INTRODUCTION

1

SECTION 1: INTRODUCTION

OVERVIEW

Ground water resource protection and management on the Eastern Shore of Virginia (see Figure 1-1 for locus map) requires the involvement and cooperation of many levels of government as well as a commitment from the private sector. The private sector plays an important role because ground water withdrawals for operations such as industrial processing and agricultural irrigation greatly exceed public water supply needs. If development progresses in the Counties of Accomack and Northampton, however, the ratio of public to private water use is expected to rise.

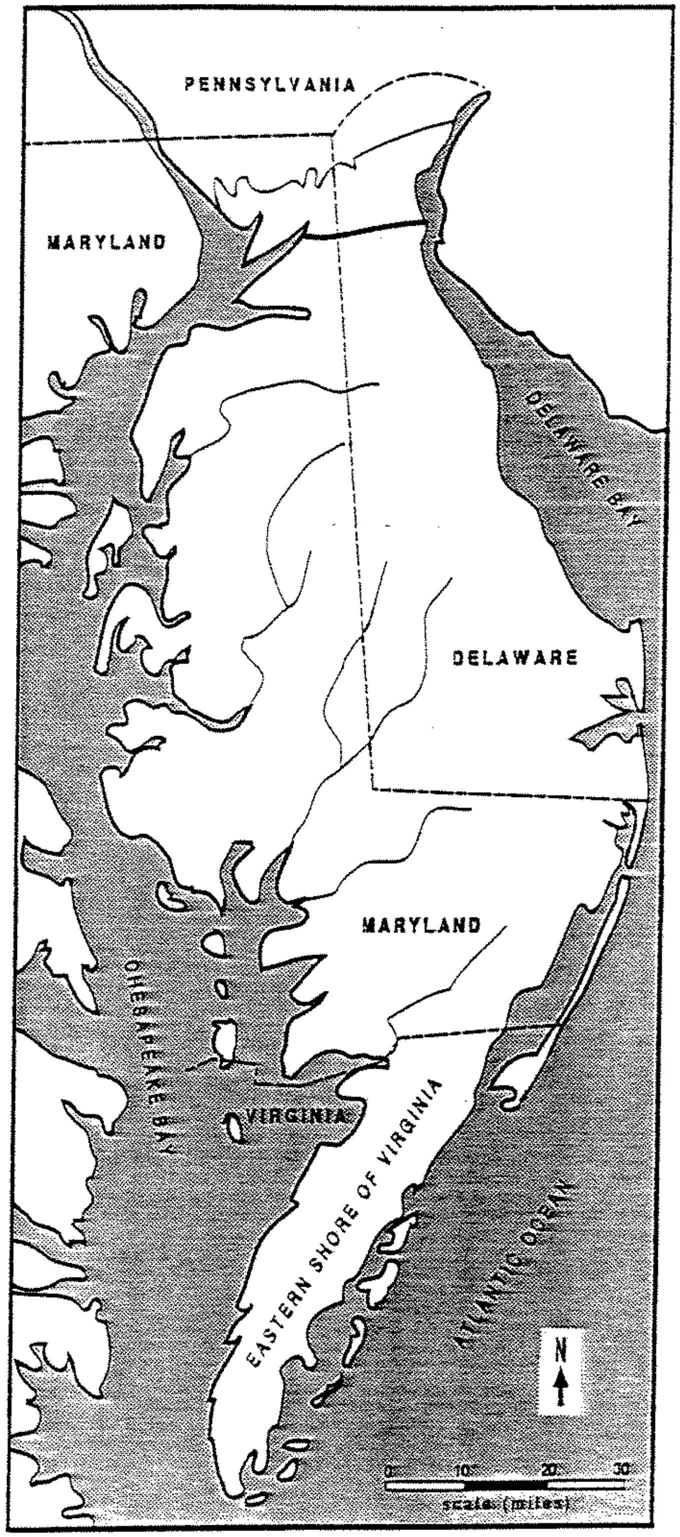
The majority of ground water is withdrawn from deeper confined aquifers found on the Eastern Shore. The water quality in these aquifers is generally very good. Ground water in the unconfined, shallow aquifer is of poorer quality than that found in deeper aquifers, and is used primarily for individual private wells and for irrigation. Septic systems, agriculture, and commercial and industrial development have all been identified as potential sources contributing contaminants to the shallow aquifer, primarily in the form of nitrogen. The current low density of development found on the Eastern Shore allows for the establishment of land use controls and cooperative efforts to protect water quality by private and public institutions.

A major concern on the Eastern Shore is overpumping of water from the deeper confined aquifers. Although the volume of water stored in the aquifers and the recharge that infiltrates naturally over the land surface has been calculated within a range of uncertainty of a factor of two to support the current rates of water withdrawal, for the Eastern Shore as a whole, further salt water intrusion may occur. In fact, Virginia State Water Control Board data from selected test wells indicate decreases in water levels and increases in salinity adjacent to the largest industrial withdrawal wells. Moreover, if the existing facilities increase their pumping rates to the maximum volumes allowed in their permits, several areas of the Eastern Shore are predicted to experience increasing problems of well interference, salt water intrusion, and a deterioration of water quality.

Several management scenarios are available to ensure that there is adequate water in the future to meet anticipated demands and to protect both the shallow and deep aquifer systems from a deterioration in water quality.

This study summarizes available information on water withdrawals, land use threats, and current control mechanisms on the Eastern Shore. Recommendations are proposed to develop a comprehensive ground water protection and supply management plan which will maintain an adequate supply of water and sustain high water quality for the future needs of the region.

Figure 1-1: Locus Map of the Eastern Shore of Virginia



EXECUTIVE SUMMARY

The Eastern Shore of Virginia is an 80 mile long peninsula that comprises about 696 square miles of area, located at the southern tip of the Delmarva Peninsula and within the Eastern Coastal Plain Province. The Eastern Shore is bounded on all sides by water, except to the north which is bordered by the Maryland mainland. The Atlantic Ocean is to the east and the Chesapeake Bay to the west and south.

Ground water is the only source of supply for domestic, industrial, and agricultural water use. A total population of approximately 47,000 use this ground water. Most of the production wells are set to draw water at various levels in the semi-confined aquifer (called the Yorktown-Eastover) found at about 300 feet below mean sea level. The water table aquifer (called the Columbia) is used extensively for agricultural irrigation and private wells.

Accomack and Northampton Counties are the administrative units that govern the Eastern Shore and control all land use activities in conjunction with nineteen small towns. The Accomack-Northampton Planning District Commission has commissioned the development of a Ground Water Management and Supply Protection Plan that will provide a comprehensive and practical series of options, alternatives and specific actions to promote compatibility between the Eastern Shore's water resources and the counties land use plans.

In 1976 the Virginia State Water Control Board designated the Eastern Shore of Virginia a "Ground Water Management Area". The Eastern Shore was the second area in Virginia to be declared a ground water management area. This declaration was based on the findings that:

- Ground water level declines have been observed in two sections of Accomack County;
- Interference between wells has been observed in the same two sections of Accomack County;
- Some evidence of localized ground water contamination has been observed in the water table aquifer of Accomack County but not in the confined aquifers;
- Even though the ground water supplies in Accomack County are not overdrawn and are not expected to be in the near future, it should be recognized that they may overdraw in some areas in the future if water withdrawals are not distributed throughout the region. Further, saltwater intrusion has not been observed to date but may occur in the future if heavy ground water withdrawals are concentrated in any one area.

The major impact of the Ground Water Management Area designation is that all water users that withdraw in excess of 10,000 gallons per day (gpd) are subject to a state permit process. Ten major existing industrial and municipal withdrawals became grandfathered and did not have to submit extensive permit applications. Currently, there are no regulations controlling agricultural water use, except for the reporting of water use on an annual basis.

The aquifers on the Eastern Shore are strongly influenced by the lithology. Annual precipitation of 42 inches per year provides the recharge to the aquifers. The upper aquifer, called the Columbia Aquifer, is unconfined, and is roughly 80 to 100 feet thick. This aquifer is used primarily for private on-site domestic wells, and agricultural irrigation. Approximately 2 million gallons per day are withdrawn by private on-site wells for domestic use. Some portion of the 8.7 million gallons per day withdrawn for irrigation comes from the Columbia aquifer.

Anywhere from 12 - 24 inches per year of precipitation recharges the Columbia aquifer on the Eastern Shore of Virginia. At an average recharge rate of 17 inches per year, approximately 324 million gallons per day recharge the Columbia aquifer. Most of this water flows from the middle of the peninsula and discharges to the Chesapeake Bay and the Atlantic Ocean. A small percentage contributes to the recharge of the deeper confined aquifer.

Water quality in the Columbia aquifer is threatened by the many land uses that discharge, leach or dispose of contaminants to the ground water. Nitrate-nitrogen is the primary contaminant of concern to the Columbia aquifer. Sources include: septic systems; agricultural fertilizers; manure storage and animal disposal; septage lagoons; and landfills. In addition, pesticides and underground storage tanks are also threats. The average nitrogen concentration in the ground water was calculated to be 2.0 milligrams per liter. The national drinking water standard for nitrogen is 10 milligrams per liter. On average, the shallow ground water quality is considered very good however, those areas located down gradient from major nitrogen users or disposers will experience much higher nitrogen concentrations.

The next water bearing zone is the Yorktown-Eastover Formation, a confined aquifer consisting of coarse shelly sands found in three layers separated by clay confining units. This aquifer can range in depth from 80 to 800 below the land surface, though most wells are pumping from layers between 150 and 300 feet deep. The clay confining layers that separate the Columbia aquifer from the Yorktown-Eastover serve to protect the aquifer from many of the water quality threats. They also act to impede the amount and rate of recharge to the aquifer. It is estimated that only 1.2 inches of precipitation recharge the Yorktown-Eastover aquifer. Based upon the ground water modelling studies conducted, approximately 11 million gallons per day is recharge to the Yorktown-Eastover. However, it should be noted that this recharge value is based on average conditions across the entire Eastern Shore, and depending upon specific site conditions can vary by a factor of two in either direction. Additional study is necessary to better define the recharge rate to the Yorktown-Eastover aquifer.

Industrial withdrawals and public water supply wells are exclusively screened in the Yorktown-Eastover aquifer, while wells used for agriculture and private household use are withdraw from the upper aquifer. Currently 4.5 million gallons per day are withdrawn from this aquifer for industrial use and public water supply, Permits from the Virginia State Water Control Board would allow withdrawals of up to 15.6 million gallon per day from this aquifer. If this were to occur, problems of well interferences and salt water intrusion, already observed near the largest industrial water users, will be greatly enhanced.

Local planning and elected officials on the Eastern Shore have been concerned for a number of years about the quality and availability of ground water. The State Water Control Board of Virginia has conducted several studies and developed a network of ground water monitoring wells on the Eastern Shore to document problems. In addition, through cooperative studies, the U.S. Geological Survey has developed reports and modelled the hydrogeology. The results of these investigations all agree that the major issues are:

- Agriculture, water quality and quantity;
- Animal wastes;
- Development impacts, septic systems, underground tanks;
- Well interference, industrial and public water supply wells,
- Salt water intrusion;
- Adequate water supply, future demands, all uses.

Each of these activities/concerns have an impact on water use and quality for either the upper aquifer, the lower aquifer or both.

A land use buildout study was conducted to assess the maximum potential for development within the spine recharge area. The findings show that under current zoning, the number of single-family dwelling units that could potentially be developed within the spine recharge area is greater than the total number of existing units county-wide. This has serious implications for future wastewater disposal,water supply and agricultural use. Buildout conditions were modelled for impacts on ground water quality due to nitrogen contamination. The area with the most likely impacts will be in WPA (B) in the vicinity of Holly Farms (Tysons Foods).

The Ground Water Supply Protection and Management Plan For the Eastern Shore of Virginia provides a review of each of these threats including land use impacts under future buildout conditions. In addition, the recharge areas to the major pumping wells have been delineated. An aquifer recharge zone was mapped based upon hydrogeologic information that suggests that the source of recharge to the confined aquifer is located along the spine of the peninsula.

Based upon the analyses conducted and the review of existing information, the study proposes the following actions:

Recommendations for Water Quality Protection

- Pursue water conservation measures with major industrial users.
- Create an overlay protection zoning district to protect the spine recharge area to the Yorktown-Eastover aquifer;
- Restrict the siting of new mass drainfields in the spine recharge area;
- Review and revise county zoning and subdivision regulations;
- Require the registration of currently unregulated underground storage tanks;
- Incorporate ground water protection requirements into site plan review;
- Develop a private well ordinance to control the siting and construction of new wells;
- Support the implementation of agricultural nutrient management plans;
- Implement the provisions of the Chesapeake Bay Program.

Recommendations for Water Quantity Management

- Revise State Ground Water Act and Regulations to allow for reevaluation of existing permits;
- Develop an Eastern Shore Water Management District to manage water withdrawals;
- Control the siting and development of new water supply wells to prevent well interference and reduce the threat of salt water intrusion;
- Continue the accurate reporting of agricultural water withdrawals, by well location and depth.
- Continue the consideration of mandatory permitting of agricultural withdrawals after review of reporting data.
- Protect open space and undeveloped land in the spine recharge area.

General Recommendations

- Implement a land use/water quality data base;
- Develop a public education program on ground water.

Continued Research and Investigation

- Investigate the nature of recharge to the Yorktown-Eastover aquifer;
- Research dilute salt water issues;
- Conduct additional hydrogeologic studies to better define the geology;
- Evaluate pesticide use on the Eastern Shore;

- Support additional agricultural nutrient management research;
- Revise the nitrogen model used in the study over time.

The Eastern Shore of Virginia is situated over a very valuable ground water resource that is the sole source of water supply to the inhabitants and is also necessary for both industrial and agricultural use. Protection of the water quality and quantity will require the implementation of many actions designed to maintain water quality, prevent against over use of the aquifer and provide for the future needs to accommodate growth on the Eastern Shore.

PURPOSE OF PROJECT

This project prepared by Horsley Witten Hegemann, Inc. (HWH), was guided and funded by the Eastern Shore of Virginia Ground Water Study Committee. The committee was formed for the purpose of assisting local governments and residents of the Eastern Shore to understand, protect and manage their ground water resources. In addition to serving as an informational and educational resource, the Committee initiates special studies concerning the protection and management of the Eastern Shore. This Ground Water Resources Protection and Management Plan is one of several ways in which the Committee intends to carry out its goals.

The Committee consists of 2 members from each county's Board of Supervisors, one citizen appointee by each Board of Supervisors, the County Administrator from each county, and the Executive Director of the Accomack-Northampton Planning District Commission.

This report responds to three aspects of the Committee's purpose:

1. The report provides management information by identifying the quantity of ground water available for use, and explaining the potential for de-watering of the ground water aquifers, salt water intrusion, and contamination.

2. The report provides recommendations regarding ground water quality protection; identification and protection of ground water recharge areas; nitrate-nitrogen loading to the water table; land application of pesticides; and hazardous material storage.

3. The report, combined with public forums, maps, and background information on the hydrogeologic cycle and ground water conditions on the Eastern Shore, advises the public as to their role in protecting ground water and identification of threats to water quality and quantity.

An additional goal of this project is to improve coordination among those municipalities, state and local governments, and private sectors responsible for the protection, management, and research regarding the Eastern Shore ground water supply.

WATER RESOURCES ON THE EASTERN SHORE OF VIRGINIA

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SECTION 2: WATER RESOURCES ON THE EASTERN SHORE

Ground water is the only source of drinking water on the Eastern Shore, and is therefore considered the most important water resource. However, an understanding of the water system as a whole is necessary to understand future land use and development decisions designed to protect water supplies. This section provides an overview of the water resources on the Eastern Shore of Virginia. Soil types and the geology which influence water quality and quantity are also discussed.

TOPOGRAPHY AND SOILS

Accomack and Northampton Counties lie in the Coastal Plain Province of Virginia. The soils of the two counties are predominantly comprised of sand, clay, and shell fragments, deposited during the Miocene Era (Fennema and Newton, 1982). The resulting land is one of the most productive in the entire Atlantic Coastal Plain.

The region is generally flat, with a central plateau. Maximum elevation of the plateau is 45 feet above mean sea level, and the slope rarely exceeds two percent. From the central northeast-southwest trending divide, the land gradually slopes toward the Chesapeake Bay and Atlantic Ocean shorelines.

Soil characteristics greatly influence the activities which may take place on the land above them, and thus play a significant role in planning and development. For example, layout and grading of roadways, excavations for foundations of new buildings, and the operation of septic tanks are all affected by soil suitability. Factors such as permeability, depth, natural fertility, and drainage are important when considering agricultural potential and future development sites. Soil drainage is particularly important on the Eastern Shore where the primary method of disposing domestic waste water is by septic systems. If the soil is not suited for wastewater disposal, waste water must be transported to an area of suitable soil, or else be treated in a central treatment facility.

According to the Soil Survey of Northampton County (Soil Conservation Service,1989 and 1990) and the Accomack County Comprehensive Plan (1989), there are five major soil associations on the Eastern Shore of Virginia. A soil association is an area of land made up of two or more geographically associated soils which occur in a similar pattern. The following paragraphs summarize the Soil Conservation Service's characteristics of these soil associations:

Bojac-Munden-Molena
This association makes up 48% of the two counties. It is nearly level to steep, moderately well drained to somewhat excessively drained, loamy and sandy soils; on broad flats, side slopes, and escarpments. Of the five associations, this one is the best for development. However, there are some development limitations due to erosion, wetness, and shallowness of sorts. Munden soil, in particular, is considered excellent for development. Septic tank suitability is moderate, generally limited by poor drainage.

Nimmo-Munden-Dragston
Covering 15% of the two counties, this association is nearly level, moderately well drained to poorly drained, consisting of loamy soils found on broad flats and depressions. The association is not always suitable for development. Septic tank suitability is severe due to a seasonal high water table and poor drainage.

Chincoteague-Magotha
Covering 28% of the two counties, this association is nearly level, very poorly drained to poorly drained, silty and loamy soils, found in tidal marshes. Not suitable for development, the soils are best utilized as wetland wildlife habitat and as spawning grounds for shellfish and finfish. This association is frequently flooded, has a moderate natural fertility, and is well suited for salt-tolerant plants.

Nimmo-Arapahoe
Located in the northwest portion of Accomack County only, this association covers 5% of the two counties. It is level, poorly drained, and suitable for development and agriculture if properly drained. The Soil Conservation Service on the Eastern Shore, however, considers the area where these soils lie to be undevelopable.

Fisherman-Beaches-Camocca
Covering 4% of the two counties, this association is nearly level to steep, moderately well drained and poorly drained, sandy soils and beaches, found on flats and low dunes and depressions. Because of the location in wetland resource areas, the soil association is not suitable for development.

Figure 2-1 displays the locations of these soils.

The soil types located on the mainland of the peninsula (except Nimmo-Arapahoe) are categorized as prime farmland. This category constitutes 68% of the land in the counties of Northampton and Accomack. Water bearing capacity of these soils is moderate, and the natural fertility is low. Typically these soils are acidic. They are well suited to cultivated crops, soybeans, small grains, vegetables, and ornamentals (SCS, 1989).

In general, the two counties contain soils that are less than ideal for proper septic system functioning, generally due to a seasonal high water table. The Accomack County Comprehensive Plan maintains that the Bojac-Munden-Molena soil associations are well drained and suitable for development and agricultural lands. These soil types constitute 44% of Northampton County's land, and 52% of Accomack County, and thus are the most prevalent soils. It should be noted that the entire town of Chincoteague, Accomack County's most developed magisterial district, is underlain by the Fisherman-Beaches-Camocca formation, which is described as unsuitable for development because of poor drainage and susceptibility to a seasonal high water table, flooding, and instability (SCS, 1989). Chincoteague receives its water from several wells on the mainland near the NASA Wallops facility, and so does not need to be as concerned about ground water contamination problems within the town. However, any residents using private wells should be wary of the quality of their water, given the number of septic systems in this poorly suited soil.

SURFACE WATER

Surface water includes ponds, streams, creeks, bays, and lagoons. The Eastern Shore is unique compared to mainland Virginia in that there are no major streams or other surface water supplies which can serve as a source of drinking water. This point underscores the importance of protecting the ground water supply, because alternative sources for drinking water do not exist. Surface water systems are, however, interconnected with ground water. The water table on the Eastern Shore of Virginia is shallow, and surface water and ground water play an important interactive role.

Although not used for drinking water, surface water systems are important for shellfish, finfish, and other wildlife on the Eastern Shore. These animals benefit the general economy of the area: the finfish industry grossed over one million dollars in 1986, and the sale of shellfish in 1986 was

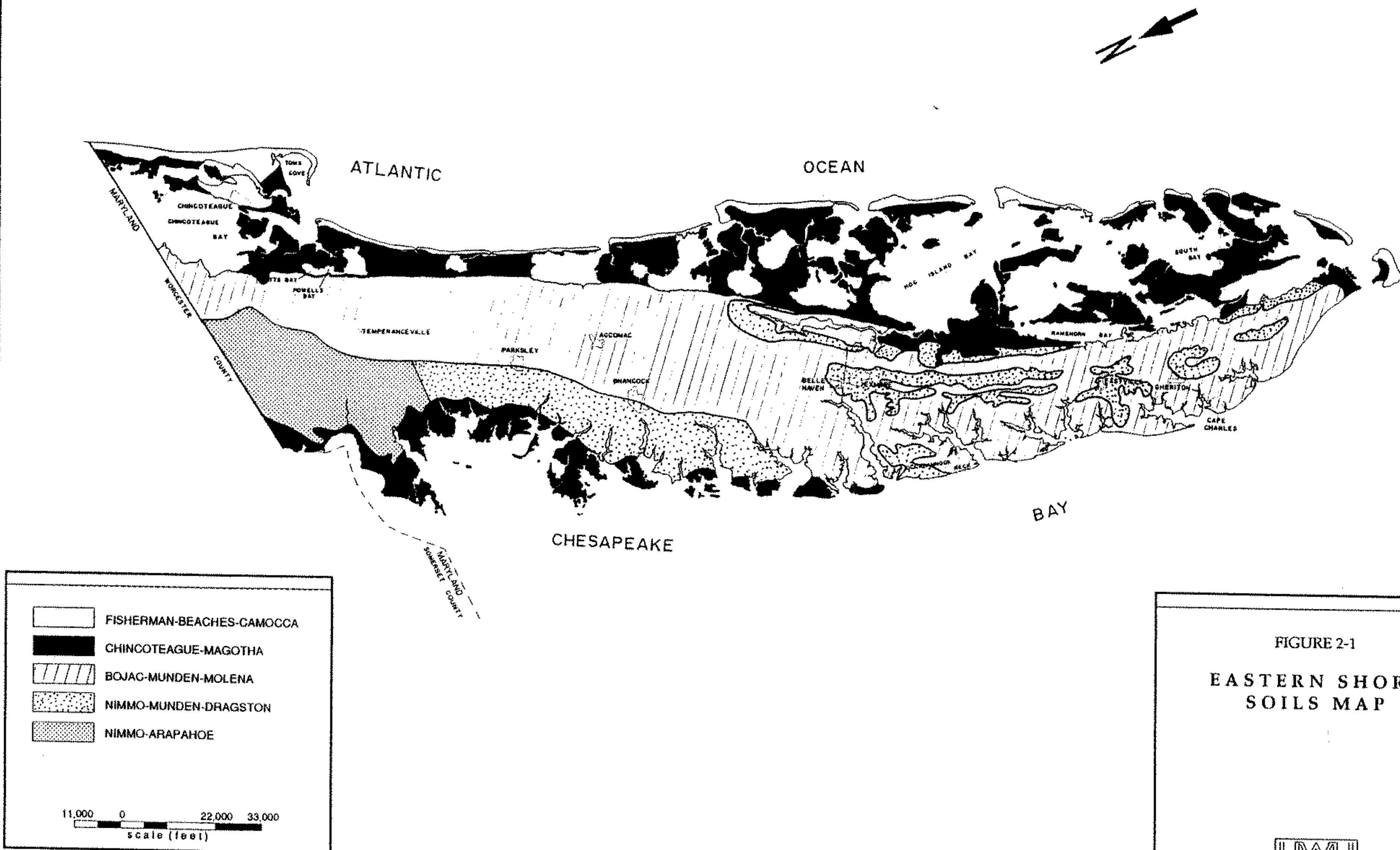


FIGURE 2-1

EASTERN SHORE SOILS MAP

HWH

valued at over nine million dollars, according to the Accomack County Comprehensive Plan (1989). The Virginia State Water Control Board and the Virginia Department of Health Shellfish Sanitation monitor the overall quality of surface water to protect public health in recreational contact and to insure that the waters can sustain aquatic life.

As a result of flat topography and well-drained soils, the peninsula has no large fresh water lakes or waterways. Instead, there are several creeks which, in the lower reaches, are tidal estuaries fed by narrow branches. The Chesapeake Bay side of the peninsula receives the majority of surface runoff, where the creeks are more pronounced. On the Atlantic Ocean side, the barrier islands create a bay and lagoon system, and this side has smaller creeks. In Accomack County, 12 creeks feed into the ocean side, and 19 creeks ebb and flow into the Bay. In Northampton County, there are 21 watersheds, with 15 on the Bay side.

Currently, a water quality monitoring project of tidal creeks in Northampton County is underway. It is a collaborative effort between the Citizens for a Better Eastern Shore (CBES), The University of Virginia, the Virginia Coast Reserve of the Nature Conservancy, the Eastern Shore Working Waterman's Association, and the Virginia Student Environmental Health Project (STEHP). The project will provide baseline information on the status of aquatic habitats and surface water resources of Northampton County. All data derived in the project will eventually be accessible to the general public, and a report completed by the end of 1991 will be submitted to the local board of supervisors and the planning district commission. Recommended actions are expected to result from the presentation of the report.

Hydrologic Units

The USDA Soil Conservation Service has grouped together the 52 watersheds on the Eastern Shore Peninsula to form fourteen (14) hydrologic units. These are essentially larger management units which have common drainage areas. Figure 2-2 indicates the boundaries of the hydrologic units. The following is a breakdown according to county and village. The units beginning with the letter "C" are on the west (Bay) side of the peninsula, and the "D" units are on the east (Ocean) side. Lower numbers are farther south than higher numbers.

Table 2-1: Towns and Villages Located by Hydrologic Units

<u>Accomack County:</u>

C04: [Belle Haven, Bloxom, Craddockville, Davis Wharf, Middlesex, half of Painter, and half of Pungoteague]
C05: [Harborton, half of Melfa, and half of Pungoteague]
C06: [Onancock and half of Onley]
C07: [Greenbush, Hallwood, Horsey, Leemont, Mappsville, Mears, Nelsonia, Parksley, Sanford, Saxis, Tasley, and half of Withams]
C08: [New Church, Oak Hall, and half of Withams]
D03: [Keller, half of Painter, Quinby, and half of Wachapreague]
D04: [Accomac, Centerville, Locustville, half of Melfa, half of Onley, and half of Wachapreague]
D05: [Temperanceville and half of Wallops Island]
D06: [Atlantic, Chincoteague, Greenbackville, Horntown, Half of Wallops Island, Wallops Station, and Wattsville]

<u>Northampton County:</u>

C01: [Dalbys]
C02: [Cape Charles, Cheriton, and Chesapeake]

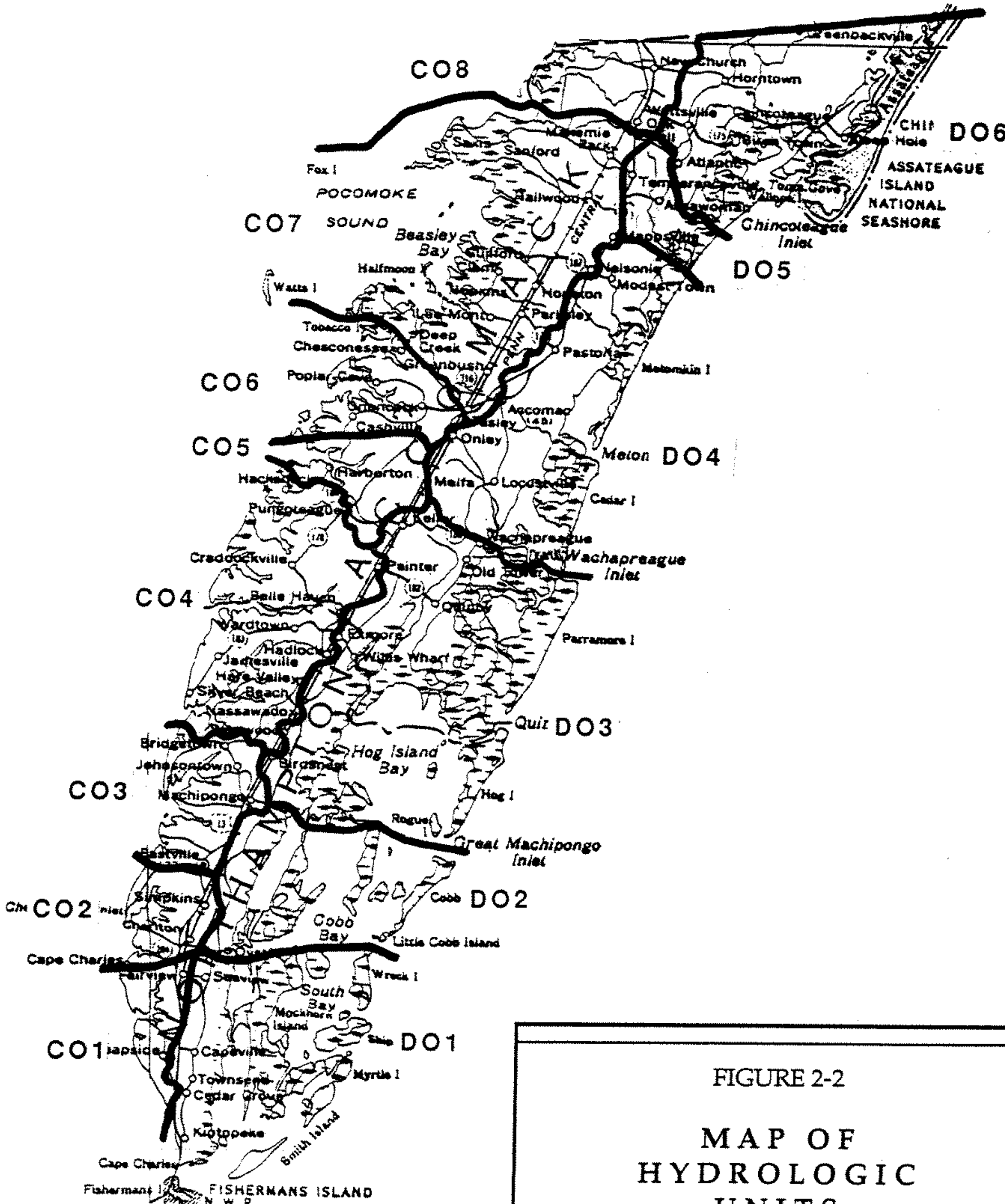


FIGURE 2-2

MAP OF HYDROLOGIC UNITS

C03: [Bridgetown, Churchneck, half of Eastville, and Machipongo]
C04: [Bayford, Birdsnest, half of Exmore, Jamesville, half of Nassawadox, and Silver Beach]
D01: [Capeville, Seaview, and Townsend]
D02: [Half of the Town of Eastville]
D03: [Half of Exmore, half of Nassawadox, Weirwood, and Willis Wharf]

Farm Ponds

In the two counties, over 325 excavated "farm ponds" supply about 85% of the water used for irrigation (Cooperative Extension Agents Jim Belote, Fred Diem, personal communication, 1991). It is unknown how many of these ponds are used as storage areas for water that has been pumped from wells. Farm pond locations, as supplied by the Accomack-Northampton Planning District Commission, are shown in Figure 2-3. Some of the locations in Figure 2-3 have multiple ponds. While it is unclear which of these ponds intersect the water table, the use of surface water for irrigation, rather than well water, reduces the stress on the use of the deeper ground water supply However, farm pond construction by creek damming may destroy valuable wetland habitat and negatively effect downstream productivity (Paul Gapcynski, William & Mary, Virginia Institute of Marine Science [VIMS], Eastern Shore Natural Resources Symposium speech 4/11/91). Two studies conducted by VIMS have shown no negative effects on downstream productivity (letter from J. Rodney Lewis, SCS, 7/8/91).

Ditches have also been constructed on the Eastern Shore to connect creeks in order to increase drainage (Fennema and Newton, 1982). This has the effect of increasing surface water runoff rates. Additionally, several dams have been built in estuaries below and at the head of tide water to supply irrigation water.

Tidal Wetlands

Both Accomack and Northampton Counties contain numerous tidal wetlands. Wetlands are some of the most ecologically productive systems in the world, and are sensitive to land development and use. Tidal wetlands serve as water filters, mitigate the impact of storms, and provide habitat for a variety of wildlife, aquatic life, and plants. Accomack County has 70,000 acres of vegetated tidal wetlands, divided between salt marshes along the Atlantic Ocean shoreline, and brackish marshes on the Chesapeake Bay shoreline. Accomack County also contains extensive non-vegetated intertidal flats on the ocean side. Non-vegetated tidal wetlands are located between mean high water and mean low water and are adjacent to tidal marshes. Tidal wetlands in Northampton County are located on both the ocean and bay sides, and total 35,000 acres.

GROUND WATER

Introduction

The Eastern Shore of Virginia depends entirely upon ground water supplies for its municipal and industrial water needs. Virtually no streams or rivers exist on the peninsula, nor are there surface water lakes or reservoirs of appreciable size.

Ground water serves the water supply needs of the Eastern Shore today, and will continue to do so in the foreseeable future. As a result of this dependence on ground water, protection of the resource, both in terms of water quantity and water quality, takes on an added importance.

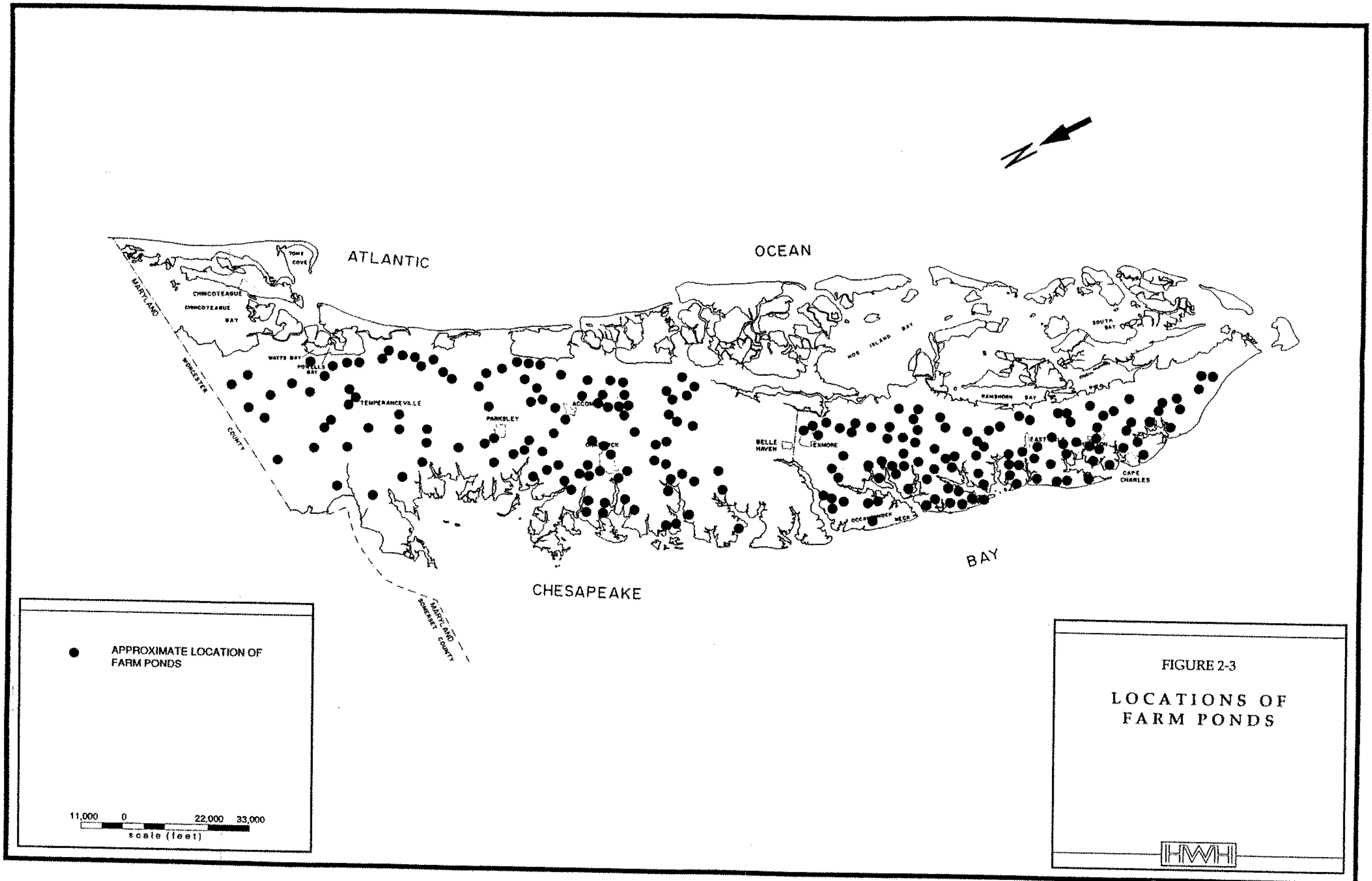


FIGURE 2-3

LOCATIONS OF FARM PONDS

Ground water on the Eastern Shore is derived from precipitation falling on the land surface of the two counties. Some of that water is intercepted by vegetation and is transpired or evaporated directly back to the atmosphere. A portion runs off as overland flow while some penetrates the soil and is used (transpired) by plants. Part of the precipitation moves through the unsaturated zone and recharges the unconfined (Columbia) aquifer. Figure 2-4 below illustrates the hydrologic cycle. Most water in the Columbia aquifer flows laterally from the center of the peninsula, contributing to the baseflow of small streams or is held in temporary storage in ponds before discharging to the Atlantic Ocean or Chesapeake Bay. A much smaller portion of water in the unconfined aquifer continues its vertical migration through the clays and silts that separate the Columbia from the underlying Yorktown-Eastover aquifer, recharging the confined aquifer system. See Figure 2-5.

Tangier Island, a small island that is part of Accomack County and is located ten miles off the coast of Virginia in the Chesapeake Bay, also obtains drinking water from ground water sources. The island has a separate hydrogeologic system from the mainland, and was not studied in detail in this report.

Figure 2-4: Hydrologic Cycle

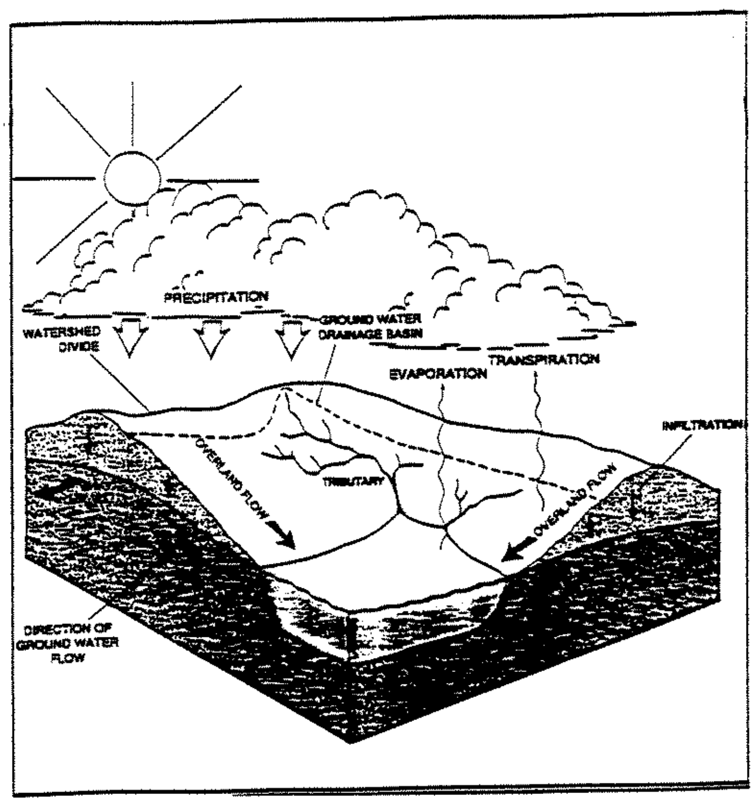
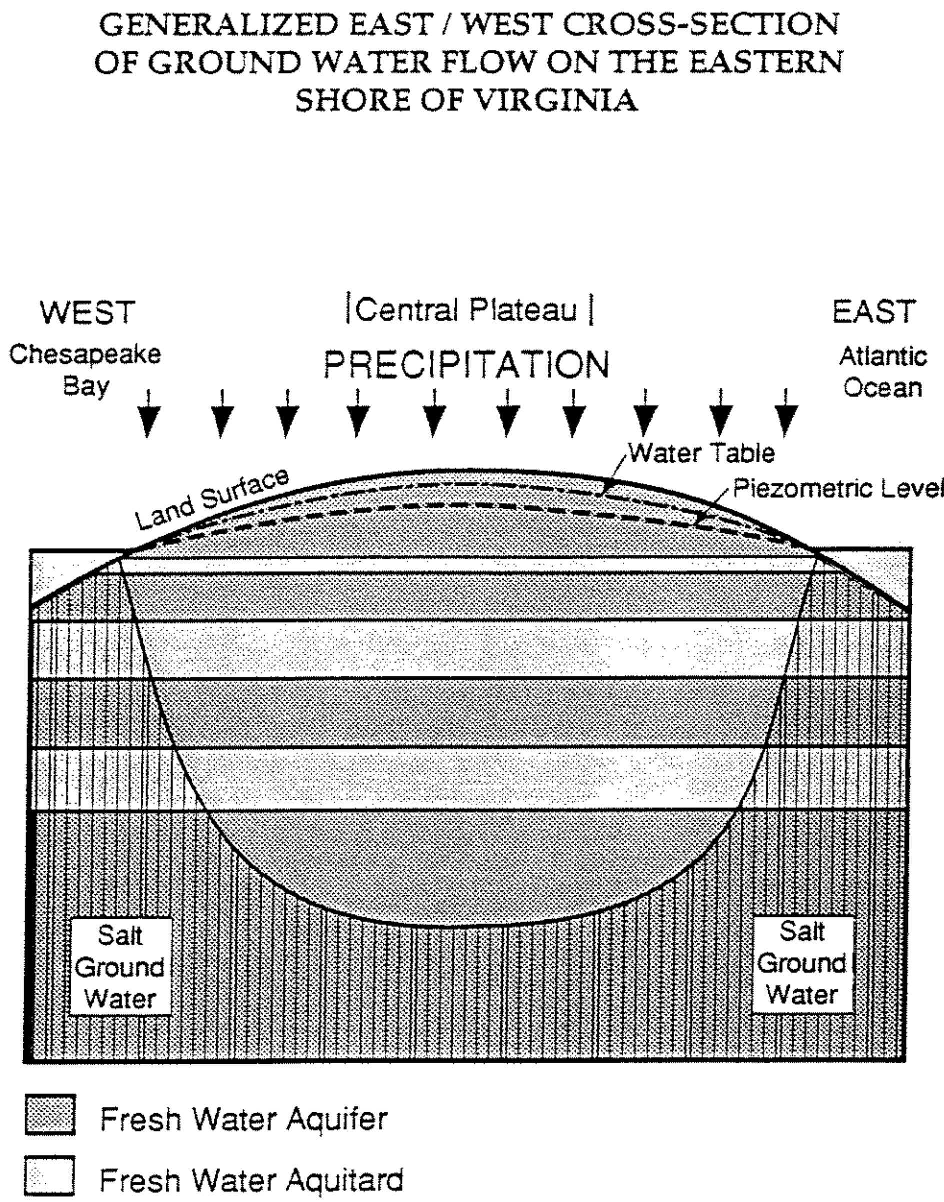


Figure 2-5 Generalized East/West Cross Section



Hydrogeology of the Eastern Shore Aquifers

The most important geologic formations with regard to ground water supply are the Columbia and the Yorktown-Eastover. The Columbia was deposited during the Pleistocene (10,000 to 15,000 years before present). The sediments are primarily sands with interfingering clay and silt beds. From a water budget calculation, it was determined that between 12 and 26 inches per year recharges the unconfined system (see Appendix F). Much of that recharge flows laterally through the Columbia aquifer and discharges to the Chesapeake Bay, streams and estuaries as well as the ocean. Some water passes through the 20- to 100-foot thick confining unit of silty clay below the Columbia and enters the other aquifer of importance to the Eastern Shore, the Yorktown-Eastover Formation.

The Yorktown-Eastover was deposited during the Miocene era, between 5 and 23 million years before present. This deposit consists of three layers of aquifer separated by confining units. Recharge to the confined system from the unconfined Columbia aquifer at steady state, pre-pumping conditions is estimated from analytical modelling at approximately 0.10 feet per year (See Appendix E). The Upper, Middle, and Lower aquifers are comprised primarily of fine to coarse shelly sands. Thickness of the permeable sections vary from as little as 10 feet to as thick as 120 feet. The aquifer deposits possess moderate permeability with transmissivities ranging from less than 1,000 gpd/ft (130 ft^2/day) to as high as 40,000 gpd/ft (5300 ft^2/day) (F&ME, 1990; Fennema and Newton, 1982). Transmissivity is the measurement of how much water moves through the aquifer, and is measured by multiplying the permeability of the aquifer by its thickness. The three aquifers are separated by confining units composed of clays and silts of much lower permeability. These units range from less than 10 feet to as much as 70 feet in thickness.

In addition to the Columbia and Yorktown-Eastover aquifers three major paleochannels (coarse sediments deposited in stream channels that cut through the older sedimentary deposits) have been identified on the Eastern Shore (Colman and others, 1990), created by the downcutting of streams during several periods of low sea level during the Pleistocene. Two of these channels cross the main body of the Eastern Shore peninsula, at Exmore and at Eastville. The third major channel crosses south of the peninsula near Cape Charles and Fisherman's Island. The streams that formed the channels cut into the Yorktown-Eastover Formation as much as 200 feet, depositing sands and gravels in the central portion of the channel overlying those sediments with less permeable sands, silts and clays (Colman and others, 1990). The width of the paleochannels is less certain but is mapped in Colman and others (1990) as roughly 1-2.5 miles wide.

Summary of Existing Technical Reports

Available technical reports, including journal articles, consultant's reports, State Water Control Board and U.S. Geologic Survey publications were reviewed for this project to better understand the previous investigations of the Eastern Shore.

The technical literature can be divided into three principal categories. The first include those reports presenting basic geologic and hydrologic data. Such reports are fundamentally compilations of data with descriptive commentary and include many of the U.S. Geological Survey papers and Virginia Division of Mineral Resources reports. For example, Teifke (1973) provides a thorough examination of the geology of the entire coastal plain of Virginia, including the Eastern Shore. The publication is a very useful one with its detailed rock type descriptions from borehole logging as well as its discussion of depositional environments for the formations that make up the region. Sinnott and Tibbitts (1968) offer a comprehensive overview of the geology and hydrology of the Eastern Shore in particular, along with well and water quality data.

The second type of report comes from independent researchers and consultants. These reports (e.g., F&ME, 1990) focus on local aspects of Eastern Shore hydrogeology. Their main utility in terms of the objectives of a ground water protection program lies in the raw data they provide from drilling logs and water quality analyses along with data from test pumping that can be used to obtain aquifer coefficients.

The third type of report is more interpretive in form, applying the basic data to the issues involving the hydrogeology of the Eastern Shore. Many of the Virginia State Water Control Board Planning Bulletins fall into this category. A series of Planning Bulletins, No. 45 (1975), No. 309 (1977) and No. 332 (1982), have charted the efforts of the Board to detail the hydrogeologic conditions of the Eastern Shore in both a conceptual and quantitative manner, along with discussions of how that understanding can contribute to solutions to ground water problems. Bulletin No. 45 offers a comprehensive view of hydrogeologic conditions on the Eastern Shore as they existed almost twenty years ago. That report identified the following key issues: (1) ground water level declines in the confined Yorktown-Eastover aquifer, (2) well interference, (3) salt water intrusion, and (4) ground water contamination that continue to trouble the area. Bulletin No. 309 (Ball, 1977) acted on a specific recommendation of Bulletin No. 45 to construct a two-dimensional numerical flow model of the confined aquifer of the Eastern Shore to apply a more quantitative approach to the understanding and management of the resource. That trend towards a quantified view of the hydrogeology was continued in Bulletin No. 332 (Fennema and Newton, 1982) which augmented Bulletin No. 45's basic information, incorporating borehole geophysical data, water quality information from established research stations and test pumping results. That report presented a series of extremely useful cross-sectional correlations along and transverse to the axis of the peninsula. A forthcoming report from the U.S. Geological Survey (Richardson, in press) continues the move towards quantification of the hydrogeologic conditions of the Eastern Shore with a three-dimensional saltwater/freshwater interface numerical model of the area.

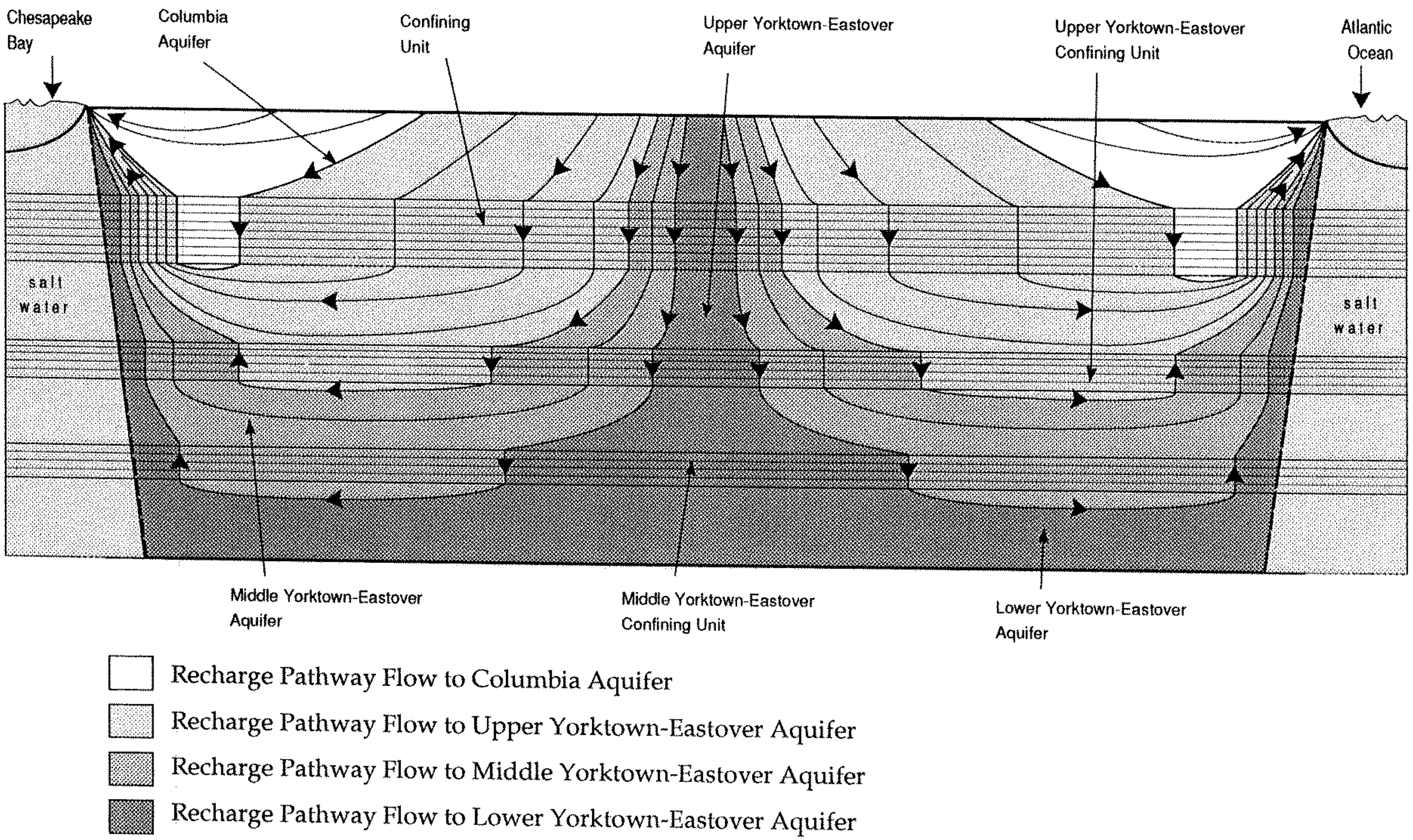
Flow and Recharge Patterns on the Eastern Shore

A conceptual understanding of the flow patterns and locations of the recharge areas on the peninsula is crucial to protecting those areas of most importance to the water supply of Accomack and Northampton counties. That conceptual model must take a three-dimensional approach which incorporates vertical components of flow to account adequately for the hydrogeologic conditions on the Eastern Shore. The key element of that model with respect to protecting the long term quality and quantity of the ground water on the Eastern Shore is the role played by the central spine of the peninsula. The center portion functions as the primary recharge source for the heavily used confined Yorktown-Eastover aquifer, and the center portion's protection is of utmost importance to the continued viability of the confined aquifer as a source of water.

The overall flow and recharge patterns can perhaps best be illustrated through the use of several models developed during the course of this project. The models are cross-sectional views of the peninsula used to observe where ground water is recharged and discharged by the various aquifer systems and the nature of flow within and between aquifers and confining units. The models used were generated numerically by McDonald-Morrissey Associates in conjunction with HWH. United States Geological Survey MODFLOW code was used to model input parameters of aquifer and confining unit thickness, permeability, recharge rates, etc., consistent with those found in the literature for the Eastern Shore. Several steady state model runs were performed to gain a better conceptual view of the ground water flowpaths and recharge areas under different pumping scenarios. While numerical in form, the runs of the model serve best as aids in developing a correct conceptual notion of ground water conditions on the Eastern Shore. Figure 2-6 describes the flow system of ground water under pre-pumping conditions on the peninsula. This figure is for conceptual purposes only and does not represent a quantitative estimate of the recharge area.

FIGURE 2-6.

Conceptual Hydrogeologic Model of Non-Pumping Ground Water Conditions on the Eastern Shore of Virginia



Precipitation falling on or across the peninsula recharges the unconfined Columbia aquifer. Much of that water moves laterally within the unconfined unit and discharges to the ocean or Chesapeake Bay. A portion continues vertically downward through the confining unit until it reaches the Yorktown-Eastover aquifer. The model shows that the deepest portion of the Yorktown-Eastover aquifer (the lower Yorktown-Eastover) receives its recharge from a very narrow strip along the central spine of the peninsula. Once in the lower Yorktown-Eastover aquifer, water moves laterally and then upward through the confining layers, finally to discharge into the Atlantic Ocean or Chesapeake Bay. The Middle and Upper Yorktown-Eastover aquifers receive their recharge in a similar manner, but from a broader area on either side of the peninsula, reflecting both the higher permeabilities of those units as well as their relative stratigraphic positions. That is, there are fewer confining units to go through before the water reaches the aquifers.

The model demonstrates the fact that recharge to the confined Yorktown-Eastover aquifer under pre-pumping conditions occurs at the center of the peninsula. Precipitation falling on the sides of the peninsula moves laterally through the Columbia aquifer, not vertically downward through the confining layer. Much of the water recharged to the Columbia, therefore, discharges to the Atlantic Ocean and the Chesapeake Bay, not the Yorktown-Eastover aquifer.

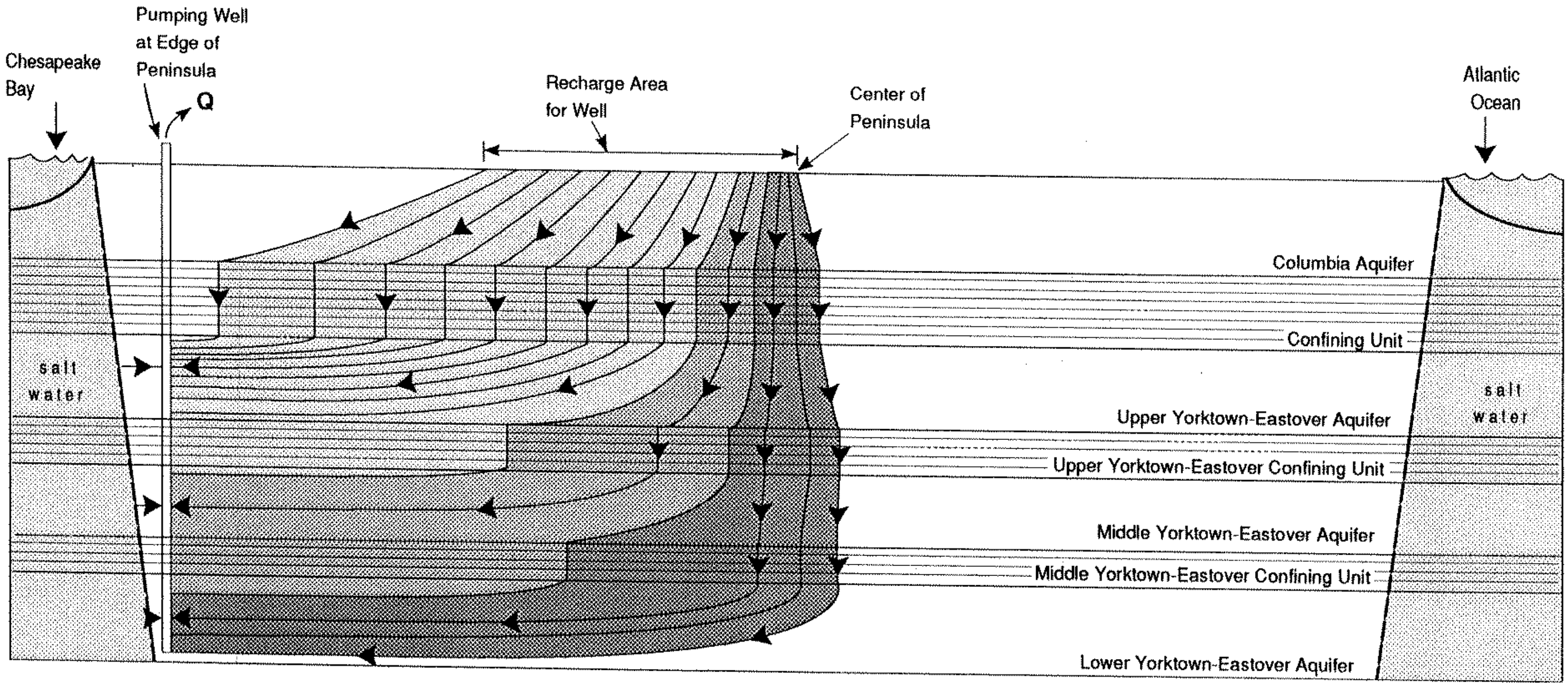
Figure 2-7 conceptually illustrates a scenario of steady state pumping conditions, detailing the pathlines of ground water movement to a pumping well located at the edge of the peninsula. In a somewhat non-intuitive manner, this cross-sectional numerical model shows that the surface area of land immediately around the well contributes nothing to its yield. Precipitation falling on the Eastern Shore in the immediate vicinity of the well will recharge the Columbia aquifer, but the majority of flow in those areas does not pass through the confining layer to recharge the Yorktown-Eastover aquifer and contribute to the yield of the well. In this cross-sectional model, recharge from precipitation to the Columbia aquifer around the wellhead will discharge to the ocean. The recharge source of a water supply on the side of the peninsula is primarily derived from the central area of the land, albeit skewed towards the direction of the well to some degree. In this model, the deepest section of the Lower Yorktown-Eastover aquifer actually obtains its water from beyond the midpoint of the peninsula in this pumping scenario.

As the distance between a pumping well and the center of the peninsula spine increases, a well will derive its water supply from more than one area. Part of its recharge will continue to come from the center of the peninsula, but part will come from other areas of the Columbia, induced by the gradients created by pumping. A detailed quantification of precisely where these areas might be was not possible under the scope of this project. With a properly constructed and calibrated three dimensional model, particle tracking routines could be used on the final head distribution to determine to a much higher degree of precision the origin of the water discharged by a well. This would offer a superior quantification of the proportion of water derived from downward leakage through the confining layer near the well relative to water derived from recharge at the center of the peninsula. Unfortunately, such a three-dimensional flow model does not yet exist for the Eastern Shore, and its construction is beyond the scope of this project. The numerical cross-sectional model was created for conceptualizing purposes, and it serves only to emphasize the importance of the center of the peninsula to the quantity and quality of water available to the confined aquifer system. While other areas of the Columbia undoubtedly contribute to the water supply of wells screened in the Yorktown-Eastover aquifer, even for wells located at the sides of the Eastern Shore, the key recharge area is the center of the land mass.

The numerical modelling which generated the conceptual hydrogeologic model for the Eastern Shore illustrates a concept vital to the development of wellhead and aquifer protection strategies on the Eastern Shore. ***Simply stated, the most important area to protect in order to assure continued good quality and large quantities of ground water throughout the Eastern Shore is the center of the***

Figure 2-7

Conceptual Hydrogeologic Model of the Eastern Shore of Virginia with a Pumping Well at the Edge of the Peninsula Screened in the Yorktown-Eastover Aquifer



Recharge Pathway Flow to Upper Yorktown-Eastover Aquifer

Recharge Pathway Flow to Middle Yorktown-Eastover Aquifer

Recharge Pathway Flow to Lower Yorktown-Eastover Aquifer

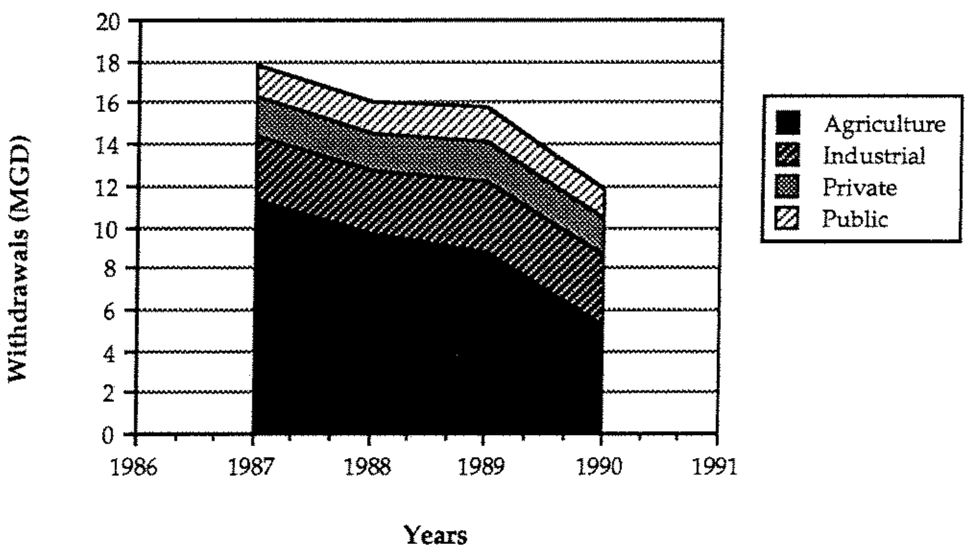
peninsula. Under pumping conditions, the important role of the central portion of the peninsula in maintaining adequate aquifer protection is even more apparent. A protection scheme that does not emphasize the center portion of the Eastern Shore, taking into consideration the three-dimensional character of the flow paths, will prove misleading and ineffective.

WATER USE

A water budget for the Eastern Shore of Virginia has been established by comparing known water withdrawals to the rate of recharge to the aquifer. This budget will help identify water quality and salt water intrusion problems as well as predict the overall future of the ground water supply of the Eastern Shore of Virginia.

This section identifies major water users, which include public, industrial, private, crop irrigation, and poultry categories. In Section 6, the water budget is analyzed with respect to the hydrogeologic conditions of the peninsula.

Figure 2-8: Water Use by Category



Crop Irrigation

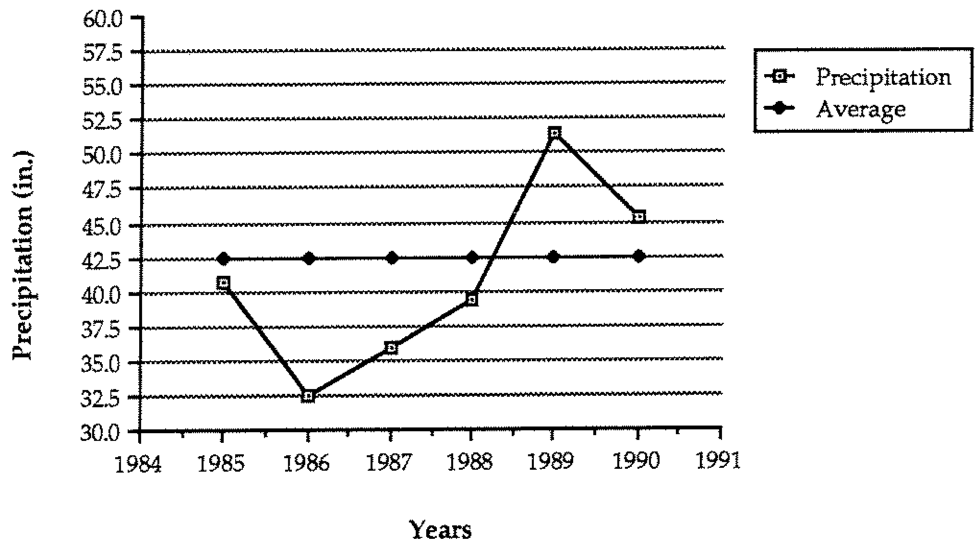
Agriculture is the most water-intensive land use on the Eastern Shore. The State Water Control Board estimates the gallons of water used for irrigation based upon a voluntary survey which is completed by farmers. As of 1991, this survey will no longer be voluntary, and it is expected that the estimations will become more comprehensive if not more accurate. The following (Table 2-2) is a summary of agricultural water use (in millions of gallons per day - MGD) according to the Virginia State Water Control Board. Table 2-3 provides greater detail of this chart.

Table 2-2: Agriculture Water Use by County (MGD)

	1987	1988	1989	1990
Accomack	6.04	6.46	6.86	2.56
Northampton	5.17	3.08	1.94	2.62

Crop irrigation involves a seasonal use of water, but the figures have been annualized to give an average daily withdrawal over the course of each year. Total irrigation did decrease from 1987 to 1989, and this coincides with an increase in rainfall, as shown in Figure 2-9.

Figure 2-9: Yearly Precipitation
Painter, Virginia, 1985-1990



Source: National Oceanic and Atmospheric Administration

Earlier in this section, it was estimated that surface water farm ponds supply approximately 85% of the irrigating water. The State Water Control Board includes source information in its survey. Table 2-4 summarizes the findings. According to the state survey, ground water contributes much more than the 15% that is estimated by the Extension Service, and a small amount of public water is also used.

Table 2-3: Irrigation Estimates, 1987-1990

Year	Geographic Area	Numbers Farms	Reporting Nurseries	Reported Acreage Irrigated	% of acreage in VA	Reported Water Applied (MG)	% of water applied in VA	Annualized Rate (mgd)	Ave. appl. (in.)	Rainfall (in.) Apr.-Sept. *
1987	Accomack	72	12	9588	21.9	2204	22.2	6.037	8.5	12.61
	Northampton	30	3	7122	16.2	1888	19.1	5.173	9.8	
	Virginia	520	47	43866	100	9916	100	27.168	8.3	
1988	Accomack	118	18	10397	26	2357	25.7	6.457	8.3	22.43
	Northampton	42	8	5760	14.4	1125	12.3	3.083	7.2	
	Virginia	430	75	39945	100	9181	100	25.152	8.5	
						1324		3.628		
1989	Accomack	43	11	10182	41.3	2502	48	6.855	9	30.27
	Northampton	41	4	5563	22.5	707	13.6	1.938	4.7	
	Virginia	278	46	24669	100	5211	100	14.278	7.8	
1990	Accomack	31		4210		935		2.56	8.18	27.21
	Northampton	24		4829		956		2.62	7.29	

Source: Virginia State Water Control Board - VA Crop Irrigation Water Use Reports for 1987-1989, 1990 figures unpublished from the SWCB. Rainfall data from NOAA, not SWCB.

Table 2-4: Accomack-Northampton Planning District Irrigation With Source Detail

	1987		1988		1989	
Water Source	Acres Irrigated	Millions Gallons	Acres Irrigated	Millions Gallons	Acres Irrigated	Millions Gallons
Surface Water	4,666	1,552	5,361	1,072	6,420	1,136
Ground Water	8,802	2,198	9,318	2,334	8,141	1,956
Mixed Source	2,510	172	1,479	77	1,082	116
Public Supply	664	171	0	0	104	1
Total	16,621	4,092	16,157	3,482	15,747	3,210

Source: Virginia State Water Control Board

Public and Industrial Water Use

Nonagricultural facilities which withdraw in excess of 300,000 gallons of ground water per month are required to obtain a withdrawal permit from the Virginia State Water Control Board (SWCB). The effect of the permit is to put a limit on the amount each facility can withdraw. The permitted amount allotted to each system may include a grandfathered amount plus an amount based upon historical use. Generally these wells are dug into the deep aquifer. The following is a summary of withdrawals in millions of gallons per day. Table 2-7 lists facilities which have permits and their withdrawals from 1985 to 1990. Some listed in the database as currently withdrawing water do not have a permitted rate of withdrawal, according to the SWCB. Those facilities without a permit have a "+" symbol in the "Permitted" column of Table 2-7 .

Table 2-5: Summary of Permitted Public and Industrial Water Use (MGD)

	1985	1986	1987	1988	1989	1990	Permitted (1991)
Public	1.3	1.3	1.4	1.4	1.5	1.2	4.5
Industrial	3.4	3.1	3.2	3.1	3.4	3.3	11.1
Total	4.7	4.4	4.6	4.5	4.9	4.5	15.6

Six incorporated towns have central water supplies. Together they withdrew approximately 1.03 millions of gallons a day in 1990. Table 2-6 lists the withdrawal amounts for each municipal supply.

Table 2-6: Major Municipal Withdrawals

Town	1990 Withdrawal (MGD)	Permitted Amount (MGD)
Cape Charles	0.134	0.261
Chincoteague	0.447	1.340
Eastville	0.060 (1989)	+
Exmore	0.166	0.320
Onancock	0.161	0.234
Parksley	0.060	0.100

Table 2-7: Average Annual Water Withdrawals, Eastern Shore, VA 1985-1990

Well No.	TOWN/FACILITY	LATITUDE	LONGITUDE	1985	1986	1987	1988	1989	1990	PERMITTED*
PUBLIC SUPPLIES										
Accomack County										
100-00041	Accomack Co. Nursing Home	374528	753721	0.0160	0.0150	0.0145	0.0145	0.0166	0.0181	0.0294
100-00039	Captain's Cove #1	380010	752534	0.0190	0.0180	0.0189	0.0117	0.0112	0.0081	+
100-00031	Captain's Cove #2	375949	752500				0.0062	0.0043	0.0044	
	Captain's Cove #5 (out of service)	375911	752528							
100-00265	Chincoteague #3	375626	752725	0.0270	0.0400	0.0751	0.0827	0.0280	0	
	Chincoteague #3A same meter as #5	375626	752725					0.0084		
	Chincoteague #3B	375626	752725					0.0084	0.0552	
	Chincoteague #3C	375626	752725					0.0084	0.0496	
100-00028	Chincoteague #4	375633	752721	0.1850	0.1840	0.1795	0.1572	0.1711	0.1392	1.34
100-00032	Chincoteague #5	375626	752723	0.0390	0.0410	0.0314	0.0126	0.0056	0.004	
100-00320	Chincoteague #6	375641	752714	0.1590	0.1340	0.1752	0.1729	0.1713	0.1349	
100-00493	Chincoteague #7A	375550	752754	0.0660	0.0790	0.0510	0.0354	0.0549	0.0351	
100-00494	Chincoteague #7B	375557	752749				0.0354	0.0435	0.0286	
100-00495	Chincoteague #7C (closed - high iron)	375604	752742				0.0000			
	NASA-Wallops Island #3	375144	753034					0.0138	0.0057	.
100-00568	NASA-Wallops Island	375035	752545					0.0099	0.0209	
	NASA-Wallops Island Well #4	375128	753045					0.0048	0.0098	
100-00002	Onancock	374233	754430				0.0782	0.0871	0.0971	0.2388
100-00004	Onancock	374233	754432	0.0990	0.0960	0.1186	0.0052	0.0044		
100-00036	Onancock	374234	754430				0.0469	0.0435	0.0486	
100-00037	Onancock	374259	754453				0.0075	0.0049	0.0054	
100-00038	Onancock	374259	754454				0.0076	0.0098	0.0101	
100-00001	Parksley #1 all wells, same	374703	753901			0.0816	0.0728	0.0738	0.0575	0.1
100-00013	Parksley #2 meter	374703	753902							
100-00014	Parksley #3 (not in service since 1984)	374704	753859							
100-00439	VA-Landing Campground	372844	754742		0.0090	0.0133	0.0111	0.0088	0.0079	+
100-00207	Wallops Island Main Base	375626	752807	0.1720	0.2050	0.1196	0.1420	0.1994	0.1009	0.263
	Wallops Island Station	375135	753034	0.0710	0.0150	0.0247	0.0220	0.0099		0.127
Northampton County										
165-00042	America House Motor 1 meter for 2 wells	370816	755808	0.0140	0.0110	0.0116	0.0089	0.0076		0.0209
165-00260	America House Motor Inn #1	370815	755810				0.0063	0.0076	0.0032	
165-00028	Cape Charles (Does not exist??)	371605	760017				0.0000		0	0.261
165-00048	Cape Charles #1	371605	760022	0.1570	0.2050	0.1852	0.1100	0.0766	0.0105	
165-00123	Cape Charles #2	371607	760011				0.0509	0.1536	0.1231	
	Cherrystone Holiday Trav-L-Park	371719	760043	0.0600						0.06
165-00030	Eastville #3	372117	755640				0.0000	0.0000		
165-00031	Eastville	372116	755640	0.0450	0.0490	0.0447	0.0000	0.0000		
165-00036	Eastville	372117	755640				0.0000	0.0000		

Table 2-7: Average Annual Water Withdrawals, Eastern Shore, VA 1985-1990

Well No.	TOWN/FACILITY	LATITUDE	LONGITUDE	1985	1986	1987	1988	1989	1990	PERMITTED*
165-00038	Eastville (backup)	372106	755620				0.0000	0.0000		
165-00014	Exmore #2	373230	754917	0.0670	0.1030	0.0675	0.0570	0.0509	0.1111	0.32
165-00015	Exmore #1	373230	754917	0.0410	0.0630	0.0773	0.0673	0.0667	0.055	
165-00026	Eastville #2 (#5)	372117	755640				0.0591	0.0580		+
165-00001	Northampton-Accomack Hospital	372835	755145	0.0190	0.0120	0.0000	0.0748	0.0749	0.1039	0.1
165-00025	Northampton-Accomack Hospital	372835	755145	0.0490	0.0580	0.0782	0.0003	0.0024	0.0015	
	Brown & Root	371500	760000							1.1
	DiCanio Residential Communities	371314	760009							0.28
165-00259	*DiCanio Chesapeake* .	371333	760006							0.022
165-00054	*Peaceful Beach, Kirkwood #1*	373114	755660							0.229
165-00055	*Peaceful Beach Campground #2*	373114	755660							
165-00063	*Peaceful Beach Campground #3*	373114	755660							
	Peaceful Beach, Kirkwood	373100	755630	0.0000	0.0000	0.0000	0.0000	0.0000		
Public Supply Total				**1.2430**	**1.2640**	**1.2594**	**1.2414**	**1.4148**	**1.1140**	**4.4617**

INDUSTRIAL SUPPLIES										
Accomack	**County**									
100-00006	Byrd Foods #1	374537	754004	0.0370	0.0060	0.0031	0.0027	0.0071	0.0101	0.6
100-00054	Byrd Packing Co.	374531	754011							
100-00367	Byrd Foods #3	374534	754007							
100-00368	Byrd Packing Co.	374536	754003							
100-00369	Byrd Packing Co.	374536	754003							
100-00009	Holly Farms #4	375318	753344			0.2045	0.2296	0.1901	0.2512	1.8
100-00010	Holly Farms #3	375311	753339			0.1998	0.1972	0.1692	0.1179	
100-00011	Holly Farms #2	375304	753332			0.2412	0.1785	0.1863	0.1598	
100-00012	Holly Farms #1	375256	753324	0.6870	0.7170	0.1619	0.1009	0.0924	0.1061	
100-00196	Holly Farms #5	375330	753355			0.0838	0.1153	0.1953	0.1581	
100-00566	Holly Farms #6	375257	753321				0.0175	0.0364	0.026	
100-00258	New Church Energy Assoc.	375833	753218	0.0970	0.1570	0.0759	0.1435	0.1991	0.1767	0.336
100-00365	New Church Energy Assoc.	375838	753218		0.0300	0.1099	0.0361	0.0775		
100-00020	Perdue Foods #4A	374403	753937	0.1060	0.0770	0.0221	0.0196	0.0618	0.224	2.6379
100-00026	Perdue Foods #2	374419	753910	0.4640	0.4710	0.4468	0.4001	0.5064	0.4974	
100-00029	Perdue Foods #3	374429	753922	0.4450	0.4100	0.4336	0.4328	0.3956	0.4156	
100-00030	Perdue Productions #1	374408	753859	0.2510	0.2140	0.2038	0.1929	0.2280	0.244	
100-00195	Perdue Foods #4	374421	753937	0.2310	0.1970	0.1622	0.0928	0.1429	0.1157	
100-00531	Perdue, Inc. #5	374425	753933			0.3217	0.3273	0.3763	0.3683	
100-00843	Eastern Shore Seafood (pump start 2/91)	375122	753336							0.3
100-00237	Shore Seafood #1	375513	754348	0.3230	0.1990	0.0000	0.0000	0.0734	0.0941	+
100-00238	Shore Seafood #2	375512	754348				0.0000	0.0243	0.0941	
	Shore Seafood #3	375512	754348					0.0734	0.0941	

Table 2-7: Average Annual Water Withdrawals, Eastern Shore, VA 1985-1990

Well No.	TOWN/FACILITY	LATITUDE	LONGITUDE	1985	1986	1987	1988	1989	1990	PERMITTED*
	Shore Seafood #4	375512	754348					0.1005	0.0941	
100-00229	Taylor Packing Co.	375232	753528	0.2070	0.1030	0.0680	0.0630	0.0440		0.5488
100-00346	Taylor Packing Co. #1	375233	753528							
100-00347	Taylor Packing Co. #2	375233	753528							
100-00348	Taylor Packing Co. #3	375233	753528							
Northampton County										
165-00108	American Original Foo same meter /#123	373045	754828	0.1190	0.1140		0.0000	0.1155	0.0617	0.45
165-00116	American Original Foods Obs. #123	373046	754825				0.0000			
165-00117	American Orig. Foods Obs. #122	373046	754825				0.1562			
165-00110	Bayshore Concrete #1	371544	760119	0.0790	0.0820	0.0727	0.0382	0.0209	0.0166	0.125
165-00111	Bayshore Concrete #3	371542	760124				0.0069	0.0141	0.0151	
165-00142	Bayshore Concrete Prod. #2	371539	760114				0.0251	0.0197	0.0178	
165-00141	Bayshore Concrete	371539	760114				0.0054	0.0019	0.004	
165-00045	C&D Seafood #2	371711	755524	0.0610	0.0460	0.0380	0.0286	0.0260	0.0297	0.152
165-00064	C&D Seafood #1									
165-00018	Custis Enterprises	372150	755522							0.441
165-00019	Custis Enterprises	372150	755522							
165-00005	Exmore Foods #7	373203	754917							2.002
165-00029	Exmore Foods #8	373160	754917							
165-00039	Exmore Foods #9	373210	754913							
165-00047	KMC Foods (clustered wells)	371746	755728						0.0033	1.6
165-00023	KMC Foods #4 (Labor Camp)	371746	755728	0.2390	0.1860	0.2748	0.2156	0.0161		
165-00024	KMC Foods #5	371731	755730							
165-00105	KMC Foods Plant Well	371732	755736							
165-00158	KMC Foods Inc.	371726	755729							
	Sea Watch International (HAS)	372219	755530	0.0660	0.0430	0.0335	0.0383	0.0389	0.0341	0.15
Industrial Total				**3.4120**	**3.0520**	**3.1573**	**3.0641**	**3.4331**	**3.4296**	**11.1427**
GRAND TOTAL				**4.6550**	**4.3160**	**4.4167**	**4.3055**	**4.8479**	**4.5436**	**15.6044**

Source: VA Water Control Board Records 1985-1990; Virginia Newton, SWCB geologist

* Permitted = Grandfathered rights + permitted withdrawals

Tangier Island supplies water for its population of 659 by means of 5 private water systems. These wells are not used for industrial purposes, only by residential and commercial facilities. According to the Eastern Shore Water Supply Plan (1988), the five wells were interconnected in 1987, and a storage tank was built in the case of emergency. Many pipes to the wells are old and leak, and it is difficult to determine flow from these wells since they are not metered. It was estimated in 1988 that the water demand for the town was .065 MGD. It is unknown how many wells exist on the island; the State says 11 and a well driller claims there are 14 wells Since Tangier Island is separate from the aquifer system on the mainland, and the water is withdrawn from a much greater depth (approximately 1,000 feet deep),this study did not focus in detail on the ground water situation on the island.

Five permitted water withdrawal facilities are currently inactive. Their permitted amounts total just over 4 million gallons per day. Table 2-8 lists those inactive facilities and their permitted withdrawal rates.

Table 2-8: Permitted Withdrawal Rates for Inactive Facilities

Facility	Permitted Amount (MGD)
Exmore Foods	2.002
Custis Enterprises	0.441
Peaceful Beach, Kirkwood	0.229
DiCanio	0.302
Brown & Root	1.100
TOTAL	4.074

In addition, there are numerous schools, hotels, restaurants, small industries, trailer parks, churches, and migrant labor camps that have private wells. Populations of community, non-community, and non-transient non-community facilities were obtained from the Virginia Department of Health. Water use by category was estimated using wastewater flow rates from Laak (1986), assuming that eighty percent of water use becomes wastewater (see page 8-3). Calculations show that these facilities use 140,000 gallons per day.

From the Eastern Shore Department of Health, it was determined that a maximum of 3,058 people can occupy the area's migrant labor camps. Because these camps become the worker's residence during the duration of the season, average water use per person is estimated at 55 gallons per person per day. Therefore, the estimation of total labor camp water use is 168,000 gallons per day. Conservatively, if the labor camps were all in operation at the same time, the total water consumption from all these private facilities (schools, churches, etc.) amounts to 308,000 gallons per day, or 0.308 MGD. Cumulatively, these facilities withdraw close to the permitted pumping rate for the Town of Exmore.

Industrial withdrawals exceed that of the public facilities. The two poultry industries, Perdue Inc. and Holly Farms (Tyson Foods) account for forty-two percent (42%) of the total permitted amount for industry. The following graphs compare withdrawals to permitted amounts. Figure 2-13 shows the seasonal fluctuations in water use during 1990.

Private Water Use

With only seven towns having public water systems, the majority of residents on the Eastern Shore of Virginia obtain their drinking water from private domestic wells. Some of these wells are shallow and withdraw water only several feet below the water table. The Virginia Water Project

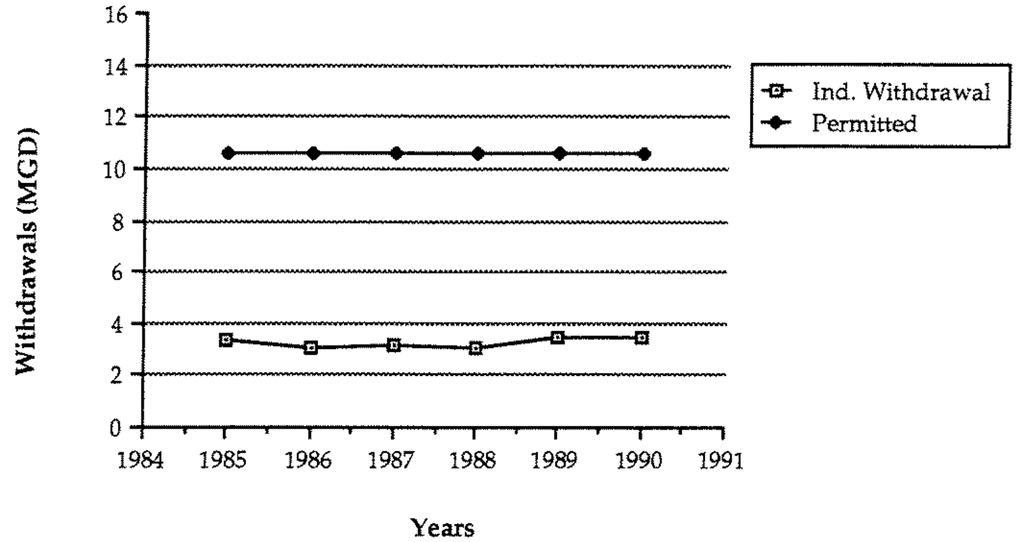
Inc. (1988) estimates that on the Eastern Shore, the number of year-round housing units with individual drilled wells, individual dug wells, or some other private water source is 14,035. At a per household use of 165 gallons per day, private water use exceeds 2.3 million gallons per day. Another method of estimating private water use involves subtracting the number of people served by public water systems as listed by the SWCB (13,246), and multiplying the remaining 1990 US Census population (31,518) by an average of 55 gallons per day. By this method, private water use is 1.7 million gallons per day.

Poultry

The State Water Control Board estimates that a chicken uses 0.09 gallons of water per day (SWCB, Bulletin #60, 1983). With a 1990 production of 21 million chickens and an average 45 day life span, on any given day there were 2.6 million chickens, and these consumed a total of 234,000 gallons per day (0.234 MGD). This is roughly close to the permitted withdrawal rate for the Town of Onancock.

While it would seem safe to assume that chickens consume the same quantity of water today as they did in 1983, current practices may have increased the poultry water use. In the summer of 1991, temperatures hovering around 100°F for several days in a row caused widespread mortality among chickens on the Delmarva Peninsula. Chicken growers reported trying the technique of misting the chickens with water and blowing fans on them to keep their body temperatures down (*The Washington Post*, July 25, 1991, Section B). This new procedure may or may not use significant quantities of water, and it may be unique to rarely hot years; nevertheless, it may account for an increase in water consumption attributed to poultry.

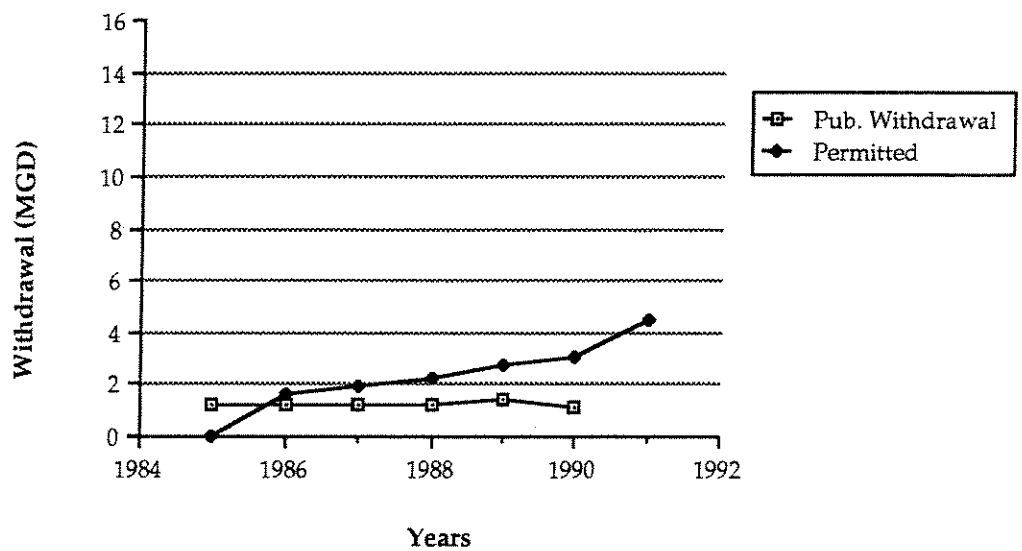
Figure 2-10: Industrial Water Withdrawals vs. Permitted Amounts Eastern Shore of Virginia, 1985-1990



Source: Virginia State Water Control Board

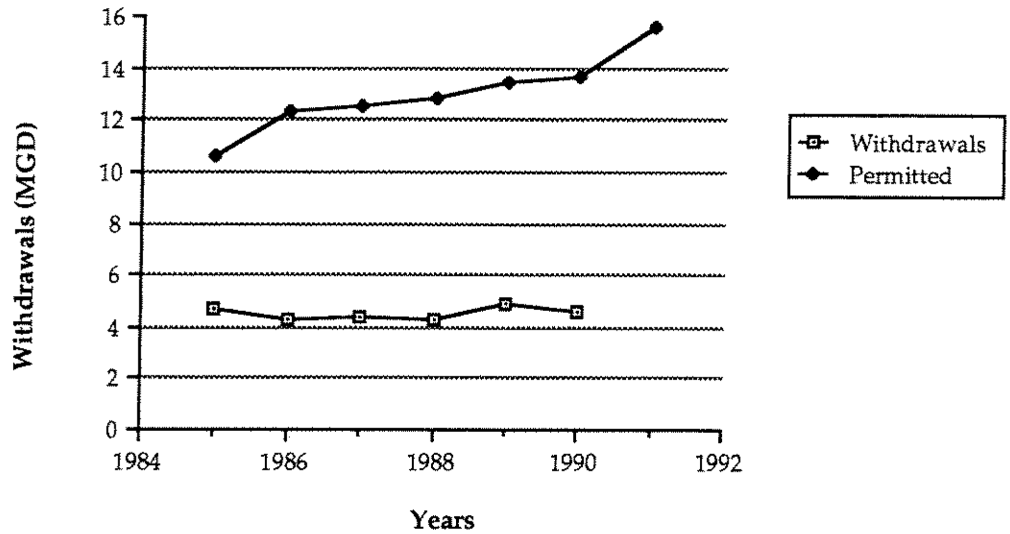
* Note: All of the industrial withdrawals were permitted prior to 1985.

Figure 2-11: Public Water Withdrawals vs. Permitted Amounts Eastern Shore of Virginia, 1985-1990



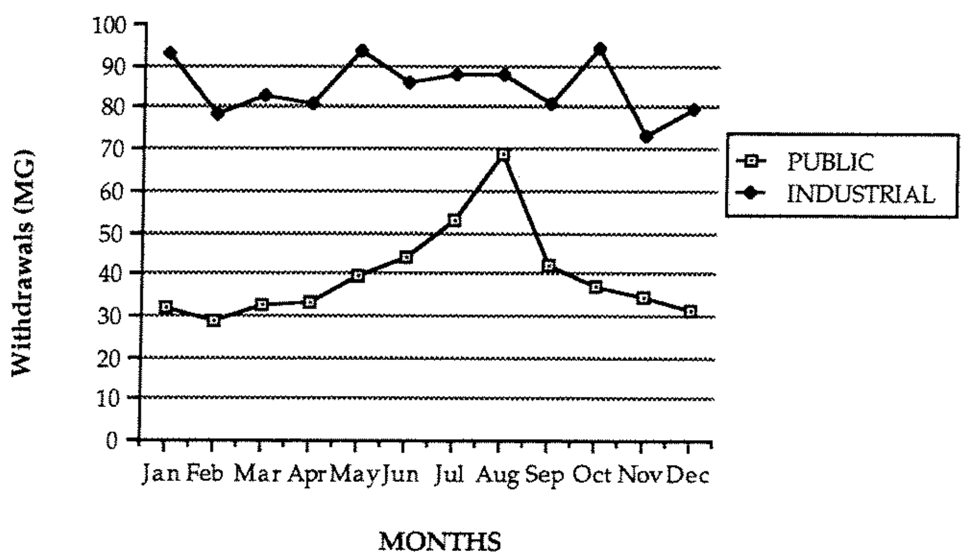
Source: Virginia State Water Control Board

Figure 2-12: Public and Industrial Withdrawals vs. Total Permitted Eastern Shore of Virginia, 1985-1990



Source: Virginia State Water Control Board

Figure 2-13: Public and Industrial Water Withdrawals by Month, 1990 Eastern Shore of Virginia



Source: Virginia State Water Control Board