere in the county; the top of the formation lies about 400 feet below sea level, in the western part of the county, to about 600 feet in the east.

The Mattaponi Formation is tapped by many wells in Lancaster County. Near Lancaster, a 740-foot well (8), put down in 1947 at a low elevation, flowed at a rate of 15 gpm (gallons per minute). Near the west branch of Corrotoman River, between Lancaster and Mollusk, a 737-foot well (6), 2 inches in diameter, was drilled in 1967 for a subdivision and yielded 125 gpm with 38 feet of drawdown from Mattaponi beds during a 2-hour pumping test. The permanent pump installation provides 40 gpm. In 1946, another 740-foot well (9), 8 inches in diameter, was drilled at Kilmarnock for public supply, and yielded 110 gpm by pumping, with a drawdown of 44 feet. In the southeastern part of the county, a 4-inch well (24) ~~with an 11-foot~~ yielded 22 gpm with 10 feet drawdown when tested. About 2 miles west of Palmer, a well (27) near White Stone Wharf, only 2 inches in diameter, was reported to flow at a rate of 50 gpm when completed at a depth of 680 feet in 1918.

At Irvington, three wells (32, 33, and 39) are recorded as having reached the Mattaponi. As of about 1918, the water level was at the surface at an elevation of about 20 feet. Well 32, drilled in 1938 for public supply to a depth of 750 feet, yielded 30 gpm by pumping; well 39, also a public-supply well, 742 feet deep, pumped 60 gpm with a 72-foot drawdown in a pumping test when the well was completed in 1945.

At Millenbeck, in the southern part of the county, well 42 reached the Mattaponi. It is 695 feet deep, and flowed 15 gpm in 1948, and was pumped at 40 gpm with a 20-foot drawdown. Another well (46) about a mile roughly south of Millenbeck, near Bertrand, flowed 18½ gpm in the late 1940's; it is 765 feet deep, and penetrates two sand beds aggregating 155 feet in total thickness between 450 and 690 feet below the surface.

In about 1920 or earlier, wells tapping the Mattaponi Formation reached confined aquifers which were under sufficient artesian head to permit flows of over 100 gpm in wells at low elevations. Thus, at Kilmarnock, in the eastern part of Lancaster County, a 637-foot 8-inch well (10) drilled in 1903 for public supply was reported at that time to flow at a rate of 140 gpm. Also at Kilmarnock, another public supply well (11), 620 feet deep and 3 inches in diameter, was reported flowing at a rate of 105 gpm in 1918. Both these wells tap the Mattaponi aquifers and are at low elevations--less than 10 feet above sea level. Nearly two miles east-southeast of Kilmarnock Wharf is a 610-foot well (13), reported to have a flow of 100 gpm in 1918.

A 3-inch well (17) in the vicinity of Ocran, northeast of White Stone, drilled prior to 1920 at an elevation of 6 feet, taps the Mattaponi; it flowed at 90 gpm in 1918. Half a mile roughly north of Palmer, a 580-foot 4-inch well (25) was drilled in 1913 tapping the Mattaponi. This well flowed 125 gpm at that time; in 1941 the flow had declined to a little over 60 gpm.

Because of the economic importance of the Mattaponi Formation in Lancaster County, representative wells tapping it have been sampled for analysis. Comparisons can be made over a period of 12 years for two wells, (27 and 32, Table 18), and for two others (13 and 25) earlier analyses made in 1918 also are available. Some of these results are discussed below.

Water from the Mattaponi Formation in the southeastern part of the county commonly is a soft sodium bicarbonate type, moderately mineralized, with a dissolved solids content ranging from about 500 to almost 900 ppm. Bicarbonate ranges from a little less than 400 to almost 550 ppm. Chlorides are significantly higher in this county than elsewhere in Northern Neck. Well 25 in southeasternmost Lancaster County, yields water containing 122 ppm of chloride and marks the edge of the high chloride wedge that extends inland as far as western James City County. Fluoride is rather high, from 2.2 to 3.8 ppm. Maximum of hardness is only about 50 ppm.

Water from a 580-foot well (25), two miles east of White Stone, was sampled for analysis in 1918, 1941, 1948, and 1953. In the most recent sample, the chloride was 122 ppm, an increase of 36 ppm over the concentration in 1918. This may reflect a true change in the quality of water rather than analytical error inasmuch as a real change in hardness has also taken place in that time span.

Although a chloride content of 122 ppm is not particularly high, and is well below the generally permissible maximum of 250 ppm recommended by the U.S. Public Health Service (1962), it is nevertheless the highest recorded for wells tapping the Mattaponi in the Northern Neck. The chloride is attributed to incomplete artesian flushing of sea water that invaded the sediments during the last marine transgression (Sanford, 1913, p. 114).

A 560-foot well (28) sampled in 1918 at Cherry Point, south of White stone, yields water with a chloride content of 40 ppm. Well 27, south of White Stone, was sampled for partial analysis in 1941, 1948, and again in 1953, but showed an apparent reduction in chloride content, from 30 to 16 ppm, in the last sample analyzed. Fluoride is high in this water, about 3 ppm, or about twice the recommended maximum of 1.5 ppm for domestic use.

At Irvington, a 750-foot well (32) also was sampled from 1941 to 1953. The diminution of chloride content from 12 to 5.6 ppm may be significant. In this water fluoride is also high, about 3 ppm.

Thus, ground water from the Mattaponi Formation is, in general, a high-fluoride, soft water with a high sodium bicarbonate content. It is low in chloride content except in the southeasternmost part of the county. The high fluoride concentrations present a minor problem where domestic use involves growing children. In such cases, low-fluoride bottled table water may be desirable. The cost of such use may be reduced by diluting the bottled water with the

high-fluoride well water in such proportions that the fluoride content of the latter would be reduced to about 1 to 1.5 ppm.

The well at Bertrand (49), yields a low chloride water in which total dissolved solids are about as high, 810 ppm, as found in any water in Northern Neck Peninsula.

Chickahominy Formation IV

The Chickahominy Formation of Late Eocene age has been tapped by many wells in Lancaster County. It consists of clay, sandy clay, and fine sand, and is 80 feet or more in thickness. Like the Aquia and lower Nanjemoy, the Chickahominy probably has been in part removed by a marine transgression--in this case the advancing Miocene seas.

Water-Bearing Character V

The Chickahominy Formation in Lancaster County yields adequate supplies where sandy beds are present. It appears to be generally a better source than the Nanjemoy, and being shallower it is reached more cheaply. The Chickahominy is the first good water bearing horizon reached by wells beneath the relatively poorly productive Chesapeake Group.

Many of the wells (20, 34, 36, 45) in the Chickahominy were drilled around the turn of the century and had small but adequate artesian flows. Some wells had considerably greater flows, as well 56, near Mollusk, put down some years earlier, ~~that~~ flowed 50 gpm in 1903. On the other hand, well 20, near Foxwells, drilled in 1896, did not flow.

Five wells (47-49, 53, and 55) in the southwestern part of Lancaster County are believed to tap the Chickahominy Formation. Well 47 in Bertrand flowed at 2 gpm in 1902 with an artesian head of 18 feet above the surface. Well 48, also at Bertrand, flowed at $1\frac{1}{2}$ gpm in 1889 with a similar artesian head. Well 55, west of Mollusk, flowed at 1 gpm in 1918.

With respect to chemical quality of ground water in the Chickahominy Formation, a 480-foot well (12) near Kilmarnock was sampled in 1918; the water is a soft sodium bicarbonate type. The chloride concentration is very low, only 4.5 ppm; the hardness, 18 ppm. In the western part of the county, well 3 at Lively, used for public supply, yields a more moderately mineralized water from this well (dissolved solids, 400 ppm) of the same type. It is of generally excellent quality but is somewhat high in iron (0.83 ppm) which ~~should~~ might be removed by aeration or other treatment. Fluoride is 1.8 ppm--not significantly above the desirable public-supply maximum of 1.5 ppm.

The well near Ocran (15), already mentioned, which may develop water from the Chickahominy or the Nanjemoy, was sampled for analysis in 1918 and in 1941. The chloride is low, 14 ppm, the total hardness, 13 ppm, and the bicarbonate about 450 ppm.

Chesapeake Group IV

The Chesapeake Group of Miocene age overlies the Eocene sediments, and in Lancaster County consists typically of clays, with minor beds of sands with some shells and shell marl. Clays and other fine sediments predominate over sand. In thickness, the Chesapeake may exceed 300 feet in the southeastern part of the county, as at Palmer (22, Table 17). It is somewhat thinner westward, up-dip, being a little over 100 feet thick at Morattico in the extreme western part of the county.

Water-Bearing Character

A few wells in the county obtain a supply from the uppermost strata of the Chesapeake Group. An analysis of water from a well finished in the Miocene at Lively (2) is shown in Table 18. It is a hard calcium bicarbonate water. Chloride and nitrate are high, respectively 53 and 68 ppm, suggesting organic pollution. Irrespective of the possibility of pollution, use of water this high in nitrate would be dangerous in infant feeding formulas because of the danger of methemoglobinemia, as discussed earlier in this report.

It is reported that a well on Taylor Creek, 2 miles northwest of Irvington, yielded "sulfur" water probably from Miocene rocks at 110 feet below the surface, but this zone was cased off and the well drilled deeper for water of more satisfactory quality.

It is reported that a well on Taylor Creek, 2 miles northwest of Irvington, yielded "sulfur" water probably from Miocene rocks at 110 feet below the surface, but this zone was cased off and the well drilled deeper for water of more satisfactory quality.

Deposits of the Columbia Group of Pleistocene age form the surficial deposits of virtually all of Lancaster County. They reach a maximum thickness of over ~~100~~ 50 feet, and consist of yellowish sands, clays, and, locally fine gravel. (See Fig. 9) They are overlain only locally by minor alluvial channel and beach deposits of Holocene ~~(Recent)~~ age.

Because the demand for water ordinarily is not great from dug wells or shallow drilled wells tapping the Columbia Group, yields are rarely reported. Doubtless, however, substantial supplies can be obtained in places on lower ground by multiple shallow well systems, but adequate precautions should be taken against surface contamination.

Figure 9.--Sands of Pleistocene age exposed in cliff on north shore of Rappahannock River southwest of White Stone, Lancaster County.

Summary of Ground-Water Conditions

Potentially good reserves are believed to exist in sands of the Potomac Group, which are as yet untapped in Lancaster County. However, chloride may be a problem, and any ground-water development should be carefully monitored.

Supplies of more than 100 gpm can be readily obtained from individual wells in the Mattaponi Formation. However, wells 6 to 8 inches in diameter, properly constructed and developed, should produce 700 to 1,000 gpm or more. The water in the Mattaponi generally is of the soft sodium bicarbonate type.

Small artesian flows and minor supplies to pumped wells are obtainable from the Nanjemoy Formation, although it is not tapped by many wells in the county because of the better potential of the shallower Chickahominy Formation.

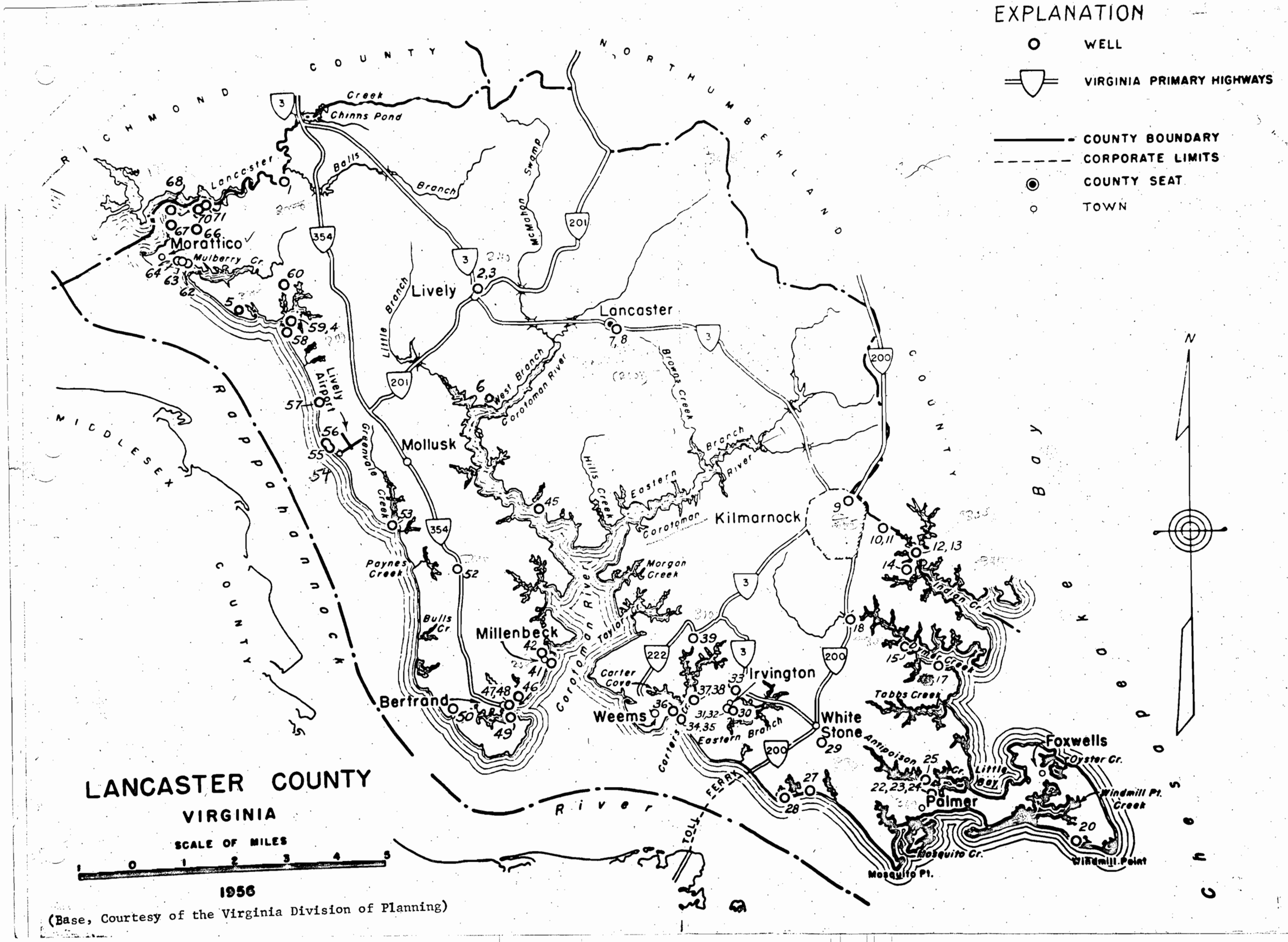
The Chickahominy is tapped by many wells in the county and provides small industrial and domestic supplies. The water is soft and of generally good quality.

The Chesapeake Group is not very satisfactory as a source of ground water. The water is likely to be hard, and iron and sulfides may be troublesome.

The near-surface Columbia Group supplies water to many small-yield domestic and farm wells. Many are dug wells, and precautions should be taken against contamination from surface drainage.

Well Records and Chemical Analyses

Records of wells, available logs, and chemical analyses of water samples in Lancaster County are given in Tables 16, 17, and 18 on the pages that follow. Locations of wells listed in Tables 16 through 18 are given in Figure 10 preceding the tables.



(Base, Courtesy of the Virginia Division of Planning)

Table 16.4.—Records of wells in Lancaster County, Virginia

Type of well: D, drilled; J, jetted; Dv, driven
Use of water: D, domestic; PS, public supply; I, industrial; S, stock

gpm, gallons per minute; Fm, formation
Temp., temperature (degrees Fahrenheit)

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
1	3 mi. NE of Morattico	Bass Smith Canning Co.	O. D. Hale	1918	2		241		Late Eocene	Chickahominy Fm	(+)			See log, Table 17.	1
2	Lively	Hale's Garage			103	Dug	60		Miocene	Chesapeake Group	-50		D	See analyses, Table 18. Excessive nitrate; unfit for drinking.	2
3	Do.	Sydnor Hydrodynamics, Inc.	Sydnor Hydrodynamics Inc.	1946	103	D	365	8	Late Eocene	Chickahominy Fm	-91		PS	See log, Table 17; analyses, Table 18.	3
4	2.7 mi. ESE of Morattico	W. T. Pittman & Sons	Reynolds & Norman	1949	5	J	725		Late Cretaceous and Paleocene	Mattaponi Fm	(+)		I	See log, Table 17. Flowed 25 gpm in 1949. Used only for washing down oyster plant.	4
5	2 mi. ESE of Morattico	H. Marston Smith	Reynolds & Norman	1949	4	J	280		Eocene	Nanjemoy Fm	(+)		D	See log, Table 17. Flows 3 gpm.	5
6	2.8 mi. WSW of Lancaster	Corrotoman-by-the-Bay Water System	Douglas & Dickinson, Inc.	1967	100 (?)	D	737	6-3-2	Late Cretaceous and Paleocene	Mattaponi Fm	-102	40	PS	Drawdown 38 feet after 2 hrs. pumping at 125 gpm	6
7	Lancaster	A. R. Beane	Reynolds & Norman	1951	5	J	438		Late Eocene	Chickahominy (?) Fm	(+)			See log, Table 17.	7
8	Do.	I. V. Farlee	W. S. Reynolds	1947	5	J	740	2	Late Cretaceous and Paleocene	Mattaponi Fm	(+)		D	Flows 15 gpm.	8
9	Kilmarnock	Town	Sydnor Hydrodynamics Inc.	1946	89		740	10-8	do	do	-75		PS	See log, Table 17. Drawdown 44 feet after pumping 24 hrs. at 110 gpm.	9
10	1 mi. ESE of Kilmarnock	do	Milligan	1903	8		637	2	do	do	(+)		PS	Flow reported 140 gpm in 1903.	10
11	Do.	do	Milligan	1914	5		620	3	do	do	(+)		PS	See analysis, Table 18. Flow reported 105 gpm in 1918.	11
12	1.8 mi. ESE of Kilmarnock	Menhaden Products Co.; formerly Eubank Tankard Co.			2		480		Late Eocene	Chickahominy Fm			I	See analysis, Table 18.	12
13	Do.	do	Milligan	Prior to 1918	2		610	3	Late Cretaceous and Paleocene	Mattaponi Fm	(+)		I	See analyses, Table 18. Flow reported 100 gpm, water level 14 ft above surface in 1918.	13
14	1.8 mi. SE of Kilmarnock	Alexandria Police Boys' Camp	Reynolds & Norman	1950	8	J	635	4-3-2	do	do	(+)		D	See log, Table 17. Pumps 10 gpm.	14
15	2.4 mi. NE of White Stone	Standard Products Co.; formerly Dymer Fish Co.		Prior to 1918	5		507	4½	Eocene	Nanjemoy and Chickahominy Fms	(+)		I	See log, Table 17 (from Bull. 5, Va. Geol. Survey); analyses, Table 18. Flow reported 120 gpm in 1913.	15
17	2.7 mi. ENE of White Stone	Bellows & Squire	Milligan	1907	6		660	3	Late Cretaceous and Paleocene	Mattaponi Fm	(+)			Flow reported about 90 gpm in 1918.	17
18	2.2 mi. NNE of White Stone	R. T. Herndon	Sydnor Hydrodynamics Inc.	1951	25	D	634	3	do	do	(-)			See log, Table 17; analysis, Table 18. Water level very near surface in 1951.	18
20	1.5 mi. SSE of Foxwells	B. L. Farinholt		1896	2		443		Late Eocene	Chickahominy Fm	(-)			Did not flow.	20
22	0.3 mi. N of Palmer	T. A. Treakle	Mitchell's Well and Pump Co.	1941	5	D	666	4-3	Late Cretaceous and Paleocene	Mattaponi Fm	(+)			See log, Table 17.	22

Table 16 ~~4~~. —Records of wells in Lancaster County, Virginia

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
23	0.3 mi. N of Palmer	Treakle Fish Factory	Mitchell's Well and Pump Co.	1945	5	D	660	6	Late Cretaceous and Paleocene	Mattaponi Fm	+12		I	See log, Table 17 ~~5~~.	23
24	Do.	T. A. Treakle	do	1946	5	D	824	6–4	do	do	(+)	22		Flows 10 gpm. Drawdown 10 ft when pumping 22 gpm. Gravel-packed well.	24
25	0.5 mi. N of Palmer	Little Bay Ice Co.	R. H. Milligan	1913	3		580	4½	do	do	+12		I	See analyses, Table 18 ~~6~~. Flowed more than 60 gpm in 1941. Flow reported 125 gpm in 1913.	25
27	1.3 mi. S of White Stone	W. H. Culver		1918	5		680	2	do	do	(+)			See analyses, Table 18 ~~6~~. Flow reported 50 gpm in 1918.	27
28	1.5 mi. SSW of White Stone	Taft Fish Co.			5		560	3	do	do	(+)		I	See analysis, Table 18 ~~6~~.	28
29	White Stone	White Stone School	Sydnor Hydrodynamics Inc.	1945	40	D	641		do	do	−35	93	D	See log, Table 17 ~~5~~. Drawdown 93 ft after 8 hours pumping at 93 gpm.	29
30	Irvington	Messick & Gumby	H. A. Crittendon	1903	4		450	1½	Eocene	Nanjemoy Fm	(+)		I	See analysis, Table 18 ~~6~~. Flow reported 2 gpm, water level 6 ft above surface, in 1903. Oyster packing house.	30
31	Do.	Sydnor Hydrodynamics, Inc.		Prior to 1912	10		580	4	Late Cretaceous and Paleocene	Mattaponi Fm	(+)		PS	Flow reported 50 gpm in 1912.	31
32	Do.	Bernard Willing		1938	8		750	8–2	do	do	(+)		PS	See log, Table 17 ~~5~~; analyses, Table 18 ~~6~~. Pumps 30 gpm.	32
33	Do.	W. McDonald Lee			25		690	3	do	do	(−)			Water level at surface in 1918.	33
34	0.5 mi. ESE of Weems Weems	I. H. Francis			6		330?	2	Late Eocene	Chickahominy Fm	(+)			Flow reported 1½ gpm in 1905.	34
35	Do.	do			5		537	3	Late Cretaceous and Paleocene	Mattaponi Fm	(+)			In 1905, flow reported 50 gpm, water level 18 ft above surface.	35
36	Weems	Doggett & Chance			3½		330	1½	Late Eocene	Chickahominy Fm	(+)			In 1896, flow reported 2½ gpm, water level 6 ft above surface.	36
37	0.8 mi. W of Irvington	Joseph Childs		1600's	5	Dug	21	48	Pleistocene	Columbia Group	−12			Reported iron taste; soft. Formerly King Carter Plantation.	37
38	Do.	Carters Creek Fish & Guano Co.			6	D	580	3–2	Late Cretaceous and Paleocene	Mattaponi Fm	(+)		I	In 1899, flow reported 50 gpm, water level 35 ft above surface.	38
39	1.5 mi. NW of Irvington	Sydnor Hydrodynamics, In c.	Sydnor Hydrodynamics Inc.	1945	6	D	742	8	do	do	−4		PS	See log, Table 17 ~~5~~. Pumps 60 gpm with 72-ft drawdown.	39

Table 16 4. —Records of wells in Lancaster County, Virginia

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
41	Millenbeck	Millenbeck Oyster Co.		1892	5		315	1½	Late Eocene	Chickahominy Fm					41
42	Do.	J. W. Sawdy	Reynolds & Norman	1948	10	J	695		Late Cretaceous and Paleocene	Mattaponi Fm	(+)	40	D	See log, Table 17 5. Pumps 40 gpm with 20-ft drawdown; flow reported 15 gpm in 1948.	42
45	3 mi. N of Millenbeck	Craille Jones & Co.			5		325	2½	Late Eocene	Chickahominy Fm	(+)?		I	Flow reported ½ gpm, 1902	45
46	0.4 mi. NE of Bertrand	T. D. McGuinness	Mitchell's Well and Pump Co.		3		765		Late Cretaceous and Paleocene	Mattaponi Fm	(+)			See log, Table 17 5. Reported to flow at 18½ gpm.	46
47	Bertrand	J. C. Ewell			12		275	2	Late Eocene	Chickahominy (?) Fm	(+)			In 1902, flow reported 2 gpm, water level 18 ft above surface.	47
48	Do.	T. J. Ratcliffe & Co.			9		272	1¼	do	do	+18	1½		In 1889, flow reported 1½ gpm, water level 18 ft above surface.	48
49	0.3 mi. S of Bertrand	V. E. Towles			3		300+	1½	do	do				See analysis, Table 18 6.	49
50	1 mi. W of Bertrand	Haynes			5		650(?)	2	Late Cretaceous and Paleocene	Mattaponi Fm				See analysis, Table 18 6.	50
52	2.4 mi. SSE of Mollusk	Faye	Mitchell's Well and Pump Co.		43	D	530		do	do				See log, Table 17 5.	52
53	1.3 mi. S of Mollusk	F. B. George		1903	6	D	225		Late Eocene	Chickahominy (?) Fm			I	Used for washing oysters.	53
54	About 1 mi. NW of Mollusk	Alexander Leland	Reynolds & Norman		2	J	315		Late Eocene	Chickahominy Fm	(−)	10	D	See log, Table 17 5. Pumps 10 gpm.	54
55	1.6 mi. W of Mollusk	B. L. Farinholt			6		255		Late Eocene	Chickahominy (?) Fm	(+)?			Flow reported 1 gpm in 1918	55
56	Do.	do			6		300	1½	Late Eocene	Chickahominy Fm				In 1889, flow reported 50 gpm, and water level 12 feet above surface. Three other similar wells nearby.	56
57	2 mi. NW of Mollusk	Gibbons	S. Conrad		3	J	318	1½	do	do	(+)		D	Water delivered by hydraulic ram. Flows 3½ gpm.	57
58	3 mi. ESE of Morattico	M. P. Wills			2	J		1½					D,S	Flow reported 3 gpm. Formerly equipped with hydraulic ram.	58
59	Do.	W. R. Pittman	S. Conrad		3	J	275?	1½	Late Eocene	Chickahominy Fm	(+)		I	Flow reported 5 gpm, 1946. Oyster packing plant.	59
60	2.4 mi. E of Morattico	J. G. Pollard	H. Lyons		10	J	275	1½	do	do	(+)		D,S	Flow reported 3 gpm, 1946. Supplies 125 head of stock. Four other similar wells nearby.	60

Table 16. —Records of wells in Lancaster County, Virginia

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
62	0.5 mi. E of Morattico	Whealton Packing Co.		19031	4		265	1½	Late Eocene	Chickahominy Fm			I	Flow reported 20 gpm in 1903; water level 15 ft above surface in 1908.	62
63	Do.	J. W. Whealton		1894	6		262	1½	do	do					63
64	Do.	Lewis Lankford Lull			8		256	1½	do	do	(+)			Flow reported 16 gpm in 1902.	64
66	0.9 mi. NE of Morattico	J. R. Crabbe			12	Dv	12	2	Pleistocene	Columbia Group			D	Water leaves iron stain.	66
67	0.7 mi. N of Morattico	B. Koons	S. Conrad		1	J	278	1½	Late Eocene	Chickahominy Fm	(+)		D	Flow reported 10 gpm in 1946.	67
68	1 mi. N of Morattico	J. R. Crabbe			12	J		2			−1½		D,S	Water stored in 500-gallon tank on windmill.	68
70	1.2 mi. NE of Morattico	F. E. Bornis			3	J	278	1½	Late Eocene	Chickahominy Fm	(+)		D,S	Flows 10 gpm.	70
71	1.4 mi. NE of Morattico	W. Clarke			7	J	275	1¼	do	do	(−)		D,S	Another similar well nearby; flowed until about 1946.	71

Table 17.--Logs of wells in Lancaster County, Virginia

Well 1, Litwalton; Bass Smith Canning Co.

(Log by O. D. Hale, driller; correlations by A. Sinnott and D. J. Cederstrom)

Altitude, 5 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Mud, black	15	15
Sand, yellow	12	27
Sand, coarse, brown	10	37
Chesapeake Group (Miocene):		
Sand, greenish	13	50
Clay, blue	50	100
Clay, sandy, green	11	111
Clay, Blue	30	141
Chickahominy (?) Formation (Upper Eocene):		
Clay, gritty, green	20	161
Clay, blue	34	195
Clay, dark-green	11	206
Nanjemoy Formation (Eocene):		
Sand, dark-gray; water-bearing	18	224
Sand, gray-green, and shells	1	225
"Rock"	$\frac{1}{2}$	$225\frac{1}{2}$
Sand, gray-green, and shells	$5\frac{1}{2}$	231
Sand, and "rock," interbedded; water-bearing	10	241

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 3, Lively; Sydnor Hydrodynamics, Inc.

(Drilled by owner; log from driller's record; correlations by A. Sinnott and D. J. Cederstrom)

Altitude, 102 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Soil	1	1
Clay, yellow; stiff	14	15
Chesapeake Group (Miocene):		
Clay, sandy; brown	111	126
Clay, blue	17	143
Silt, blue	13	156
Clay, blue	188	344
Chickahominy Formation (Upper Eocene):		
Sand, gray, medium-fine, and clay	11	355
Clay, brownish-gray; Foraminifera	10	365

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 4, Somers; W. R. Pittman & Sons

(Drilled by Reynolds & Norman. Sample descriptions by G. C. Chaterji from 53 to 500 feet; remainder by James H. Kempf; correlations by D. J. Cederstrom)

Altitude, 5 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Undescribed (no samples)	53	53
Sand, light greenish-gray, quartz, very fine, with subordinate iron ores and mica flakes	11	64
Chesapeake Group (Miocene):		
Silt, sandy, light greenish-gray, iron ores, with a few shell fragments	11	75
Clay, yellowish-gray	11	86
Clay, greenish gray, with a little sand	21	107
Silt, sandy, greenish-gray, with quartz and iron ores	20	127
Sand, fine, gray; angular and rounded quartz grains iron ores, zircon, glauconite, shell fragments	10	137
Silt, greenish-gray, with rounded quartz grains and some iron ores; fragments of fossil tests in lower portion	24	161
Silt, yellowish-gray, with fine quartz grains; iron ores and glauconite in upper portion	21	182
Silt, olive gray, with fine quartz, iron ores, and Foraminifera	21	203

(more)

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 4, Somers; W. R. Pittman & Sons--Continued

	Thickness (feet)	Depth (feet)
Chickahominy Formation (Upper Eocene):		
Sand, fine, light greenish-gray; quartz and iron ores; shell fragments and Foraminifera	8	211
Silt, sandy, dark olive gray, with quartz grains, iron ores, and shell fragments	15	226
Sand, very fine, light gray, with silt; quartz grains, iron ores and shell fragments richer in silt in lower portion	21	247
Nanjemoy Formation (Eocene):		
Sand, very fine, olive gray, with a little clay; quartz, minor iron ores, and shell fragments	10	257
Sand, fine, dark olive gray, with a little clay; quartz, glauconite, iron ores, and shell fragments	8	265
Sand, fine, gray; quartz, glauconite, iron ores, and a few shell fragments	13	278
Sand, fine, light olive gray; quartz, glauconite, iron ores, and shell fragments	11	289
Undescribed (no samples)	22	311
Clay, dark olive gray; glauconitic, with quartz grains and shell fragments	34	345
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Clay, dark olive gray; somewhat more glauconitic, with quartz grains and shell fragments	57	402
Clay, olive gray, glauconitic	18	420
Silt, light olive gray, with a little glauconite and quartz	10	430
Silt, olive gray, with glauconite and fine quartz sand	40	470

(more)→

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Wells 4, Somers; W. R. Pittman & Sons--Continued

	Thickness (feet)	Depth (feet)
Mattaponi Formation--Continued		
Silt, light olive gray, with minor glauconite, quartz, and mica flakes	20	490
Silt, light olive gray, with minor glauconite, quartz, and fragments of carbonized wood	10	500
Silt, pale yellowish-brown, with abundant medium to coarse grains of glauconite and some quartz	10	510
Silt, pale yellowish-brown, with some flakes of mica	12	522
Silt, light olive gray with flakes of mica	13	535
Undescribed (no samples)	82	617
Sand, very fine, light brown, with mica flakes	40	657
Sand, very fine, light brown, with medium to very coarse quartz grains	21	678
Sand, very fine, light brown, with some mica flakes	11	689
Sand, very fine, light brown, with rare mica flakes	4	693
Sand, fine to medium, pale yellowish-brown, with common mica flakes and angular to subangular quartz grains	11	704
Sand, medium to coarse, pale yellowish-brown, Subangular to angular quartz grains, well-sorted; very rare glauconite	21	725

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 5, 1.8 miles east-southeast of Morattico; H. Marston Smith

(Log from driller's record furnished by Reynolds & Norman; correlations by D. J. Cederstrom)

Altitude, 4 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Subsoil	35	35
Chesapeake Group (Miocene):		
Clay, sandy, blue	10	45
Clay, blue; tough clay layer at about 210 feet	165	210
Chickahominy(?) Formation (Upper Eocene):		
Mud, brown; tough clay layer at about 244 feet	34	244
Clay, tough, and thin layers interbedded with blue clay and sand	13	257
Nanjemoy Formation (Eocene):		
Sand, black and white; water-bearing	23	280

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 7, Lancaster; A. R. Beane

(Log in part from driller's record furnished by Reynolds & Norman; correlations by A. Sinnott and D. J. Cederstrom)

Altitude, 5 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Subsoil	30	30
Clay, blue, and sand	45	75
Chesapeake Group (Miocene):		
Clay, pink and white	25	100
Clay, blue	38	138
Clay, light green and blue	12	150
Sand, fine, white, and shell	2	152
Clay, green	112	264
Clay, tough	1	265
Sand, white, and shells	12	277
Clay, silty, brown	13	290
Clay, silty, brown	11	301
Chickahominy Formation (Upper Eocene):		
Clay, tough; Foraminifera	9	310
Clay, gray	9	319
Undifferentiated Upper Eocene, Eocene, and Paleocene Sediments:		
Undescribed (probably penetrates water-bearing sands)	119	438

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 9, Kilmarnock; Town of Kilmarnock

(Log from driller's record furnished by Sydnor Hydrodynamics, Inc.; correlations by D. J. Cederstrom)

Altitude, 89 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Topsoil	1	1
Clay, yellow	11	12
Clay, sandy, yellow	55	67
Chesapeake Group (Miocene):		
Clay, blue	71	138
Clay and sand; hard	5	143
Clay and sand, soft; shells	7	150
Clay, blue	35	185
Clay, sandy	5	190
Clay, blue	33	223
Clay, blue, soft; somewhat sandy	15	238
Clay, blue	11	249
Clay, blue; fine sand and shells	5	254
Clay, blue	142	396
Chickahominy(?) Formation (Upper Eocene):		
Clay, sandy, blue; shells	5	401
Clay, sandy, hard	13	414
Clay, sandy, blue	5	419
Clay, and hard sand	24	443

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 9, Kilmarnock; Town of Kilmarnock--Continued

	Thickness (feet)	Depth (feet)
Chickahominy(?) Formation (Upper Eocene)--Continued		
Clay, blue, streaks of gray "rock"; Foraminifera	32	475
Clay, blue, glauconitic	14	489
Clay, light green, sticky, with layers of black and brown sand	6	495
Nanjemoy Formation (Eocene):		
Clay, blue, and black sand	75	570
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Clay, blue	48	618
Clay, sandy, black	27	645
Clay, mottled, light brown	28	673
Clay, sandy, gray	25	698
Sand, medium; hard	34	732
Clay, gray	8	740

(end)

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 14, 1.8 miles southeast of Kilmarnock; Alexandria Police Boys' Camp

(Lithology by James H. Kempf, based on samples collected at depth indicated; thicknesses approximate; correlations, and notes on Foraminifera, by D. J. Cederstrom)

Altitude, 5 feet

	Thickness (feet)	Depth (feet)
Chesapeake Group (Miocene):		
Undescribed (no samples)	65	65
Sand, very fine to fine, light olive gray glauconite, mica flakes, and shell fragments	50	115
Sand, very fine to fine, light olive gray glauconite, mica flakes, and shell fragments	60	175
Sand, fine to medium, grayish-green; shell fragments and siliceous spicules common, with some glauconite and mica flakes	45	220
Silt, grayish-green; some mica flakes and shell fragments; Miocene Foraminifera	140	360
Chickahominy Formation (Upper Eocene):		
Sand, fine to medium, light olive gray; abundant glauconite, shell fragments common, rare pyrite; late Eocene Foraminifera	20	380
Sand, medium to coarse olive gray; very abundant coarse yellow quartz grains; medium clear quartz grains; 30-40% of sample is fresh glauconite; shell fragments; late Eocene Foraminifera	60	440
Nanjemoy(?) Formation (Eocene):		
Sand, medium to coarse, olive gray; yellow quartz grains and mica rare; about 25% glauconite	20	460

MORE ->

? note Percent symbol

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 14, 1.8 miles southeast of Kilmarnock; Alexandria Police Boy's Camp--Continued

	Thickness (feet)	Depth (feet)
Mattaponi(?) Formation (Upper Cretaceous and Paleocene):		
Sand, medium, greenish black; quartz and shell fragments common, mica rare; about 80% glauconite; Foraminifera of Aquia aspect	40	500
Sand, medium, dark greenish gray, glauconite, with about 15% silt; quartz rare	40	540
Sand, medium to coarse, dark greenish gray; about 45% glauconite and 45% quartz; 10% silt; Foraminifera and mica rare	60	600
Sand, coarse to medium, white; subangular clear and milky quartz	35	635

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 15, At Ocran, 2.4 miles northeast of White Stone; Standard Products Co.; formerly, Dymer Fish Co.

(Log from Bull. 5, Virginia Geol. Survey; correlations by A. Sinnott and D. J. Cederstrom)

Altitude, 5 feet

	Thickness (feet)	Depth (feet)
Columbia and Chesapeake Groups, undifferentiated (Pleistocene and Miocene):		
Clay, blue; tough; 30inch sand bed at 170 feet	237	237
Marl, with shells and gravel	2	239
Gravel, water-bearing; water level rises to within 10 feet of the surface	2	241
Clay, blue	7	248
Sand, coarse, mixed with yellow and green clay; overlain by thin rock layer	2 ½	250 ½
Undescribed	2 ½	253
Chickahominy and Nanjemoy Formations, undifferentiated (Upper Eocene and Eocene):		
Clay	132	385
Sand, medium coarse; dark	3	388
Clay, blue	47	435
Sand, coarse, dark buff; underlain by white sand; water-bearing, flows 7 gpm.	8	443
"Rock," hard; very tough; porous	21	464
Sand, coarse; mixed with micaceous clay;	10 ½	474 ½
Undescribed (no sample)	1 ½	476
"Rock," hard	3	479
Mattaponi(?) Formation (Upper Cretaceous and Paleocene):		
Clay, blue, and sand	28	507

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 18, 2.2 miles north-northeast of White Stone; R. T. Herndon

(Log from driller's record furnished by Sydnor Hydrodynamics, Inc.; correlations by D. J. Cederstrom)

Altitude, 5 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Topsoil	1	1
Sand, fine, brown, and mud	39	40
Chesapeake Group (Miocene):		
Clay, blue, and mud	6	46
Mud, blue, and "quicksand"	10	56
"Quicksand" and mud	69	125
Clay, light gray	43	168
Clay, dark gray, with a few shells and fine sand	27	195
Shells, "quicksand" and mud	32	227
Clay, dark brown	18	245
Clay, dark gray	70	315
Clay, and mud	23	338
Chickahominy(?) Formation (Upper Eocene):		
Sand, fine, and green mud	34	372
Clay, dark	22	394
Sand, black, and mud; some black sandstone	23	417
Nanjemoy Formation (Eocene):		
Clay, hard	25	442
Shells, cemented	5	447

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 18, 2.2 miles north-northeast of White Stone; R. T. Herndon--Continued

	Thickness (feet)	Depth (feet)
Nanjemoy Formation--Continued		
Clay, dark	21	468
Mattaponi(?) Formation (Upper Cretaceous and Paleocene):		
Clay, hard	21	489
Clay, dark	13	502
Clay, hard	2	504
Mud and "quicksand"	18	522
Sand, black and mud	14	536
Clay, light gray	4	540
Sand, black, and mud	38	578
Sand, gray, fine, and clay	3	581
Sand, and fine gravel, muddy	6	587
Sand, and gravel	47	634

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 22, Palmer; T. A. Treakle

(Log from driller's record furnished by Mitchell's Well and Pump Co.; correlations by A. Sinnott and D. J. Cederstrom)

Altitude, 5± feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Sand	90	90
Chesapeake Group (Miocene):		
Clay, blue	85	175
"Rock"	5	180
Sand	25	205
Clay, green	75	280
Sand	40	320
Mud, blue	45	365
Chickahominy(?) Formation (Upper Eocene):		
Sand	34	399
Clay, blue	11	410
Shells	10	420
Sand and "rock," interbedded	30	450
Nanjemoy Formation (Eocene):		
Mud, blue, and sand	30	480
Mud	40	520
Mattaponi(?) Formation (Upper Cretaceous and Paleocene):		
Sand	25	545
Clay	30	575
Sand, black	5	580
"Rock"	45	625

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 22, Palmer; T. A. Treakle--Continued

	Thickness (feet)	Depth (feet)
Mattaponi(?) Formation--Continued		
Sand	5	630
"Rock"	10	640
Sand	15	655
"Rock"	10	665
Gravel	1	666

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 23, Palmer; Treakle Fish Factory

(Log from driller's record furnished by Mitchell's Well and Pump Co.; correlations by A. Sinnott and D. J. Cederstrom)

Altitude, 5± feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Clay, yellow, and sand	10	10
Chesapeake Group (Miocene):		
Clay, blue, and caving sand	70	80
Sand, blue	10	90
Clay, blue	40	130
Mud, blue	115	245
Marl, blue	85	330
Chesapeake Group (Miocene) and Chickahominy Formation (Upper Eocene), undifferentiated:		
Mud, yellow; some sand	126	456
Nanjemoy Formation (Eocene):		
"Rock"	6	462
Mud, blue, and shell marl	13	475
Sand, black	5	480
Sand, black, and mud	40	520
Mattaponi(?) Formation (Upper Cretaceous and Paleocene):		
"Rock"	3	523
Mud, blue	7	530
Marl, blue	50	580
"Rock"	3	583
Sand, black	14	597
Sand, yellow; very fine	38	635
Sand, yellow; fine	25	660

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 29, White Stone; White Stone School

(Log modified from driller's record furnished by Sydnor Hydrodynamics, Inc.; correlations by A. Sinnott and D. J. Cederstrom)

Altitude, 40 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Sand, and clay	6	6
Sand, fine, and gravel	18	24
Chesapeake Group (Miocene):		
Marl (?), gray	43	67
Gravel, and sand	8	75
Marl, dark	5	80
Sand	5	85
Sand, hard, and gravel	5	90
Marl, gray	130	220
Marl, green	150	370
Chickahominy Formation (Upper Eocene):		
Sand, some gravel	17	387
Marl, green	28	415
Clay, gray	10	425
Nanjemoy Formation (Eocene):		
Clay, green	27	452
"Rock", hard	11	463
Clay, green	12	475

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 29, White Stone; White Stone School--Continued

	Thickness (feet)	Depth (feet)
Mattaponi(?) Formation (Upper Cretaceous and Paleocene):		
Clay, dark	63	538
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Clay, light	55	593
Sand and clay	2	595
Sand, with some black sand (probably glauconite)	9	604
Sand, black (probably glauconite)	5	609
Sand, dark, with some black sand	5	614
Sand, chiefly white	2	616
Sand, white	17	633
Clay, black	1	634
Sand, white; fine	7	641

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 32, Irvington; Bernard Willing

(Log from driller's record furnished by Mitchell's Well and Pump Co.; correlation by A. Sinnott)

Altitude, 8 feet

	Thickness (feet)	Depth (feet)
Undescribed (no samples)	394	394
Mattaponi(?) Formation (Upper Cretaceous and Paleocene):		
"Rock"	8	402
Shells	48	450
Sand and shells	30	480
Clay, blue	55	535
"Rock"	31	566
Sand	9	575
"Rock"	10	585
Shells and clay	65	650
Undescribed (no sample)	25	675
Sand	5	680
"Rock"	30	710
Sand; water-bearing	20	730
"Rock"	10	740

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 39, Irvington; Sydnor Hydrodynamics, Inc.

(Log modified from driller's record furnished by owner; correlations by A. Sinnott and D. J. Cederstrom)

Altitude, 6± feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Sand, fine	17	17
Sand, white, and gravel; water-bearing	10	27
Chesapeake Group (Miocene):		
Marl, Black; shells	63	90
Clay, gray	70	160
Clay, greenish; shells at 200 feet	47	207
Clay, gray	63	270
Clay, green	45	315
Chickahominy(?) Formation (Upper Eocene):		
Sand, fine	15	330
Clay, green	4	334
Clay, and shells	11	345
Marl, dark	15	360
Marl, green; some glauconite; brown clay	20	380
Nanjemoy Formation (Eocene):		
Marl, green; some glauconite; brown clay	20	400
Shells; indurated beds	8	408
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Marl, dark gray; glauconitic	72	480
Marl, gray	63	543

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 39, Irvington; Sydnor Hydrodynamics, Inc.--Continued

	Thickness (feet)	Depth (feet)
Mattaponi Formation--Continued		
Gravel and black sand	3	546
Clay, gray	7	553
Sand, fine	18	571
Clay, brown	30	601

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 42, Millenbeck; "The Cow Shed," J. W. Sawdy

(Log modified from driller's record furnished by Reynolds & Norman; correlations by A. Sinnott and D. J. Cederstrom)

Altitude, 10 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Soil and silt	32	32
Chesapeake Group (Miocene):		
Clay, blue	200	232
Clay, green	28	260
Clay, tough; underlain by nearly 2 feet of white sand	2	262
Clay, brown; hard	38	300
Chickahominy(?) Formation (Upper Eocene):		
Clay, tough	14	314
Clay, greenish brown	21	335
Nanjemoy(?) Formation (Eocene):		
Clay, tough	25	360
Clay, yellow; hard	15	375
Clay, greenish-brown; gray sand 1-½ feet thick at 375 feet	20	395
Mattaponi(?) Formation (Upper Cretaceous and Paleocene):		
Clay, blue; black sand 1 foot thick at about 435 feet	95	490
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Clay, dark gray	10	500
Clay, tough	10	510
Clay, brown; tough	20	530

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 42, Millenbeck; "The Cow Shed," J. W. Sawdy--Continued

	Thickness (feet)	Depth (feet)
Mattaponi Formation--Continued		
Undescribed; thin layer of white sand at about 535 feet	30	560
Blue material; hard	15	575
Brown material; thin layer of black sand at about 585 feet	15	590
Undescribed (no sample)	30	620
Tan material; hard	10	630
Sand, brown; coarse	5	635
Sand, and white clay, mixed; grading into white water-bearing sand at increasing depth	60	695

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 46, Bertrand; T. D. McGinnes

(Log modified from driller's record furnished by Mitchell's Well and Pump Co.; correlations by A. Sinnott and D. J. Cederstrom)

Altitude, 5 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene), and Chesapeake Group (Miocene), undifferentiated:		
Clay, sandy, blue	233	233
Clay, blue, and sand	86	319
Chickahominy Formation (Upper Eocene), and Nanjemoy Formation (Eocene), undifferentiated:		
Clay and sand	65	384
"Rock," and sand, interbedded	66	450
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Sand	75	525
"Rock," and sand, interbedded	20	545
Sand and clay	65	610
Sand	80	690
Sand and clay	75	765

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 52, Ottoman, 2.4 miles south-southeast of Mollusk; Faye

(Log from driller's record furnished by Mitchell's Well and Pump Co.; correlations by A. Sinnott)

Altitude, 42 feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Sand, white	50	50
Chesapeake Group (Miocene):		
Sand, blue, and shells	30	80
Sand, blue, and clay	80	160
Clay, blue, and shells	100	260
Chickahominy Formation (Upper Eocene):		
Shell rock (coquina)	3	263
Sand, white; may be water-bearing	34	297
Sand, white, and shells	19	316
Sand, yellow	10	326
Nanjemoy Formation (Eocene):		
Sand, black	14	340
Sand, gray	1	341
Sand, yellow	1	342
"Rock"	17	359
Sand, black, and "rock"	57	416
Shells, and sand	59	475
Mud, blue, and shells	8	483
Undescribed	37	520
Mattaponi Formation (Upper Cretaceous and Paleocene):		
Sand, white; water-bearing	10	530

Table 17.--Logs of wells in Lancaster County, Virginia--Continued

Well 54, about 1.5 miles west-northwest of Mollusk;
Alexander Leland

(Log from driller's record furnished by Reynolds & Norman; correlations by A. Sinnott and D. J. Cederstrom)

Altitude, 2± feet

	Thickness (feet)	Depth (feet)
Columbia Group (Pleistocene):		
Subsoil and sand	30	30
Chesapeake Group (Miocene):		
Clay, blue	40	70
Clay, gray	50	120
Clay, blue	120	240
Chickahominy Formation (Upper Eocene):		
Sand, white, and shells; thin bed of tough clay at 250 feet	10	250
Clay, brown	20	270
Clay, tough, and sand layers	40	310
Nanjemoy Formation (Eocene):		
Sand, black, below 315 feet (no record of thickness); water-bearing		

Verifax 3

18

Table ~~6~~.--Chemical analyses of ground waters from wells in Lancaster County, Virginia
(Parts per million, except specific conductance and pH)

Well number	2	2	3	3
Location	Lively	Lively	Lively	Lively
Depth (feet)	60	60	365	365
Geologic age	~~Pleistocene~~ Miocene	~~Pleistocene~~ Miocene	Late Eocene	Late Eocene
Formation or Group	Chesapeake ~~Columbia~~ Group	Chesapeake ~~Columbia~~ Group	Chickahominy Formation	Chickahominy Formation
Date	Mar., 1946	May 15, 1953	June 9, 1948	May 15, 1953
Silica (SiO_2)	12	12	25	---
Iron (Fe)	.25	.02	.83	---
Calcium (Ca)	33	24	5.2	4.8
Magnesium (Mg)	16	18	2.4	2.3
Sodium (Na)	} 12	21	} 148 calc.	{---
Potassium (K)		4.6		
Carbonate (CO_3)	0	0	10	26
Bicarbonate (HCO_3)	48	59	374	360
Sulfate (SO_4)	1.5	.5	11	---
Chloride (Cl)	51	53	4.0	3.6
Fluoride (F)	.1	.0	1.8	1.6
Nitrate (NO_3)	75	68	.6	1.1
Dissolved solids	311	250	400	---
Hardness as $CaCO_3$	148	137	23	22
Specific conductance (micromhos at 25°C)	---	416	634	634
pH	6.3	7.4	8.4	8.7

18

Table 6.--Chemical analyses of ground waters from wells in Lancaster County, Virginia--Continued
(Parts per million, except specific conductance and pH)

Well number	11	12	13	13	15	15
Location	ESE of Kilmarnock	ESE of Kilmarnock	ESE of Kilmarnock	ESE of Kilmarnock	NE of White Stone	NE of White Stone
Depth (feet)	620	480	610	610	507	507
Geologic age	Late Cretaceous and Paleocene	Late Eocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Eocene and Late Eocene	Eocene and Late Eocene
Formation or Group	Mattaponi Formation	Chickahominy Formation	Mattaponi Formation	Mattaponi Formation	Nanjemoy and Chickahominy Formations	Nanjemoy and Chickahominy Formations
Date	July 5, 1918	July 5, 1918	July 5, 1918	Feb. 27, 1941	July 5, 1918	Feb. 27, 1941
Silica (SiO_2)	34	53	34	---	28	---
Iron (Fe)	.06	.08	.07	---	.04	---
Calcium (Ca)	2.7	4.1	3.1	---	2.6	---
Magnesium (Mg)	1.4	1.8	1.9	---	1.5	---
Sodium (Na)	} 205 calc.	230	---	---	---	---
Potassium (K)			---	---	---	---
Carbonate (CO_3)	39	70	42	---	31	---
Bicarbonate (HCO_3)	418	463	399	469	406	469
Sulfate (SO_4)	34	6.9	37	27	39	27
Chloride (Cl)	10	4.5	11	6	14	14
Fluoride (F)	---	---	---	2.7	---	2.9
Nitrate (NO_3)	.6	1.1	.61	---	.61	---
Dissolved solids	534	598	526	---	523	---
Hardness as $CaCO_3$)	12	18	16	4	13	9
Specific conductance (micromhos at 25°C)	---	---	---	---	---	---
pH	---	---	---	---	---	---

18

Table 6.--Chemical analyses of ground waters from wells in Lancaster County, Virginia--Continued
(Parts per million, except specific conductance and pH)

Well number	NNE 18	25	25	25	25	27
Location	of White Stone	N of Palmer	N of Palmer	N of Palmer	N of Palmer	S of White Stone
Depth (feet)	620	580	580	580	580	680
Geologic age	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene
Formation or Group	Mattaponi Formation	Mattaponi Formation	Mattaponi Formation	Mattaponi Formation	Mattaponi Formation	Mattaponi Formation
Date	May 15, 1953	July 5, 1918	Feb. 28, 1941	June 9, 1948	May 15, 1953	Feb. 27, 1941
Silica (SiO_2)	13	---	---	13	---	---
Iron (Fe)	.29	---	---	.05	---	---
Calcium (Ca)	1.9	8.0	---	4.5	1.9	---
Magnesium (Mg)	.7	6.8	---	1.7	.8	---
Sodium (Na)	193	} 280 calc.	{ ---	} 271 calc.	{ ---	---
Potassium (K)	4.9		---		---	---
Carbonate (CO_3)	31	108	---	16	8	---
Bicarbonate (HCO_3)	412	364	470	438	452	512
Sulfate (SO_4)	33	53	40	51	---	34
Chloride (Cl)	8.3	86	113	113	122	33
Fluoride (F)	2.8	---	3.7	3.4	3.2	3.8
Nitrate (NO_3)	.6	2.0	---	1.0	.7	---
Dissolved solids	499	872	---	702	---	---
Hardness as $CaCO_3$	8	48	8	18	8	6
Specific conductance (micromhos at 25°C)	817	---	---	1200	1180	---
pH	8.7	---	---	8.3	8.4	---

264

18

Table 6.--Chemical analyses of ground waters from wells in Lancaster County, Virginia--Continued
(Parts per million, except specific conductance and pH)

Well number	27	27	28	30	32	32
Location	S of White Stone	S of White Stone	SSW of White Stone	Irvington	Irvington	Irvington
Depth (feet)	680	680	560	450	750	750
Geologic age	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Eocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene
Formation or Group	Mattaponi Formation	Mattaponi Formation	Mattaponi Formation	Nanjemoy(?) Formation	Mattaponi Formation	Mattaponi Formation
Date	June 9, 1948	May 15, 1953	July 5, 1918	July 3, 1918	Feb. 28, 1941	June 9, 1948
Silica (SiO_2)	---	---	27	57	---	12
Iron (Fe)	0.86	---	.07	.05	---	.04
Calcium (Ca)	---	2.9	3.2	3.9	---	1.4
Magnesium (Mg)	---	.5	2.3	2.8	---	.6
Sodium (Na)	---	---	} 265	248	{ ---	} 241 calc.
Potassium (K)	---	---			---	
Carbonate (CO_3)	---	13	84	67	---	15
Bicarbonate (HCO_3)	516	487	425	529	441	547
Sulfate (SO_4)	34	---	46	3.7	40	29
Chloride (Cl)	30	16	40	16	11	12
Fluoride (F)	2.2	3.2	---	---	2.3	3.4
Nitrate (NO_3)	.8	1.0	.7	1.1	---	.6
Dissolved solids	---	---	684	670	---	587
Hardness as $CaCO_3$	15	9	17	21	6	6
Specific conductance (micromhos at 25°C)	939	889	---	---	---	951
pH	---	8.4	---	---	---	8.7

Table 18.--Chemical analyses of ground waters from wells in Lancaster County, Virginia--Continued
(Parts per million, except specific conductance and pH)

Well number	32	49	50	50	50
Location	Irvington	Bertrand	W of Bertrand	W of Bertrand	W of Bertrand
Depth (feet)	750	300	650	650	650
Geologic age	Late Cretaceous and Paleocene	Late Eocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene	Late Cretaceous and Paleocene
Formation or Group	Mattaponi Formation	Chickahominy (?) Formation	Mattaponi Formation	Mattaponi Formation	Mattaponi Formation
Date	May 15, 1953	July 9, 1918	July 8, 1918	June 9, 1948	May 15, 1953
Silica (SiO_2)	---	50	23	---	14
Iron (Fe)	---	---	0	---	.17
Calcium (Ca)	1.4	tr.	tr.	---	1.6
Magnesium (Mg)	.6	5	2.4	---	1.9
Sodium (Na)	---	} 301	260 calc.	{ ---	212
Potassium (K)	---			---	6.7
Carbonate (CO_3)	19	127	120	19 ~~9.8~~	37
Bicarbonate (HCO_3)	442	542	415	537	481
Sulfate (SO_4)	---	tr.	28	25	20
Chloride (Cl)	5.6	12	4	8	5.0
Fluoride (F)	2.4	---	---	2.2	2.4
Nitrate (NO_3)	.8	1.4	.25	.6	.9
Dissolved solids	---	810	656	---	538
Hardness as $CaCO_3$	6	20	10	18	12
Specific conductance (micromhos at 25°C)	783	---	---	885	879
pH	8.6	---	---	---	8.6

266 - (last page before References)

References

Cederstrom, D. J., 1943, Chloride in ground water in the Coastal Plain of Virginia: Virginia Geol. Survey Bull. 58, 36 p.

p.217 _____ 1945a, Selected well logs in the Virginia Coastal Plain north of James River: Virginia Geol. Survey Circular 3, 82 p.

_____ 1945b, Geology and ground-water resources of the Coastal Plain in southeastern Virginia: Virginia Geol. Survey Bull. 63, 384 p.

_____ 1946, Chemical character of ground water in the Coastal Plain of Virginia: Virginia Geol. Survey Bull. 68, 62 p.

p.218 _____ 1957, Geology and ground-water resources of the York-James peninsula, Virginia: U.S. Geol. Survey Water-Supply Paper 1361, 237 p.

Clark, W. B., 1895, Cretaceous deposits of the northern half of the Atlantic Coastal Plain: Geol. Soc. America Bull., v. 6, p. 479-482.

Clark, W. B., and Martin, G. C., 1901, The Eocene deposits of Maryland: Maryland Geol. Survey, Eocene, p. 21-92.

Clark, W. B., and Miller, B. L., 1912, The physiography and geology of the Coastal Plain province of Virginia: Virginia Geol. Survey Bull. 4, 274 p.

Cooke, C. W., 1931, Seven coastal terraces in the southeastern states: Washington Acad. Sci. Jour., v. 21.

Cushman, J. A., 1944, Foraminifera from the Aquia formation of Virginia: Cushman Lab. Foraminiferal Research Contr., v. 20, p. 17-28.

Cushman, J. A., and Cederstrom, D. J., 1945, An upper Eocene foraminiferal fauna from deep wells in York County, Virginia: Virginia Geol. Survey Bull. 67, 58 p.

Darton, N. H., 1891, Mesozoic and Cenozoic formations of eastern Virginia and Maryland: Geol. Soc. America Bull., v. 2, p. 431-450.

Dean, H. T., 1936, Chronic endemic dental fluorosis (mottled enamel): Jour. Am. Med. Assoc., v. 107, p. 1269-1272.

_____ 1942, Fluorine and dental health: Am. Assoc. Adv. Sci. Bull., v. 1, no. 6, p. 47.

DeBuchananne, G. D., 1968, Ground-water resources of the Eastern Shore of Virginia and the James, York, and Rappahannock River basins of Virginia east of the Fall Line: U.S. Geol. Survey Hydrol. Inv. Atlas HA-284, 2 sheets.

Faucett, R. L., and Miller, H. C., 1946, Methemoglobinemia occurring in infants fed milk diluted with well waters of high nitrate content: Jour. Pediatrics, v. 29, p. 593.

Ferguson, H. F., 1953, The ground-water resources, in The water resources of St. Marys County: Maryland Dept. Geology, Mines and Water Resources Bull. 11, p. 16-189.

Lamar, W. L., and Whetstone, G. W., 1947, Chemical character of surface waters of Virginia, 1945-46: Virginia Div. Water Resources and Power, Bull. 8, 46 p.

Loeblich, A. R., Jr., and Tappan, Helen N., 1957a, Plankton ic Foraminifera of Paleocene and early Eocene age from the Gulf and Atlantic Coastal Plains, in Loeblich, A. R., Jr., Studies in Foraminifera: U.S. Natl. Mus. Bull. 215, p. 173-198.

_____ 1957b, Correlation of the Gulf and Atlantic Coastal Plain Paleocene and lower Eocene formations by means of planktonic Foraminifera: Jour. Paleontology, v. 31, no. 6, p. 1109-1137, November.

Maxcy, K. F., 1950, Report on the relation of nitrate concentrations in well waters to the occurrence of methemoglobinemia: Nat. Research Council, Bull., Sanitary Eng., p. 265, App. D.

Moore, W. E., 1956, Pleistocene terraces south of the James River, Virginia [summary], in Va. Acad. Sci. Geology Sec., Guidebook, 7 p.

Oaks, R. Q., Jr., and Coch, N. K., 1963, Pleistocene sea levels, southeastern Virginia: Science, v. 140, p. 979-983.

Russell, R. J., and Russell, R. D., 1939, Mississippi River delta sedimentation: in Recent Marine Sediments, Parker D. Trask, editor: Tulsa, Okla., Am. Assoc. Petroleum Geologists.

Sanford, Samuel, 1913, The underground water resources of the Coastal Plain province of Virginia: Virginia Geol. Survey Bull. 5, 361 p.

Name of single author should precede names of author and colleagues

Sinnott, Allen, and Whetstone, G. W., 1962, Fluoride in well waters of the Virginia Coastal Plain: Virginia Dept. Conserv. and Econ. Devel., Div. Mineral Resources, Virginia Minerals, v. 8, no. 1, p. 4-11.

Sinnott, Allen, 1967, Records of wells on the Northern Neck peninsula, Virginia, including well logs and chemical analyses of ground water: U.S. Geol. Survey open-file report, 152 p.

_____ 1968, Results of aquifer tests in sands of the Potomac Group in the Franklin area, southeastern Virginia (1949-1950): U.S. Geol. Survey open-file report, 80 p.

p 220 U.S. Public Health Service, 1962, Drinking water standards: Public Health Service Publication No. 956, 61 p.

Virginia Division of Planning, 1964, Economic Data Summary, Lancaster County, Richmond, Va.

_____ 1965, Economic Data Summary, Stafford County, Richmond, Va.

_____ 1965, Economic Data Summary, Northumberland County, Richmond, Va.

_____ 1967, Economic Data Summary, King George County, Richmond, Va.

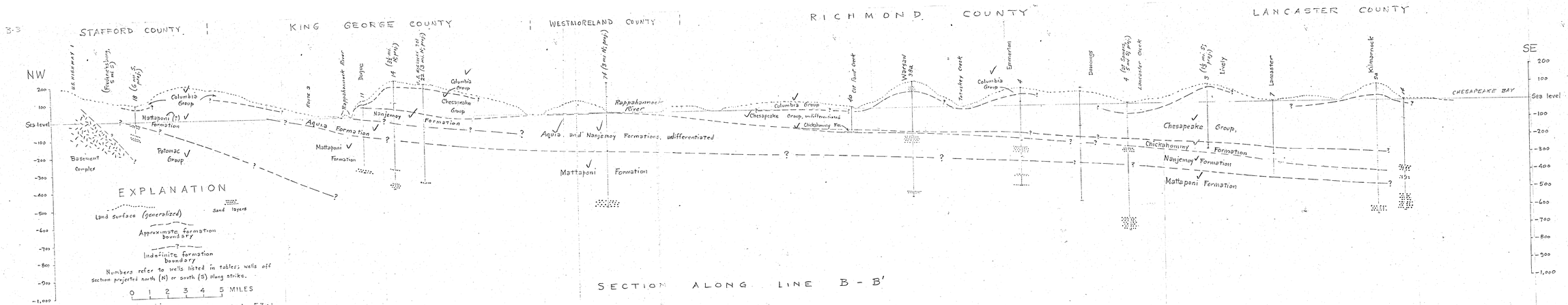
_____ 1967, Economic Data Summary, Westmoreland County, Richmond, Va.

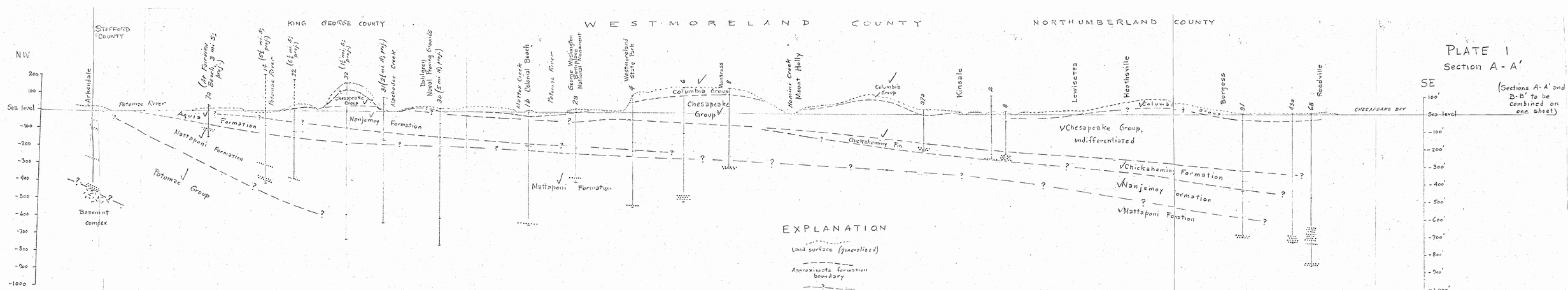
_____ 1967, Economic Data Summary, Richmond County, Richmond, Va.

Waring, F. H., 1949, Significance of nitrates in water supplies: Am. Water Works Assoc. Jour., v. 41, no. 2, p. 147-150.

p 215 Wentworth, C. K., 1930, Sand and gravel resources of the coastal plain of Virginia: Virginia Geol. Survey Bull. 32, 146 p.

PLATE 1
Section B-B'




AA'
NW
SE
STAFFORD COUNTY
KING GEORGE COUNTY
WESTMORELAND COUNTY
NORTHUMBERLAND COUNTY
PLATE I
Section A - A'
(Sections A-A' and B-B' to be combined on one sheet)
Sea level
Potomac River
Arkendale
Aquia Formation
Nanjemoy Formation
Mattaponi Formation
Potomac Group
Basement complex
Chesapeake Group
Columbia Group
Chickahominy Fm
Chickahominy Formation
Nanjemoy Formation
Mattaponi Formation
Chesapeake Group, undifferentiated
Kinsale
Lewisetta
Heathsville
Burgess
Reedville
CHESAPEAKE BAY
EXPLANATION
Land surface (generalized)
Approximate formation boundary
Indefinite formation boundary
(Numbers refer to wells listed in tables; wells off section projected north (N) or south (S) along strike)
0 1 2 3 4 5 MILES
Scale ratio, vertical to horizontal, 53:1

VIRGINIA DIVISION OF MINERAL RESOURCES

~~6/30/69~~ Sinnott, Allen
Ground-water resources of Northern Neck, Va.

SYSTEM	SERIES	FORMATION OR GROUP	Lithology	Origin	Distribution	Water-bearing character
Quaternary	Holocene	Surficial? Unnamed deposits	Unnamed silts, sands, and gravels.	Wind deposits; beach, littoral, and shallow marine and estuarine deposits; minor stream deposits.	Beaches, bars, spits, and dunes; deposits in creek beds.	In limited areas, and in favorable topographic situations, beach deposits may yield small quantities of ground water of fair quality.
	Pleistocene	Columbia Group	The Columbia Group consists largely of unconsolidated yellowish cross-bedded clayey sands and gravels. In places, may reach about 100 feet in thickness. The formations have not been differentiated in this report.	Terrestrial and deltaic deposits in the western part of the peninsula, grading to estuarine and shallow-water marine deposits eastward near Chesapeake Bay.	The Columbia Group underlies the entire Northern Neck peninsula; exposed at the surface everywhere except where covered by beach deposits or other deposits of Holocene age.	Supplies small quantities of ground water to many shallow dug and driven wells throughout the area. Quality good, but locally high in iron.
Tertiary	Miocene	Chesapeake Group: Yorktown Formation; St. Marys Formation; Choptank Formation; Calvert Formation	The Chesapeake Group consists of sands, clays, shell marls, and diatomaceous earth. The uppermost and youngest unit, the Yorktown Formation, contains abundant sand and shell beds. It is underlain by the St. Marys Formation, which consists chiefly of blue or gray clay beds. The basal and oldest unit is the Calvert Formation, which contains abundant sandy diatomaceous earth. The Choptank Formation, between the Calvert and St. Marys, ~~[illegible]~~ These formations have not been differentiated for this report. The Chesapeake Group ranges in thickness up to 400 feet in the Northern Neck peninsula.	Formed by marine deposition. Seas submerged entire area of the present Coastal Plain, and in places may have extended a few miles west of the present Fall Zone.	The Chesapeake Group underlies the entire Northern Neck peninsula except along the Fall Zone. The two older formations, particularly the Calvert, are well exposed in many places in the banks of streams and in stream beds, and along road cuts in most of the peninsula, except in Eastern Northumberland and Lancaster Counties, where they are concealed by younger deposits. The Calvert Formation is well exposed in cliffs along the south bank of the Potomac River and North bank of the Rappahannock River.	Although not of major importance as a source of ground water, the Chesapeake Group yields small to moderate supplies to wells in the Northern Neck.
	Upper Eocene	Chickahominy Formation (subsurface)	The Chickahominy Formation consists largely of clays, marls, and minor sand beds; contains subordinate amounts of glauconite and pyrite, and a rich foraminiferal fauna. It generally ranges in thickness from about 20 to 60 feet, and more than 100 feet thick in the easternmost part of the peninsula.	Deposited in marine waters.	Developed in the subsurface beneath the eastern half of the Northern Neck peninsula; disappears westward in a featheredge in southeastern Westmoreland County.	Furnishes ~~some~~ moderate supplies to many ~~stock~~ wells where ~~many~~ layers are product, but ~~not otherwise of importance as a water-bearing formation~~ in eastern counties
	Middle and Lower Eocene	Nanjemoy Formation	The Nanjemoy Formation of early and middle Eocene age consists of gray marl, glauconitic quartz sand and a few thin limestone beds. Marlboro Clay Member lies at base in many places in the western part of the Northern Neck.	Deposited in marine waters.	These formations are exposed at the surface near the Fall Zone, and disappear eastward below tide level midway down the peninsula. Farther east, they are present only in the subsurface.	A few flowing wells on the peninsula furnish small supplies from these formations.
	Paleocene	Aquia Formation	The Aquia Formation, of Paleocene age, underlies the Nanjemoy and consists of glauconitic sandy marl and basal quartz sand beds. In most localities these two formations are difficult to distinguish in the subsurface; they have been differentiated in only a few well logs in the text.		Where they have been differentiated, the Nanjemoy is several times thicker than the Aquia; the latter is probably absent beneath eastern Northumberland and eastern Lancaster Counties. Total thickness ranges from about 250 feet in King George County to about 80 feet beneath Northumberland and Lancaster Counties.	
Cretaceous	Upper Cretaceous	Mattaponi Formation (subsurface)	The Mattaponi Formation, of Late Cretaceous and Paleocene age, consists of mottled clays, glauconitic sand, and basal quartz sand. About 400 feet thick in King George County, and somewhat thinner down the peninsula—about 250 feet thick in eastern Northumberland County.	Deposited under shallow-water marine and estuarine conditions.	Not exposed at the surface. Underlies entire Northern Neck peninsula.	A prolific water-bearing formation, furnishing moderate to large supplies to many wells in the entire Northern Neck peninsula. In this area, the water from sands in the Mattaponi is generally of excellent quality.
	~~Upper Cretaceous~~ Lower Cretaceous	Potomac Group: Patapsco Formation; Patuxent Formation	The Potomac Group, of Early ~~and Late~~ Cretaceous age, consists of sands, clays, and minor gravel lenses. Not differentiated into formations in this report. May reach more than 2,000 feet in thickness beneath the easternmost part of the peninsula. Westward, it thins to a featheredge along the Fall Zone.	Deposited by streams, chiefly as deltaic deposits; contains plant fossils.	Underlies most of the area. Exposed at the surface only near the Fall Zone.	Tapped by only a few wells on the Northern Neck peninsula, chiefly near the Fall Zone. Potentially a prolific future source of ground water of excellent quality.
Pre-Cretaceous		Unnamed bedrock of the basement complex; may include Newark Group of Triassic age	Crystalline basement rocks, including metamorphic rocks and igneous bodies, in places cut by later igneous intrusives. Consolidated red arkosic sandstones of the Newark Group of Triassic age may underlie parts of King George County. These rocks lie at and near the surface along the Fall Zone in eastern Stafford County, and lie at progressively greater depth eastward, reaching a maximum depth of possibly 3,000 feet beneath easternmost Northumberland and Lancaster Counties.	Meta-sediments, including schists and gneisses; igneous intrusives. Triassic sandstones deposited in geosynclinal troughs.	Underlie entire area. Exposed at the surface only in eastern Stafford County.	Yield small to moderate supplies of water to wells in the Fall Zone; elsewhere, not commonly reached by wells, and not ordinarily regarded as aquifers.

Reduce this line to 10½ inches

~~Potomac Group is Lower Cretaceous. Age of Patapsco Fm. changed to Early Cretaceous, by J. E. Hazel.~~