FINAL REPORT

GROUND-WATER PROTECTION REPORT FOR NORTHEAST DORCHESTER COUNTY

PART I - SUMMARY OF GROUND-WATER CONDITIONS

PREPARED FOR:

DORCHESTER COUNTY DEPARTMENT
OF PLANNING AND ZONING
DORCHESTER COUNTY DEPARTMENT OF HEALTH

JULY 1987

GERAGHTY & MILLER, INC.
Ground-Water Consultants

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INTRODUCTION

> *The State of Maryland is committed to protect the physical, chemical, and biological integrity of the (State's) ground-water resources in order to protect human health and the environment, to insure that an adequate supply of the resource is available and that in all situations to manage that resource for the greatest beneficial use of the citizens of the state.*
>
> *Maryland Ground-Water Steering Committee*

Ground water is an extremely valuable natural resource to the citizens of Dorchester County. Ground water is the sole source of drinking water and is essential for both industry and agriculture. The protection of the Dorchester County ground-water resources involves the control of many potential sources of contamination such as underground storage tanks, landfills, lagoons, and the subject of this report, on-site sewage disposal.

Maryland's regulations for on-site wastewater disposal in areas where public sewer systems are unavailable were modified in 1985 to better account for the protection of ground-water resources[1]. These regulations address the siting and design of on-site sewage disposal systems. The principal mechanism for protecting ground-water resources is the recognition of a 'treatment zone' to occur beneath a septic system infiltration trench. The mandated treatment zone consists of four feet of unsaturated, unconsolidated material sufficient to attenuate effluent below the bottom of the on-site sewage disposal system prior to the waters recharging the uppermost ground-water unit.

1 COMAR 10.17.02, entitled "sewage disposal systems for homes and other establishments in the counties of Maryland where a public sewage system is not available."

The 1985 regulations allow for on-site sewage disposal systems to be sited in areas where less than four feet of treatment zone is present under specific hydrogeologic conditions providing a management plan to protect ground-water resources is in place. Such a reduction in the treatment zone thickness is commonly referred to as "ground-water penetration." The Dorchester County Commission has chosen to allow such siting where these specific conditions are met. This report is the first step toward better defining where such conditions may likely occur and to compile information important to developing a management approach to protect the County's vital ground-water resources in the context of on-site sewage disposal.

Treatment Zone Concept

The bulk of available data and research indicates that a two- to four-foot depth of suitable, unsaturated soil material will provide a high degree of treatment of septic tank effluent. It has been reported that such a treatment zone provides that almost complete removals of Chemical Oxygen Demand, (COD), Biological Oxygen Demand (BOD), suspended solids, phosphorus and bacterial contaminants can be achieved. Data to support similar reduction of viruses are not as conclusive. Removal and inactivation of viruses are more variable and depend on a number of conditions such as soil clay content, organic matter, pH, moisture content, and residence time in the soil.

Other chemical constituents, such as nitrogen, exchangeable cations, chloride, sulfates, sulfides, other anions and trace organics, undergo various reactions in the soil treatment zone and may be attenuated to different degrees. Many of these chemical constituents are not attenuated to any great extent and over time will move downward with soil waters and mix with underlying ground waters. Increases in total dissolved solids, chlorides and nitrate-nitrogen of ground waters may be experienced. The significance of these impacts and the resulting degradation of ground-water quality becomes more important as densities of on-site sewage disposal systems increase. Cumulative effects of impacts from on-site sewage disposal systems, and other sources of contaminants associated with suburban land use, have produced significant ground-water pollution in some areas along the east coast.

The depth of unsaturated soil material below the bottom of on-site systems that is needed for adequate treatment is primarily dependent on site-specific soil properties. Soil properties, such as clay content and mineralogy, percent of rock fragments, and permeability, will have the greatest effect on the degree of treatment of septic tank effluent. Generally, soils with rapid permeabilities may require greater unsaturated depths than soils with slow permeability to achieve the same level of treatment. In some instances of rapid and very rapid permeabilities, even four feet will not provide adequate treatment. It is generally recognized that two to four feet of unsaturated soil provides effective treatment.

With 1985 regulations, the State has adopted a four-foot treatment zone, not only to provide a high degree of treatment, but for two additional, practical reasons. These reasons involve 1) the difficulty of estimating accurately depth to the seasonal high water table based on minimal observations, and 2) typical installation problems that often result in actual treatment zone depths being less than design depths. Use of a four-foot treatment zone allows for a reasonable margin of safety when considering the practical limitations of evaluating sites and installing systems.

The presence of an unsaturated soil treatment zone will not provide complete treatment of all constituents in septic system effluent waters. Some alteration of ground-water quality in the vicinity of the infiltration field will occur regardless of thickness and soil properties of the treatment zone. While the majority of pathogens and particulates will be removed, various species of nitrogen (particularly nitrates) and inorganic ions such as chlorides will not be significantly removed. For this reason, other management practices, in addition to the treatment zone requirement (i.e., density controls), may be necessary to fully protect ground waters that serve as sources of drinking water.

In summary, incorporating an adequate soil-treatment zone below the bottom of on-site sewage disposal systems will provide almost complete removal of most septic tank effluent contaminants of public health concern.

Conditions for Relaxing Treatment Zone Requirement

Maryland Health regulations allow for the use of on-site sewage disposal systems with less than four feet of treatment zone if:

a) The receiving aquifer had been designated as Type III (other than Type I or Type II), pursuant to COMAR 10.50.01; or

b) The receiving aquifer has limited potential to serve as a drinking-water source. Criteria for determining that an aquifer has a limited potential to serve as a drinking-water source are:

i) Provision of insufficient potable water to serve as a year-round supply due to seasonally fluctuating water tables,

ii) Interconnection with tidewater such that if pumped for water supply, brackish water or saltwater intrusion into the aquifer has or would occur,

iii) Depth to ground water would preclude on-site sewage disposal except by ground-water penetration and there is evidence the aquifer has already been polluted by, or is in imminent danger of being polluted by, agricultural or other potentially polluting activities in the area.

Ground-Water Protection Report

Areas where the conditions for less than four feet of treatment zone are met are to be described in a ground-water protection report along with appropriate management actions such as density limits, and system design and construction requirements to minimize the potential for degradation of the aquifer designated for discharge. The ground-water protection report, after accepted by the State, is to be incorporated into the county water and sewage plan. The ground-water protection report must also show the following for those areas where a less than four-foot treatment zone are to be allowed:

a) A quantitatively and qualitatively superior potable water supply is available from one or more deeper confined aquifers which are separated from the disposal aquifer by a confining aquiclude.

b) Steps are taken by the county health department to ensure that the aquifer (or portion of aquifer) designated for waste disposal is not currently and will not be used for a potable water supply.

c) Discharge to a surficial aquifer (or portion of a surficial aquifer) will not contaminate a deeper aquifer of Type I or II, pursuant to COMAR 10.50.01, or any aquifer used for water supply.

d) Water-supply wells tapping confined aquifers beneath the disposal aquifer shall be grouted through the disposal aquifer.

e) The on-site sewage disposal system and recovery area is located 100 feet from any well in a confined aquifer.

f) Unimproved lots served by these on-site sewage disposal systems shall be not less than two acres in size.

Guidelines for preparing the ground-water protection report specify that at least two management areas are to be delineated. Area A represents those conditions where maximum protection and a treatment zone of appropriate thickness required will be needed. Area B is to represent those areas where the criteria for disposal without a zone are likely to be met. The Dorchester County Department of Health made preliminary determinations of the extent of each of these areas as shown in Figure 1. They also designated a third area, Area C, where information was generally insufficient to allow placement into either A or B. It is anticipated that as more information becomes available, Area C will be reclassified into either Area A or Area B.

The objective of the work represented in this report was to identify and characterize ground-water conditions in Areas A and C including:

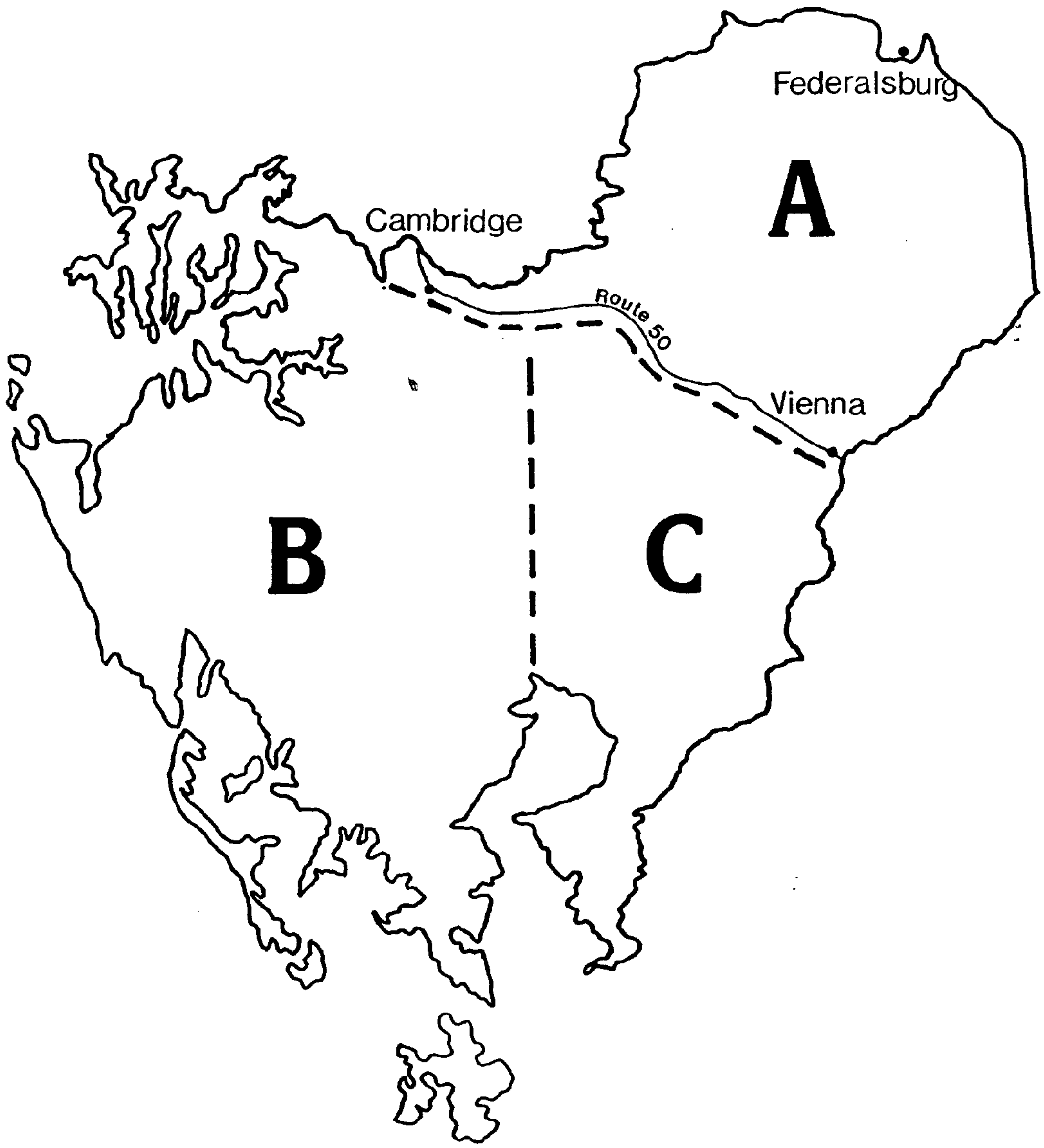

Figure 1. MANAGEMENT AREAS FOR ONSITE WASTE WATER DISPOSAL IN DORCHESTER COUNTY.

- Shallow confining layers (i.e., those within 25 feet of land surface)
- Water-quality conditions in the surficial aquifer
- General ground-water use patterns based on existing information.

The information provided in this report will be used to more concisely determine the areas where a less than four-foot treatment zone may be allowed and for establishing appropriate management practices to protect ground-water quality and underground drinking-water sources.

METHODS OF INVESTIGATION

Pertinent existing hydrogeologic information was compiled to determine the presence of shallow confining units, determine ground-water quality in the surficial aquifer, and to examine ground-water use for drinking water within Areas A and C, (shown in Figure 1) referred to as the study area.

Shallow/Confining Unit

In order to determine the presence of any confining units within 25 feet of land surface in the study area, over 400 lithologic descriptions were examined. Geologic logs published by the Maryland Geological Survey and the U.S. Geological Survey were considered primary sources of information (Mack et al, 1971; Rasmussen and Slaughter, 1957; Wilson, 1984). Well completion reports with a driller's log filed with the Dorchester County Department of Environmental Health were also examined. The well completion reports were considered reliable as general indications of geologic conditions.

A search for lithologic data was conducted in the records of the Dorchester County Health Department, where copies of all well permits, and well completion reports including water well driller logs, are filed. Over 1000 logs were reviewed. Approximately 50 percent of the water well driller logs were unuseable due to incompleteness or difficulties in interpreting the driller's log. Water well driller logs are not expected to provide detailed descriptions of lithology. The log descriptions are made based on cuttings in the drilling mud, not on undisturbed samples taken from discrete depth intrevals. Thin confining units are very difficult to detect from drilling cuttings.

The collected logs were recorded on G&M Well Data Sheets along with other information, such as the results of water-quality analysis. The log data sheets are found in Appendix B. Each log data point was then plotted on a county map and the depths to the first clay or silt units were noted where such information was available. Areas likely to be underlain by a continuous confining unit within 25 feet of land surface were identified when a confining layer of at least five-feet thickness was indicated consistently at approximately the same elevation (within 10 feet) in at least ten contiguous logs.

Water Quality

Water-quality data for the surficial unconfined aquifer in the study area were assembled from two sources. Basic data report No. 10 of The Maryland Geological Survey, Maryland Ground-Water Information: Chemical Quality Data (Woll, 1978) summarizes previously published shallow-aquifer, water-quality data at a small number of sites in the study area. Additionally, Dorchester County Health Department water-quality data for domestic supply wells was used. Given the objective to characterize the chemical quality of water from the surficial unconfined aquifer, data was accepted only if the depth or screened interval of the sampled well was recorded. No data from wells of 100-feet depth or greater were accepted and only data from those wells greater than 25 feet deep with an accompanying log showing no confining units above the screened interval were accepted. Data from all drive-point wells, which were assumed to be in the water-table aquifer, were accepted.

Nitrate concentration levels were the most frequently reported chemical-quality indicators. Other parameters occasionally recorded in the Dorchester County files included pH, iron, fluoride, chloride, hardness (as $CaCO_3$), ammonia, and total solids. Nitrate level, by far the most numerous data, was chosen as a general indicator of shallow ground-water quality in the study area.

Nitrate concentrations are reported in milligrams per liter (mg/l) of pure nitrogen. Nitrate concentrations can also be reported as mg/l of NO_3, a value 4.5 times greater than a pure nitrogen value because the three oxygen atoms are included in the weight. The nitrogen content of fertilizer is also routinely reported as pure nitrogen. The nitrate concentration at each data point was plotted on a county-wide map and areas of apparent elevated nitrate levels (i.e., greater than 5 mg/l in at least 10 contiguous data points) were generally delineated. Elevated levels of nitrate (i.e., concentrations above 3 to 5 mg/l) can be generally associated with human activities resulting in reduced ground-water quality conditions.

Ground-Water Use for Drinking Water

Well completion records submitted to the State of Maryland were used to determine the drinking water use of various aquifers in the study area. The State of Maryland Department of Health and Mental Hygiene provided a computer printout of information on all well permits, i.e., well depth and screened intervals, by Maryland grid coordinates. This information was examined for each Maryland grid cell, an area 10,000 feet by 10,000 feet. The presence of wells in each of the major aquifers was noted and mapped.

GROUND-WATER CONDITIONS

Information on the geology, soils, and ground-water availability in Dorchester County is available from a number of different sources. Information on soil resources can be found in the Soil Survey of Dorchester County, Maryland (Matthews, 1963). Maryland Geological Survey Report of Investigations #17 (Mack et al, 1971), #18 (Rasmussen and Slaughter, 1957), and #40 (Bachman, 1984) provide information on the hydrogeology and water resources of Dorchester County. A description of the uppermost geologic deposits and corresponding stratigraphy are found in U.S. Geological Survey Professional Paper 1067-A (Owens and Denny, 1979) and the Geologic Map of Dorchester County (Owens and Denny, 1986). These resource documents provide a basic understanding of the distribution of the shallow hydrogeologic conditions in Dorchester County important to the management of ground-water resources and on-site sewage disposal systems.

Dorchester County lies on the Atlantic Coastal Plain, a wedge-shaped mass of unconsolidated sedimentary deposits which overlie hard crystalline rocks. The stratigraphy and associated nomenclature for geologic units of the eastern shore coastal plain are indicated in Table 1. Geologic units found in Dorchester County vary somewhat from that shown in Table 1. The shoreline complex geologic unit refers to the Kent Island Formation. The upper Miocene complex (Pocomoke Aquifer, Ocean City Aquifer, and Manokin Aquifer) are absent. The surficial geologic units are the Beaverdam Formation, the Kent Island Formation, and units of the Chesapeake Group, as shown in Figure 2.

Within these geologic units are layers of water-bearing sands and gravels, referred to as aquifers, that readily

TABLE 1.
COASTAL PLAIN STRATIGRAPHIC NOMENCLATURE AND AQUIFERS OF THE EASTERN SHORE OF MARYLAND (FROM BACHMAN, 1984)

System	Series (Group)	Geologic Unit	Thickness (feet)	Hydrogeologic Unit(s)	Dominant Lithologic Character
QUATERNARY & TERTIARY (?)	Holocene	Holocene deposits	0 - 40	---	Soil, alluvial sand and silt, dune sand, and peat. Disconformable base.
	Pleistocene and Pliocene (?) (Columbia Group)	Shoreline complex	0 - 230	Columbia aquifer	Lenticular deposits of sand, silt, clay, and peat. Some beds of coarse sand and fine gravel. Tan; some gray and blue clay.
		Salisbury Formation: Beaverdam Fm. and Pensauken Fm. of Owens and Denny (1979)			Beaverdam Sand: Light gray to light tan, fine to coarse grained, moderately sorted, feldspathic sand. Pensauken Formation: Light tan to orange tan, medium to coarse grained, moderately to poorly sorted, pebbly feldspathic sand.
?	?	?			
TERTIARY	Miocene (Chesapeake Group)	Upper Miocene Aquifer Complex	0 - 50	Upper confining bed	Lenticular silts, clays, and fine sands. Green-blue silt and fine gray sand most common, but occasionally includes blue-green pebbly clay.
			0 - 80	Pocomoke aquifer	Sand, gray or tan-gray; coarse and pebbly generally, but locally fine.
		[Yorktown and Cohansey Formations (?) of Rasmussen and Slaughter (1955)]	0 - 85	Lower confining bed	Blue and gray clayey silt and sand; some peat. Some beds of shell and calcite and/or limestone.
				Ocean City aquifer	Coarse gray sand, fine gravel.
			0 - 240	Manokin aquifer	Fine to very coarse gray sand, and some lignite or peat. Some silty sand and clay. Occasional beds of shell and/or "rock".
		St. Marys Formation	0 - 190	Confining layer	Gray fossiliferous clay, silt, fine sand, and silty and sandy clay.
		Choptank Formation	0 - 240	Frederica aquifer and confining layer	Gray fine sand. Thin beds of shell and calcite. Green or brown clay and fine sand. Thin beds of shell and calcite or limestone.
		Calvert Formation	0 - 680	Cheswold aquifer and confining layers	Gray sand and diatomaceous silt and clay. Shell beds.
	Eocene	Piney Point Formation	0 - 220	Piney Point aquifer	Olive-green to greenish-gray quartz sand, slightly to moderately glauconitic; shell beds.
		Nanjemoy Formation	0 - 294	Confining layer	Gray to dark gray, glauconitic, silt, sand, and clay.
	Paleocene	Aquia and Hornerstown Formations (undivided)	0 - 165	Aquia aquifer	Green to brown, fine to coarse grained, glauconitic sand; interstratified with grayish-green silt and clays; calcite cemented sands and fossil beds.
		Brightseat Formation	0 - <100	Confining layer	Dark gray clay and fine, silty, micaceous sand.
CRETACEOUS	Upper Cretaceous	Matawan and Monmouth Formations (undivided)	0 - 960 ?	Matawan-Monmouth aquifers	Dark greenish-gray to reddish-brown, fine to occasionally coarse quartz sand. Facies may be glauconitic, micaceous, shelly and/or clayey.
		Magothy Formation	<50 - 100	Magothy aquifer	Light gray to white "sugary", medium to coarse grained quartz sand and fine gravel; interbedded dark gray clays in upper part.
	Lower Cretaceous (Potomac Group)	Patapsco Formation	<50 - 1,750	Aquifers and confining layers	Interbedded, variegated (gray, brown, and red) silt and clay, and argillaceous, subrounded, fine to medium quartz sand.
		Arundel and Patuxent Formations (undivided)	<50 - 2,950	Aquifers and confining layers	White to light gray to orange brown, moderately sorted, angular and subrounded quartz sand; also gray to ocherous silt and clay beds, which occur in amounts ranging from less than 25% to greater than 75% of formation.
JURASSIC (?)	---	Unnamed	0 - 135	---	White quartzite conglomerate, dark gray, reddish-green and apple green shales, sandy shales, and arkosic sandstones. Does not outcrop on the Eastern Shore.
PALEOZOIC (?) & PRECAMBRIAN	Basement Complex			---	Believed to be chiefly schist, granite, gabbro, and gneiss.

1/ The nomenclature is that of the Maryland Geological Survey.

2/ Compiled from Rasmussen and Slaughter (1957), Hansen (1972; oral commun., 1982), and Weigle (1974).

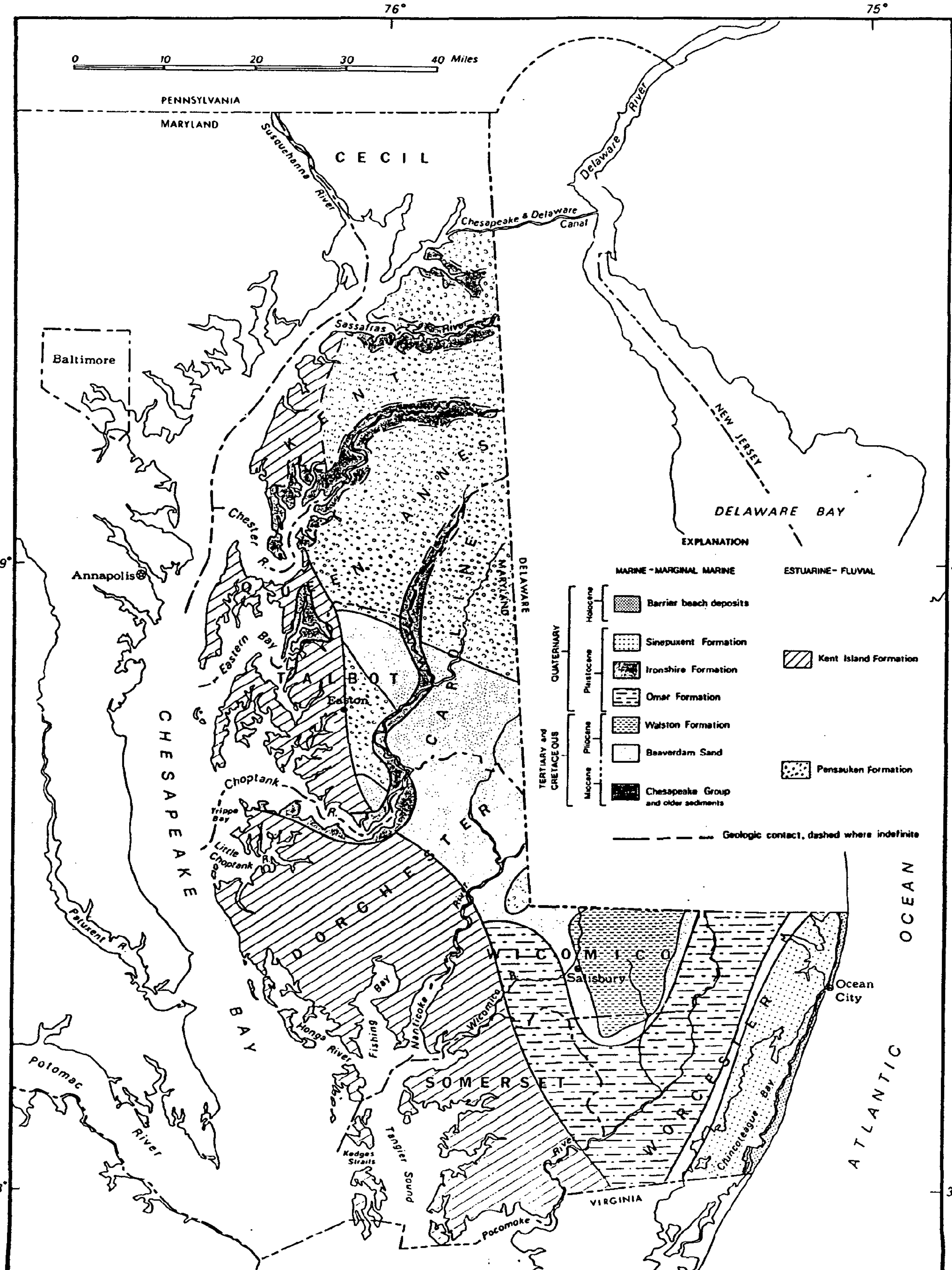

Figure 2. Generalized Geology of the Maryland Part of the Delmarva Peninsula. (From Bachman, 1984 - Adapted from Owens and Denny, 1979 and Owens and Minard, 1979)

supply ground water to wells. Between the aquifers are silty and clayey layers referred to as aquitards or confining units. The principal aquifers found in the study area are:

1) Pleistocene deposits referred to as the Beaverdam sand or the Columbia Formation. This aquifer also includes the Pensauken Formation from Owens and Denny (1986). The Parsonsburg sand may provide water to drive point wells in a few locations in Area C, Elliot Island, for example.

2) Sandy and shelly aquifers in the Choptank and Calvert Formations (Miocene age). In descending order, these aquifers may be referred to in other literature as the Fedierica Aquifer (Choptank Formation), Federalsburg Aquifer (Calvert Formation), and Cheswold Aquifer (Calvert Formation).

3) Sands of the Piney Point Formation (Eocene).

A generalized cross-section showing these aquifer units and the confining units between them are shown in Figure 3. The uppermost aquifer throughout the majority of the study area is the Pleistocene aquifer. A brief description of each of these aquifers taken from Mack et al (1971) follows:

The *Pleistocene Aquifer* contains the Beaverdam sands and Pensauken Formation, often collectively referred to as the Columbia Formation. Within Area A, the Pleistocene Formation ranges from a few feet to up to 100 feet in thickness. This aquifer is known to have a very high permeability and transmissivity, meaning it can provide large quantities of water to wells providing that there is sufficient available drawdown. Wells in the Pleistocene are reported to be capable of yielding as much as 1,500 gallons-per-minute. Water quality in the Pleistocene Aquifer is generally good. Iron levels are relatively low, the water is soft, and low in total dissolved solids. The Pleistocene Aquifer may have locally elevated concentrations of nitrates, as will be discussed in the water-quality section.

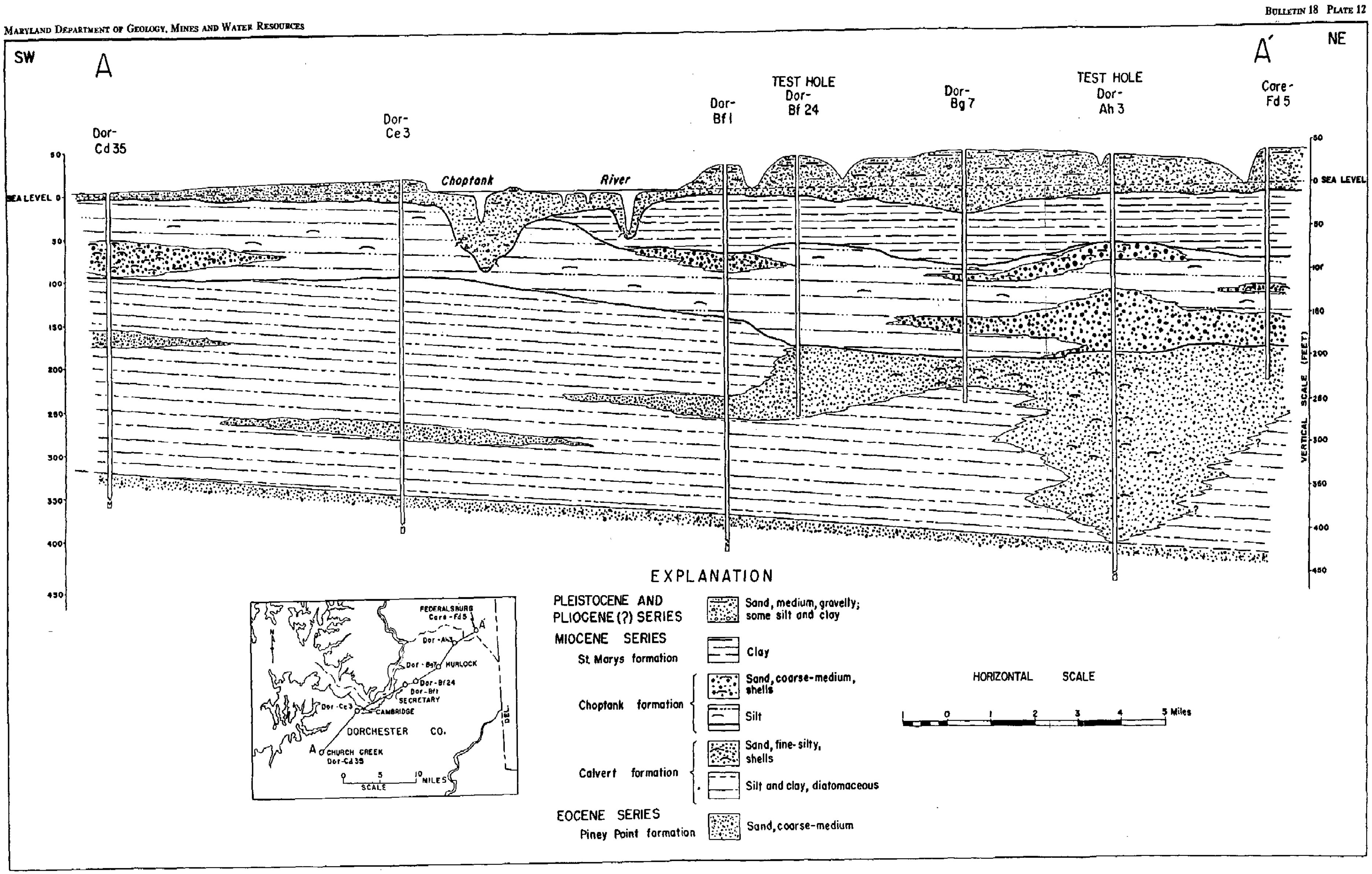

Figure 3. Generalized Geologic Cross-Section for Northeast Dorchester County.
(From Rasmussen and Slaughter, 1957)

The *Miocene Aquifers* are found in the Choptank and Calvert Formations. The aquifer in the Choptank Formation is commonly referred to as the Federica Aquifer. Within the Calvert Formation are two aquifers commonly referred to as the Federalsburg Aquifer and the Cheswold Aquifer. Available information suggests that these aquifers may be highly interconnected and, therefore, behave as a single aquifer; although, in some areas, the degree of interconnection may be limited and each of these aquifers, if present, would behave as a single aquifer. The water-bearing sands in the Miocene Formations lie approximately 200 to 300 feet below land surface. Generally, the transmissivity of these sands is relatively low, sufficient to support single-family wells, but have limited yield for larger capacity wells. Water quality in these aquifers is generally soft. Iron concentrations are generally higher than those of the Pleistocene Aquifer. Southeast of Salem in Area C, the total dissolved solid concentrations are reported to be higher than the recommended limit of 500 mg/l.

The *Piney Point Formation* (Eocene age) contains water-bearing sands from 400 to 500 feet below land surface. It is the main source of water for Cambridge and is the most important artesian aquifer in the study area. The transmissivity of the Piney Point is relatively high, with one well in the Cambridge area yielding 1,120 gallons-per-minute. However, water levels in the Piney Point have been lowered extensively in the Cambridge area. Water quality in the Piney Point is sufficient for domestic and industrial purposes without treatment in Area A. In Area C, the dissolved solids content is reported to be greater than the drinking water standard (500 mg/l). Water quality does vary significantly in the Piney Point from very hard to soft. The very hard waters often contain excessive iron and are high. South of the Choptank River, water from the Piney Point

Formation typically has an odor of hydrogen sulfide which requires treatment such as aeration to remove the gas.

The *Aquia Formation Aquifer* (Paleocene Age) is not present in the area of study and appears to pinch out on a line north of the Choptank River in Talbot County. The Aquia is present in the northwestern portion of Area B, west of Cambridge, and locally important as a source of drinking water.

Very little is known about the geologic or water-bearing characteristics of the aquifers below the Piney Point Formation throughout the study area. One well penetrating the *Magothy Formation* (Cretaceous Age) in the Cambridge area found the water quality to be relatively soft with acceptable dissolved solids and iron levels. This aquifer may be present throughout the area of study, but should not be considered as a source of drinking water until additional information is available.

Ground-Water Use for Drinking Water

Ground water is the sole source for drinking water in Dorchester County. A general treatment of ground-water resources of Dorchester County is found in the Maryland Geological Survey Report of Investigations No. 17 (Mack, et al, 1971) and Bulletin 18 (Rasmussen and Slaughter, 1957). As reported, the principal aquifers are the Pleistocene deposits, Miocene aquifers, (i.e., sandy zones in the Choptank and Calvert Formations) and the Piney Point Formation. The general pattern of use for drinking water of these three aquifers is shown in Map 3. Within the area of study, the primary sources of drinking water are the Pleistocene Aquifer and Miocene age aquifers. Use of the deeper Piney Point aquifer is principally in the Cambridge area, although wells screened in this unit are found in scattered locations elsewhere. The suitability of deeper aquifers, including the Magothy Formation as a source of drinking water has not been fully determined. At least one well is known to withdraw from the Magothy in the Cambridge area. Mack, et al, (1971) indicates it may be a significant source.

The available information suggests that, should the surficial aquifer, that is, the Pleistocene Aquifer in Area A, become contaminated, there appears to be deeper confined aquifers capable of supplying limited quantities of drinking water. The Miocene age aquifers (Choptank and Calvert Formations) appear to be discontinuous across the area and may not always be present as a deeper replacement source. The Piney Point Formation, which tends to be in the 350- to 450-feet range, is considerably deeper than the many wells screened in the upper 50 to 100 feet of Pleistocene materials.

Within Area C, the uppermost aquifer may be a thin sandy zone within the Kent Island Formation or within the thin Parsonsburg sand deposits, as is the case at Elliot Island. These units are used as sources of drinking water in scattered locations. The Miocene age aquifers are also used and, rarely, the Piney Point aquifer. The available information indicates that both the Miocene age aquifer and the Piney Point aquifer may not meet secondary Drinking Water Standards (i.e., total dissolved solids less than 500 mg/l) in Area C.

<u>Ground-Water Quality in the Surficial Aquifer</u>

The quality of ground water in the surficial aquifer within the study area is generally reported to be good and can be used for most purposes without treatment (Mack, et al, 1971). However, little information is available on the many constituents of concern to human health. The principal ground-water-quality concern for drinking water are the elevated nitrate levels in the Pleistocene Aquifer (Area A).

Bachman (1984) reports that of 604 water samples taken from wells in the Pleistocene Aquifer across the Delmarva Peninsula, over half of the samples had nitrate concentrations of 3 mg/l as nitrogen or higher, indicating that the water in the aquifer has been affected by human activity. He also reported that nitrogen concentrations exceeded the primary drinking water standard of 10 mg/l in 15 percent of the samples. Nitrate concentrations were found to be higher in areas of urban and agricultural land uses and moderately well drained soils.

Bachman (1984) concluded that the major factors affecting nitrate concentration are the presence of a nitrogen source, hydrogeologic conditions, and soil drainage. Areas with poorly drained soils may have a lower nitrate concentration due to a soil chemical environment to promote denitrification. Sources of nitrate that enter the ground water with recharging infiltration include on-site sewage disposal, lagoons, agricultural fertilization, feed lots and poultry production facilities, and lawn fertilization. The high nitrogen levels in some areas were thought to occur due to the rapid leaching through sandy soils. Sandy, well drained soils have a chemical environment that promotes the nitrification of the other forms of nitrogen and limits chemical processes that remove nitrates (i.e., denitrification).

Water-quality standards for ground-water in Type I and Type II aquifers have been set as part of COMAR 10.50 (see

Table 2). These standards include heavy metals, selected inorganic parameters (including total dissolved solids) and a few volatile organic chemicals and pesticides. With respect to on-site sewage disposal systems, the principal constituents of concern are nutrients, (e.g., nitrates and phosphates) and pathogens (i.e., bacteria and viruses).

Nitrates are commonly used as an indicator of the presence of other constituents of concern to public health. For example, in agricultural areas, nitrate-contaminated ground waters may also be found to carry leachable pesticides. For this reason, G&M chose to focus on nitrate levels in the surficial ground waters and shallow ground waters. The water-quality data included approximately 87 wells where nitrate concentrations were available and the lithology or the zone of well withdrawal, could be clearly determined. The location of these wells and the nitrate content, mg/l, is displayed on Map Sheet 3. These samples were primarily taken from the Pleistocene Aquifer. Approximately 12 percent of the well samples had a nitrate content greater than the drinking water standard of 10 mg/l. The mean nitrate concentrations in surficial ground waters in the area of study was 5.7 mg/l. These results are similar to those reported by Bachman (1984).

Two distinct areas were delineated where the nitrate concentrations appears to be elevated, (i.e., concentrations were frequently greater than 5 mg/l) as shown on Map Sheet 3. One such area is in the vicinity of Hurlock and Solomon's Temple. A second area of elevated nitrate concentrations occurs to the north and east of Eldorado. A listing of nitrate values are provided in Appendix A.

TABLE 2.
MARYLAND GROUND-WATER QUALITY STANDARDS
COMAR 10.50

Inorganic Chemicals	
Arsenic	0.05 mg/l
Barium	1.0 mg/l
Cadmium	0.010 mg/l
Chromium	0.05 mg/l
Lead	0.05 mg/l
Mercury	0.002 mg/l
Nitrate (as N)	10.0 mg/l
Selenium	0.01 mg/l
Silver	0.05 mg/l
Fluoride	4.0 mg/l
Organic Chemicals	
Endrin	0.0002 mg/l
Lindane	0.004 mg/l
Methoxychlor	0.1 mg/l
Toxaphene	0.005 mg/l
2,4-D	0.1 mg/l
2,4,5-TP, Silvex	0.01 mg/l
Total trihalomethanes	0.10 mg/l
Radioactivity	
Combined radium-226 and Radium-228	5 pCi/l*
Gross alpha particle activity activity (including radium-226 but excluding radon and uranium)	15 pCi/l
Average annual concentration of beta particle and photon radioactivity not to produce annual dose equivalent greater than	4 millirem per year

*pCi/l=picocuries per liter

Presence of Confining Units within 25 Feet of Land Surface

A major emphasis of the investigation was to determine the presence of continuous confining units within 25 feet of land surface that are five feet or greater in thickness. Examination of lithologic logs, including well completion logs, indicates that such units, if present, are relatively sparse in Area A. The data were insufficient to draw conclusions about Area C. Two general areas as located on Map Sheet 4 were found where at least 10 observations indicated the presence of a confining unit within 25 feet of land surface. The supporting data, however, are insufficient to fully conclude that these confining units are laterally extensive. For this reason, it is recommended that specific site investigations be performed where the presence of such a confining unit is suspected.

Information available from the U.S.D.A. Soil Conservation Service indicates that a large portion of the study area is underlain at shallow depth, i.e. within 5 to 10 feet, by a thin, 6- to 24-inch, silty layer of varying thickness. A typical soil description with such a layer is provided in Table 3. The thin silty layer is present generally below the elevation of 35 feet in Area A as shown on Map Sheet 4. The occurrence of this thin silty layer is generally recognized; but, its presence at any site should be field verified.

The thin silty layer may provide additional protection to underlying ground waters due to 1) a chemical environment favoring denitrification, 2) fine pore sizes to enhance filtering, and 3) an order-of-magnitude smaller permeability than overlying sands that promotes lateral flow toward surface waters.

TABLE 3.
SOIL PROFILE DESCRIPTION OF INGLESIDE SOIL SERIES
WITH SILTY RESTRICTIVE UNIT AT 56 TO 72 INCHES
(COURTESY OF USDA SOIL CONSERVATION SERVICE)

Typical Pedon: Ingleside sandy loam, on a smooth one percent slope in a cultivated field. (Colors are for moist soil).

Ap--0 to 10 niches; dark brown (10YR 4/3) sandy loam; moderate fine granular structure; very friable, slightly sticky, slightly plastic, common very fine, and few fine, and medium roots; common very fine tubular pores; slightly acid; abrupt smooth boundary. (7 to 11 inches thick)

E--10 to 15 inches; brown (10YR 5/3) sandy loam; weak medium subangular blocky structure; very friable, slightly sticky, slightly plastic; common fine and very fine roots; many very fine, and common fine, and few medium tubular pores; slightly acid; abrupt smooth boundary. (0 to 5 inches thick)

Bt1--15 to 24 inches; dark yellowish brown (10YR 4/6) sandy loam; moderate medium subangular blocky structure; friable, slightly sticky, slightly plastic; common very fine and fine roots; common very fine and fine tubular pores; common distinct clay films on faces of peds and clay bridging between sand grains; slightly acid; very clear wavy boundary. (4 to 15 inches thick)

Bt2--24 to 33 inches; strong brown (7.5YR 4/6) sandy loam; moderate medium subangular blocky structure; friable, slightly sticky, slightly plastic; few very fine roots; common very fine and fine tubular pores; common prominent clay films on faces of peds and clay bridging between sand grains; slightly acid; clear wavy boundary. (6 to 15 inches thick)

BC--33 to 43 inches; yellowish brown (10YR 5/6) sandy loam; weak medium subangular blocky structure; very friable, slightly sticky, slightly plastic; few very fine roots; common very fine and fine irregular pores; clay bridging between sand grains; slightly acid; gradual wavy boundary. (2 to 10 inches thick)

C1--43 to 48 inches; yellowish brown (10YR 5/8) loamy sand; single grain; loose; few very fine and fine irregular pores; moderately acid; clear wavy boundary. (9 to 25 inches thick)

C2--48 to 56 inches; light yellowish brown (10YR 6/4) loamy fine sand; common medium distinct light brownish gray (10YR 6/2) mottles, and common medium prominent strong brown (7.5YR 5/8) mottles; single grain; loose, moderately acid; clear smooth boundary. (6 to 10 inches thick)

2C3--56 to 72 inches; pale brown (10YR 6/3) silt loam; common medium faint gray (10YR 6/1) mottles, and common fine prominent strong brown (7.5YR 5/8) mottles; massive; friable, slightly sticky, slightly plastic; moderately acid.

PRINCIPAL FINDINGS

The principal findings of this study are summarized below.

- The shallow Pleistocene Aquifer (Beaverdam/Columbia Formation) and Miocene age aquifers (Choptank and Calvert Formations) are the principal sources of ground water within the area of study. The Piney Point Aquifer is receiving more use, but mostly in the Cambridge area. Should the surficial aquifer become contaminated in Area A, it appears that a deeper, confined aquifer is present in some areas to allow for limited replacement of shallow water supplies. Within Area C the available information indicates that deeper confined aquifers are the principal sources of drinking water. Some shallow wells are reported in the Parsonsburg Sand and Kent Island Formation.

- Ground-water quality of the surficial aquifer within the study area is generally good; however, nitrate levels are elevated in some portions of the Pleistocene Formation (Area A). In a sample of well-water analyses, 12 percent gave a nitrate level exceeding drinking-water standards. Elevated nitrate levels may be indicative of the presence of other constituents of concern to human health.

- Elevations less than 35 feet mean sea level in Area A are likely to be underlain by a thin, silty restrictive layer that may provide for significant treatment effects and limited protection of the deeper water-bearing units in the Pleistocene Aquifer. An examination of lithologic logs indicates two small areas that may possess a confining unit at least five feet thick within 25 feet of the land surface. Determination of the presence of the thin silty restrictive layer or thicker confining layers will require on-site investigations due to the limited data available for this study.

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