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Water resources : planning for future demand in the York River Basin

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York River Basin: Water Resources Report

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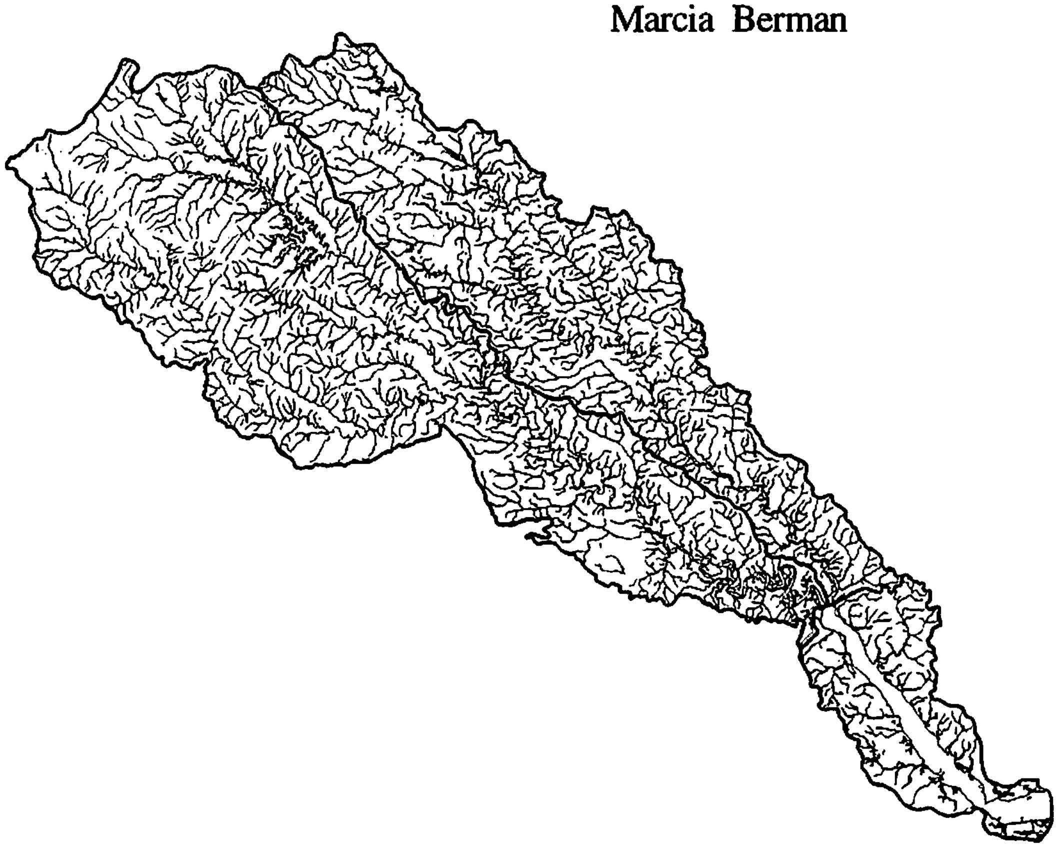

Center for Coastal Management and Policy
Department of Resource Management and Policy
Virginia Institute of Marine Science
College of William and Mary
Gloucester Point, VA 23062
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Comprehensive Coastal Inventory

Center for Coastal Management and Policy

WATER RESOURCES: PLANNING FOR FUTURE DEMAND IN THE YORK RIVER BASIN

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Jurisdictions in Study Area:

Caroline County
Gloucester County
Hanover County
James City County
King & Queen County
King William County
Louisa County
New Kent County
Orange County
Spotsylvania County
York County
City of Williamsburg

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1.0 INTRODUCTION

1.0 INTRODUCTION

This report analyzes issues related to water supply and demand for the York River Basin (YRB) in Virginia.

1.1 PURPOSE

This report seeks to present a framework from which alternative solutions for water resource management can be developed at the watershed scale for the YRB. It is not the intent of this report to define specific solutions to the potential conflicts between supply and demand of water resources in the YRB. The framework presented recognizes that effective long term planning and management of water resources depends on three major components:

1. The logical unit of management for both the quantity and quality of water resources is at the basin or watershed scale.

2. The methods for determining current and future water supply and demand require improvement.

3. For planning and management of water resources at the basin scale to succeed, institutional changes are necessary to require regional or inter-jurisdictional cooperation.

First, it is necessary that the surface and ground water reserves of Virginia be recognized as a single resource. The quantity, quality, and location of water resources in the YRB are determined by the natural processes and anthropogenic impacts that occur within its physical boundaries. Because water quantity, quality, and location are determined by the physical parameters of the environment, the geographical limits of watersheds must be acknowledged as the logical unit of management. Watershed boundaries are of critical importance to understanding the carrying capacity of water resources. As a fluid resource, surface and ground water move in a direction determined primarily by topography and subsurface geology. Thus the flux of water can be quantified within an area of limited precipitation input. This given area is the watershed. Defining the physical limits of a watershed allows the opportunity to establish a baseline from which to determine the natural and anthropogenic factors affecting water quantity and quality. These characteristics indicate that at the basin scale, water supply exists in a long-term state of equilibrium. From a planning perspective, this presents the challenge of meeting the escalating, multiple-use demands being placed on what are essentially water resources of limited volume.

Second, coastal regions continue to experience rapid rates of population growth. Today, approximately 43 percent of the nation's population live in coastal counties, and it is estimated that this is expected to increase by 50 million residents over the next 50 years[22]. Of the eleven counties that make up the York River Basin nine are recognized as coastal counties by the state. Virginia, the fifth fastest growing state in the nation, experienced a 15.7 percent increase in population during the past decade[9]. The YRB itself is projected to experience a growth rate of 78 percent over the next 40 years[42]. The jurisdictions throughout the YRB will be forced to deal with the pressures and demands associated with this influx of residents and businesses. Furthermore, based on previous studies and the methodology presented in this report, it is projected that portions of the region will be faced with water supply deficits, possibly as early as the year 2000. To adequately plan for this inevitable growth, quantitative and qualitative methods must be improved to determine available water supply and project future water demands at the watershed scale.

Finally, the state's current legal system and institutional management of water resources lack the capacity to deal with the complexities of future supply and demand issues. Parameters affecting the supply, quality, and geographic availability of water transcend political boundaries. Policy and planning for the efficient and equitable distribution of water resources should be restructured to manage resources at the watershed scale which will require inter-jurisdictional coordination at a variety of levels. Regional cooperation is essential to reduce competition and conflicts and to protect the future availability of the state's water resources.

This report seeks to identify the major issues associated with the long range management of the quantity and quality of ground and surface water at the watershed scale. General recommendations which foster improved regional planning methods and inter-jurisdictional cooperation are discussed whenever appropriate.

1.2 REPORT ORGANIZATION

This report consists of eight major sections. Chapter 2 briefly discusses the variety and applicability of the data sources used to generate this report. Chapter 3 gives a brief orientation to the characteristics of the YRB. Chapter 4 presents an overview of the existing supply of water resources within each county. This chapter also identifies issues that impede the thorough understanding of determining available water supply. Chapter 5 presents a basin wide summary of current and past water demand for the even years from 1982 to 1990. Chapter 6 presents a summary of population and water demand projections to the year 2030. This chapter also discusses the major issues surrounding discrepancies in population and water demand projections. Chapter 7 summarizes the relationships between and variables associated with estimating population growth, and water demand and supply projections for the entire YRB. Finally, Chapter 8 concludes this report by presenting general concepts and recommendations supporting long term planning and management of water resources at the watershed scale. A variety of appendices are also provided.

2.0 EXISTING DATA SOURCES & RELATED REPORTS

2.0 EXISTING DATA SOURCES & RELATED REPORTS

Throughout the last decade a wide variety of analytical reports covering supply and demand of water resources in the YRB have been completed. To meet the continually rising demand for water resources, counties and cities have recognized the need to analyze their individual situations in more detail. These reports have been published by numerous sources including private engineering firms, county and city planning departments, planning district commissions, regional planning authorities, state academic institutions, the State Water Control Board (SWCB), and federal agencies such as U.S. Geological Survey (USGS) and the Environmental Protection Agency (EPA).

The broad spectrum of agencies and private firms responsible for the existing data has lead to a variety of disparate, sometimes conflicting reports covering the issues of water supply and demand. Different approaches to addressing the issues of water supply and demand are presented by these existing reports, making comparisons and aggregation of data by jurisdiction difficult. In addition, some of the recommendations suggested in the reports have been implemented and others rejected. It was thus evident that a datum for information was somewhat difficult to establish for this report.

2.1 GENERAL APPROACH

For the purposes of this study two reports were identified as the most effective for providing a datum primarily because they deal with an analysis of the entire York River Basin. These reports, published by the SWCB, are titled *York Water Supply Plan* and *James Water Supply Plan*. In 1988, the State Water Control Board, as directed by the Virginia Assembly, completed reports documenting the supply and demand of water resources for each of the eleven planning areas identified within the state[46]. These reports which cover each of the nine major river basins, present advisory plans and programs for the management of offstream and ground water resources[46]. The *York Water Supply Plan* and *James Water Supply Plan* receive specific mention here primarily because they are the most effective compilation of information addressing water resource issues facing the YRB. These documents are the primary source of quantitative and qualitative data used in the development of this report. They provide the most thorough compilation available of assumptions, methodology, and water withdrawals for the entire watershed. While these documents do not present a specific comprehensive plan for the management of all water resources in the basin they bring to light many significant issues which need to be addressed at a watershed scale.

Valuable information pertaining to ground water resources was also obtained from numerous reports published by USGS. Likewise, while reviewing information regarding ground water, additional issues needing to be addressed at the watershed scale were also identified. The remaining portion of this report will present information primarily from these two main sources (SWCB, USGS) pertinent to water supply and demand.

3.0 OVERVIEW OF THE PLANNING AREA: YORK RIVER BASIN

3.0 OVERVIEW: THE YORK RIVER BASIN

This chapter provides a general description of the major characteristics of the York River Basin (YRB).

3.1 GEOGRAPHIC CONTEXT AND PHYSICAL DESCRIPTION

The YRB extends through Central and Eastern Virginia, covering approximately 2,661 square miles. Oriented along a northwest to southeast line, the Basin is bounded by the Rappahannock River to the north, on the south and west by the James River Basin, and on the east by the Chesapeake Bay[46]. Approximately two thirds of the YRB lies within the Coastal Plain physiographic province, and the western one third lies in the Piedmont province[40] **(Figure 3-1).**

The watershed varies in width from 5 miles at the mouth of the York River where it empties into the Chesapeake Bay, to 40 miles at the headwaters in Louisa and Orange Counties[46] **(Figure 3-2a).** As one of the nine major river basins in Virginia, the York River watershed ranks eighth in size (square miles) with an average runoff of approximately 1,643 million gallons per day (mgd)[30]. Discharges are higher than average from January through April and less than average from July through September[2]. Traversing approximately 220 miles, the network of tributaries and rivers can be subdivided into three subbasins: the York, the Mattaponi, and the Pamunkey[45]**(Figure 3-2b).**

The York River Subbasin begins at the confluence of its two main tributaries, the Mattaponi and Pamunkey Rivers at West Point, Virginia. The subbasin includes all tributaries which feed directly into the York River. A portion of the mainstem of the York River is water quality limited and the tributaries are "effluent limited"[45]. Classified by the SWCB as "effluent limited," the tributaries require at a minimum, secondary treatment of all waste water discharged into them[45].

York River Watershed and Province Boundaries

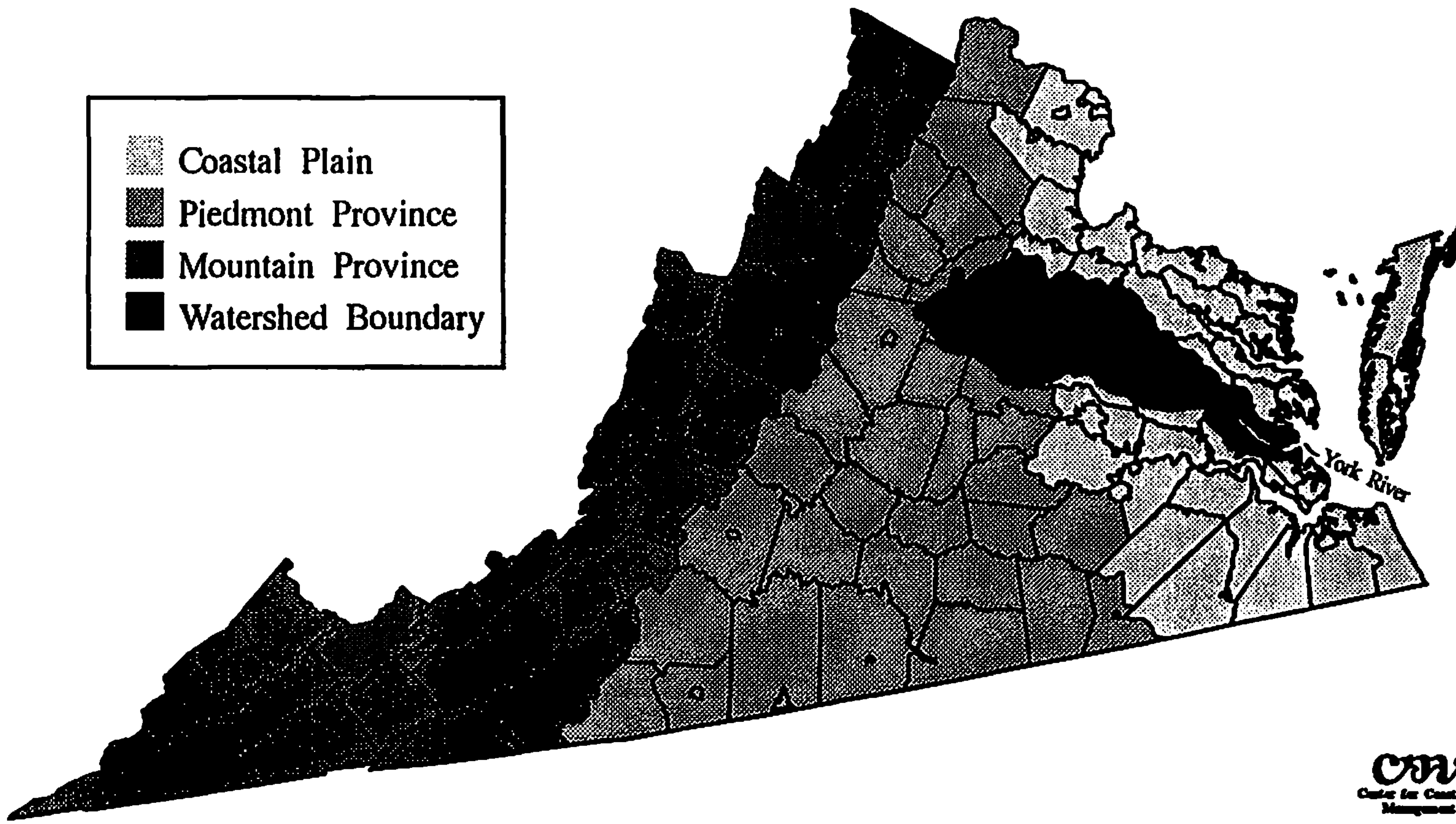

Figure 3 - 1

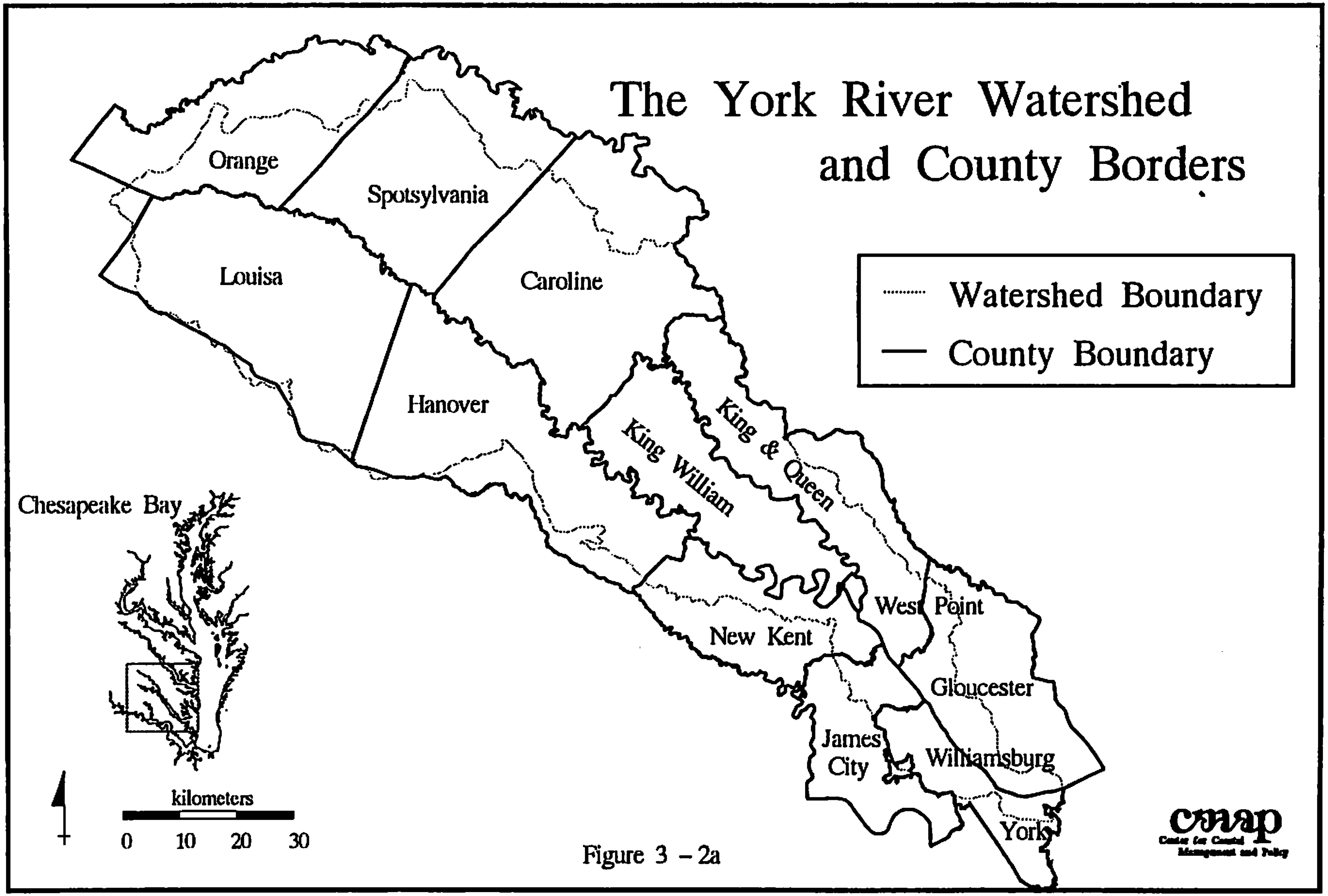
The York River Watershed
and County Borders
Watershed Boundary
County Boundary
Orange
Spotsylvania
Louisa
Caroline
Hanover
King & Queen
King William
West Point
New Kent
Gloucester
James City
Williamsburg
York
Chesapeake Bay
kilometers
0 10 20 30
cmap

Figure 3 – 2a

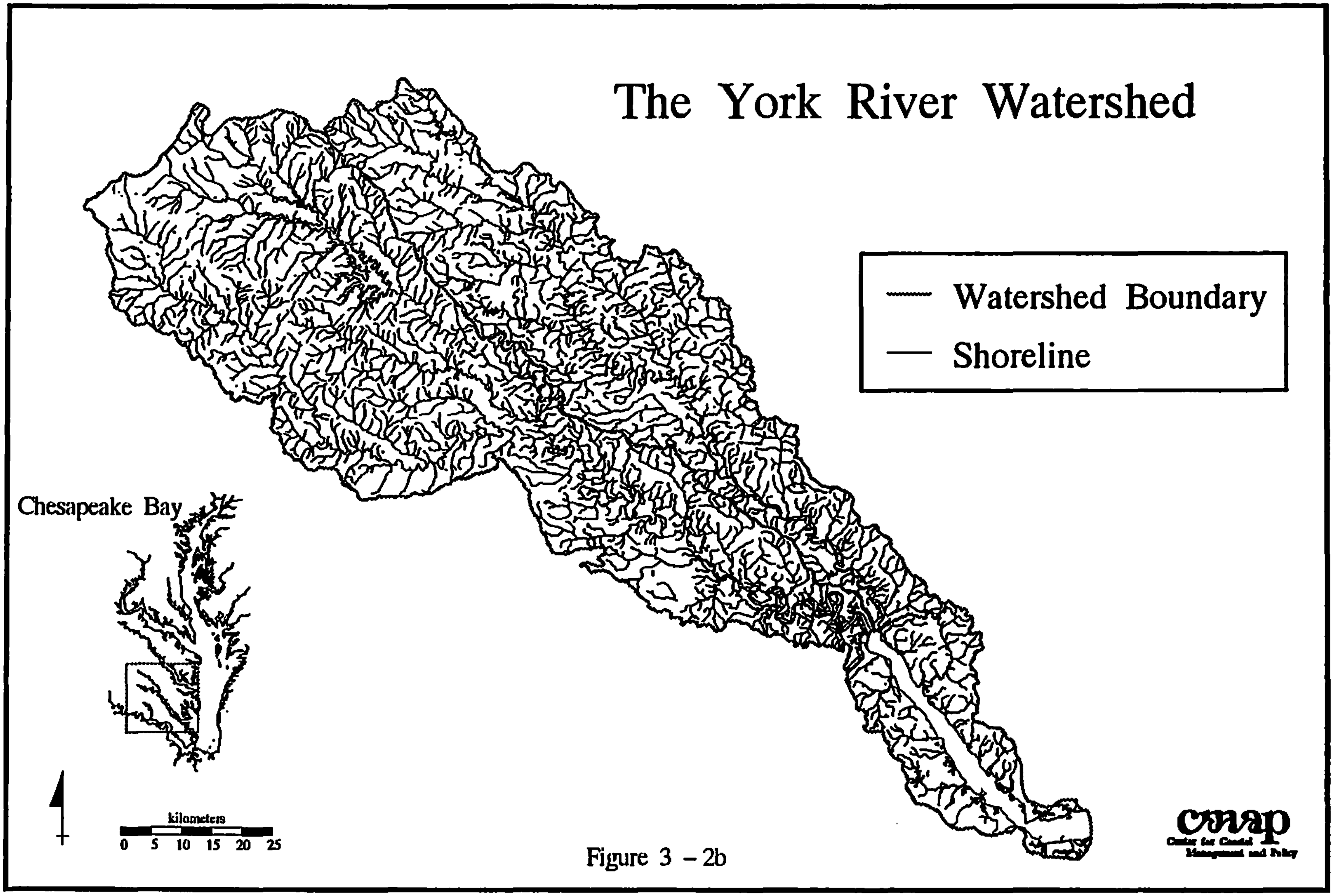
The York River Watershed
Watershed Boundary
Shoreline
Chesapeake Bay
kilometers
0 5 10 15 20 25

Figure 3 – 2b

The entire York River from the head waters at West Point to its mouth is considered tidal because it is influenced by the ebb and flow of tide cycles which transport salt water and nutrients from the Chesapeake Bay upstream[2]. Tidal flux and the interaction of fresh water discharge and salt water from the Bay cause varying salinity levels throughout the York River. Salinity gradients between the surface and bottom waters tend to increase with increasing fresh water discharge in the spring and to decrease in the summer and fall[2]. As fresh water flows decrease during the summer, salt water migrates further upstream[2]. Another important factor affecting salinity levels in the York River is the spring-neap tidal cycle[2].

The Mattaponi River Subbasin consists of all tributaries feeding the Mattaponi River and the mainstem from its headwaters in Caroline County to its confluence with the York River. The major tributaries of the Mattaponi River are the Matta, Po and Ni Rivers. Approximately 60 miles of the Mattaponi River are considered tidal[2]. All waters within this hydrologic region are classified by the SWCB as "effluent limited"[45].

The Pamunkey River Subbasin includes all tributaries and the mainstems of the North Anna River, South Anna River, and the Pamunkey River. The major tributaries to the Pamunkey River are the North Anna River, South Anna River, and the Little River. Tidal influence continues for approximately 37 miles up the Pamunkey from its confluence with the York River[2]. Most of the Pamunkey River Subbasin is classified as effluent limited[45].

3.2 POPULATION

Population trends throughout the York River Basin are discussed in detail in Chapter 6.0.

3.3 LAND USE

The majority of the York River Basin is rural in character with forested areas and agriculture representing the dominant land use type. No major population centers exist within the Basin. Approximately 72% of the land consists of forested, recreational, and natural wildlife areas[46]. Agriculture land accounts for about 18% and urban areas, surface water (reservoirs and rivers), and federal lands make up the remaining 10% of the watershed.

Statistical trends suggest changes in future land use throughout the region. Between 1980 and 1990 various indicators show a continual increase in residential growth, and a decrease in agricultural and forested lands. It is now acknowledged that the entire York River Basin is becoming increasingly popular to people seeking to live in rural areas and commute to major population centers for employment. Situated in close proximity to the three major population centers of the state, Northern Virginia, Richmond, and the Tidewater area, this trend will continue. For an extensive analysis of projected land use trends on a county by county basis refer to *Current and Projected Land Use in the York River Basin.*

Understanding and projecting land use trends is a fundamental step in the effort to plan appropriately for the future use of water resources throughout the York River Basin. It must be recognized that land use has critical implications to water quantity, quality, and distribution. As the York River Basin continues to experience growth in population and development, meeting the demand and distributing water to new locations is becoming an acute planning issue.

Development into rural areas, regardless of the type of land use, contributes to surface and ground water use and is the catalyst for most water contamination. Another issue that is of growing concern involves the distribution of water service. New development does not conveniently occur where water service exists. While it is believed that the YRB has an adequate supply of water resources, this water is not evenly distributed geographically throughout the basin. Thus it must be acknowledged that as development continues to occur in rural areas, localized deficits and competition for expanded service will increase.

3.4 ECONOMY

Agriculture has long been the economic foundation in the York River Basin. Cash crops are grown throughout the Basin, especially in the eastern half of the watershed, with livestock production primarily in the western half[46]. Other significant operations that make up the economic base of the region include industries providing lumber, paper products, furniture, food processing, petroleum refining, mining, and power generation. The local economy also benefits from military operations, tourism and recreation, and a variety of commercial businesses serving the region.

The unemployment rate within the YRB averaged 5.5 percent in 1991. The per capita income for the Basin was $18,027 in 1990 which was about $1,700 less than the overall state average. Economic indicators such as these are useful in planning efforts directed at identifying trends in development. They can also provide information to predict a locale's ability to pay for water service infrastructure[46]. As land use and economic trends continue to be influenced to a greater degree by regional activities, inter-jurisdictional cooperation in regional analysis of natural resources and infrastructure capacity becomes more necessary and ultimately beneficial. For an extensive analysis of economic trends on a county by county basis refer to the *York River Watershed: Economic Analysis.*

3.5 RECREATION

The following discussion of recreational resources considers only the water related recreational opportunities the York River Basin affords. Located between the three major population centers in the state of Virginia - Northern Virginia, Tidewater Virginia, and Richmond - recreational resources of the watershed are easily accessible to a majority of the state's population.

The streams and rivers of the YRB are valued for their scenic and historic qualities, offering some of the most picturesque natural areas in the state. Portions of Dragon Run, and the Mattaponi, North Anna, South Anna, Pamunkey, and Little rivers have the potential for inclusion into the Virginia State Scenic Rivers System[46]. Historic sites, plantations, the Pamunkey and Mattaponi Indian Reservations are integral historical and cultural components of these river resources.

The scenic quality and current water quality of the rivers also contribute to the popularity of fishing, canoeing, boating, picnicking, and hiking. Fish populations of the York River are composed of resident, anadromous, and catadromous species. Large, continuous tracts of undisturbed land bordering most of the water bodies benefit numerous wildlife species serving as critical habitat corridors.

While this is only a general overview of water related recreation, the implication of these activities can not be overlooked. The significance of water-based recreational activities presents another source of competition vying for the use of the basin's river resources. Water related recreation is dependent on instream levels of water quality and quantity that are somewhat different than those necessary for potable water. Minimum instream flow levels for recreational purposes are primarily a function of the biological requirements of aquatic flora and fauna. It is acknowledged that this criteria differs from that established for minimum instream levels necessary to provide a potable water supply.

3.6 MISCELLANEOUS PARAMETERS

There are a variety of other characteristics which can affect the balance between supply and demand of the water resources of the York River Basin. The climatology of the region acts as the generator of the hydrologic cycle which is the source of all surface and ground water. The most significant element of the local climate is the amount of average precipitation. The average annual precipitation over the York River Basin is 44 inches, ranging from 41 inches at Piedmont Field Station in Orange County to 47 inches in Williamsburg[46]. Generally, stations in the Coastal Plain receive more rainfall than stations in the Piedmont province of the watershed due to the influence of the ocean[46]. The highest monthly precipitation generally occurs in August, with the lowest average monthly level usually occurring in April[46].

The navigable capabilities of the rivers must also be recognized. The York River is navigable for its entire length, while the Pamunkey and the Mattaponi are navigable as far northwest as Bassetts Ferry and Aylett, respectively[46]. Navigational activities will continue to be active in the future for military, commercial, and recreational purposes. These activities have an indirect effect on water quality and are also dependent on water quantity within the rivers.

Other significant users dependent on water resources are power companies, paper companies, and municipal waste treatment facilities. The major users along the York River include the York River Sewage Treatment Plant (STP), the Amoco Refinery, and the Yorktown VEPCO Power Plant[45]. Other users throughout the watershed include the Doswell STP, the Ashland STP, Emerson Electric-Rigid Kollman, Chesapeake Corporation in West Point, the North Anna Lake VEPCO Power Plant, and the Bear Island Paper Company of Ashland. Each of these users are permitted major dischargers. Requiring large quantities of water for their operations, they also impact the water quality of the river water they border.

The implications of these different characteristics must be recognized and included in the equation of a management effort aimed at dealing with the supply and demand of the water resources of the York River Basin. Geographical relationships between different uses in need of water must also be identified to address conflicts between upstream and downstream users.

3.7 GROUND WATER

Ground water has historically provided an important part of the water supply throughout the York River Basin. This section provides a general understanding of the major characteristics of ground water resources within the basin. A brief explanation of the "hydrologic cycle" is important to the understanding of ground water resources. Ground water, a major source of water flowing to streams, ponds and reservoirs, is defined as water in the subsurface that is under a pressure equal to or greater than atmospheric pressure[39].

The hydrologic cycle, which has neither a beginning nor an end, describes the continuous movement of water above, on, and below the surface of the earth[39]. As diagrammed in **Figure 3-3a and Figure 3-3b** the hydrologic cycle involves the interaction of the atmosphere, the land, and the ocean. This circulation system is responsible for providing both the surface and ground water resources of the YRB.

<u>The Coastal Plain Province</u>

The state of Virginia is divided into five different physiographic provinces shown in **Figure 3-4.** The eastern two-thirds of the York River Basin lies in the Coastal Plain physiographic province and the remaining one-third lies in the Piedmont. **Figure 3-5** presents a schematic diagram of the hydrologic cycle throughout the Coastal Plain province.

As depicted by this diagram ground water originates from precipitation which percolates through the ground to form the water-table aquifer. It is estimated that the water table of the Coastal Plain province is recharged by 10 to 15 inches of rain fall annually[39]. The remaining precipitation is lost to surface runoff or evapotranspiration. Throughout a layered series of aquifers and confining units, ground water moves downward recharging lower level aquifers, or laterally and upward toward natural discharge sites such as seeps, springs, streams, the Chesapeake Bay, or Atlantic Ocean. Upon reaching the eastern edge of the region, fresh ground water encounters salty ground water primarily in the lower aquifers[39]. Density differences between these two types of water forces fresh ground water upwards eventually discharging it into the Chesapeake Bay or the Atlantic Ocean[39].

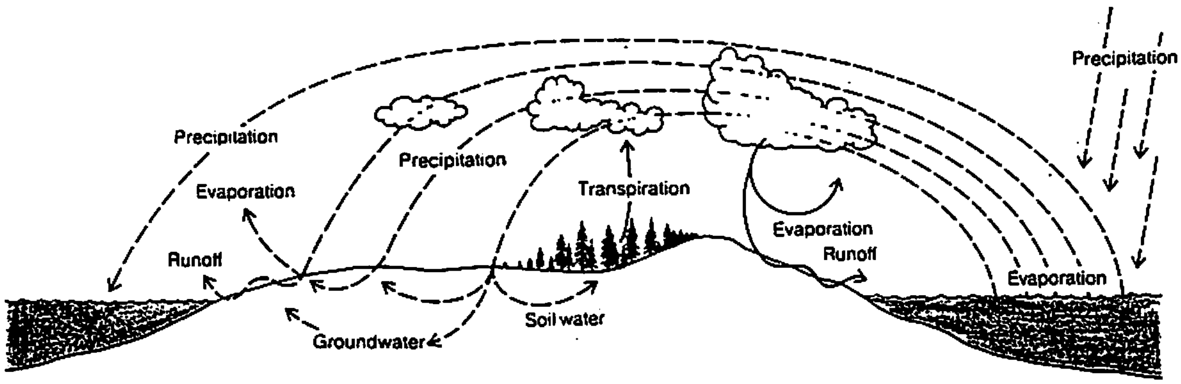

Figure 3.3a. The hydrologic cycle.

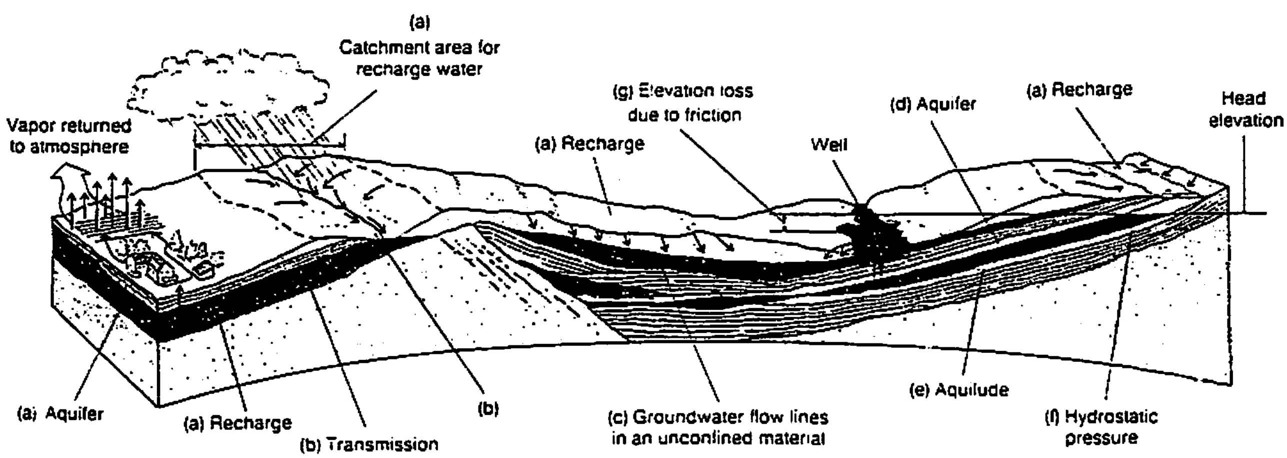

Figure 3.3b. A composite diagram illustrating (a) recharge, (b) groundwater transmission, (c) groundwater in an unconfined material, (d) aquifers, (e) aquiludes, (f) hydrostatic pressure, and (g) elevation loss in artesian flow due to friction.

Source: Marsh, William M., *Earthscape: A Physical Geography*, 1987. (#21)

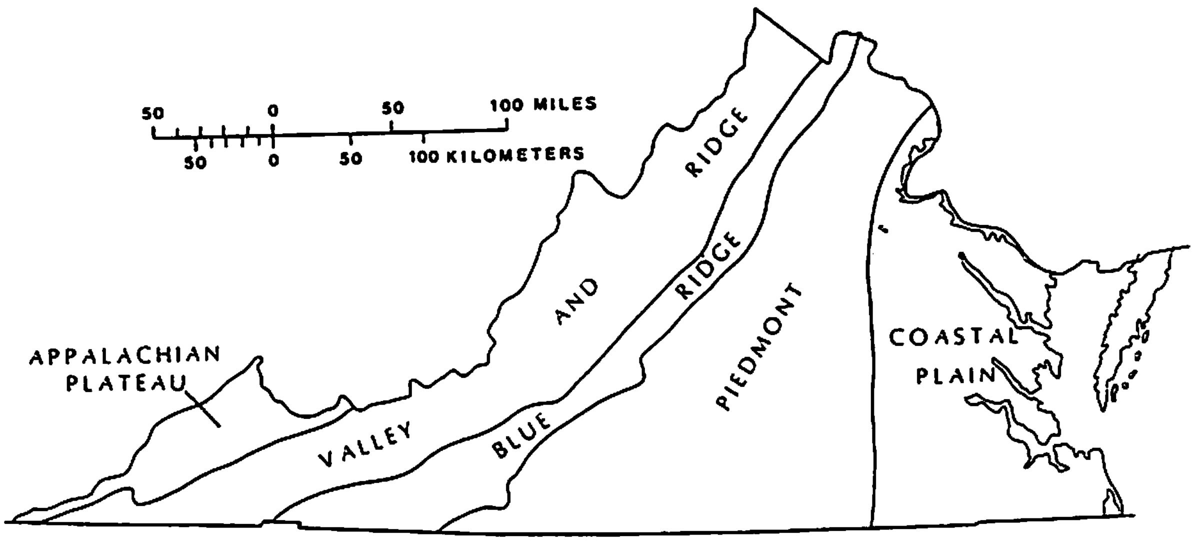

Figure 3.4. Physiographic provinces of Virginia.

Source: *U.S. Geological Survey WRI Report* 85-4235, 1985. (#38)

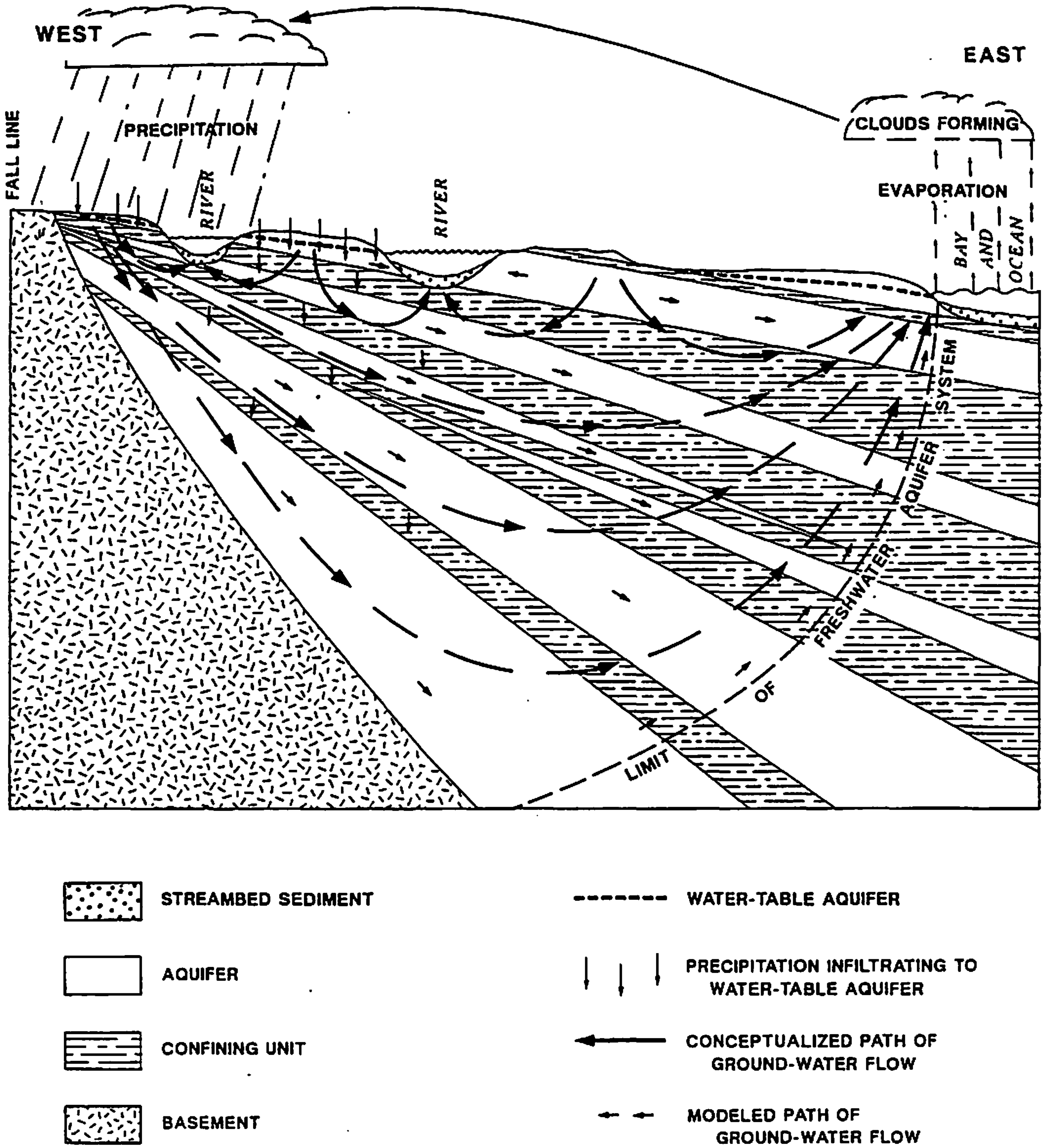

Figure 3-5. Generalized hydrologic cycle for York-James Peninsula.

Source: *U.S. Geological Survey WRI Report* 88-4059, 1988. (#39)

The Coastal Plain province is underlain by layered, sedimentary deposits that generally thicken and dip eastward toward the coast[39]. Alternating sand and clay deposits form a layered series of aquifers and confining units which define the hydrogeologic framework[39] **(Figure 3-6)**.

Of the eight different aquifers that exist throughout the Coastal Plain province, jurisdictions within the York River Basin obtain their ground water from the Yorktown-Eastover, Columbia, Chickahominy-Piney Point, Aquia, Brightseat-Upper Potomac, Middle Potomac, and Lower Potomac aquifers. According to a 1988 ground water resources study by the U.S. Geological Survey, the Brightseat-Upper Potomac, Aquia, Middle Potomac, and Lower Potomac aquifers supplied approximately 87 percent of the ground water withdrawn in 1983[39].

As discussed earlier the natural flow of ground water is eastward, eventually discharging in the Chesapeake Bay and Atlantic Ocean. However because of the continuous withdrawal of large volumes of water, the dominant direction of flow of these aquifers is now toward the major pumping centers[39]. Major centers of ground water withdrawal within the Basin include Williamsburg, the central part of James City County, and eastern parts of Hanover County[39]. In 1983, major ground water withdrawal sites of the Coastal Plain were identified by the USGS as shown in **Figure 3-7**.

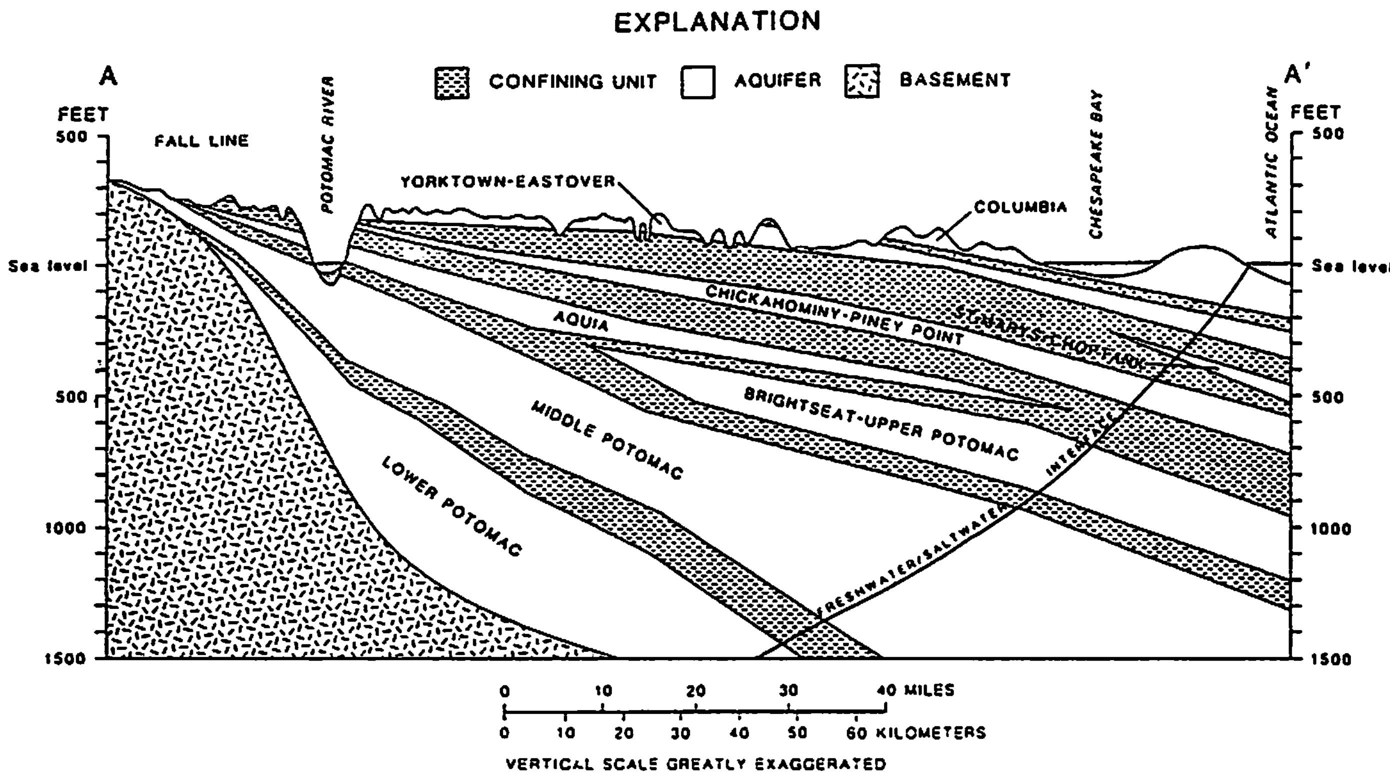

Figure 3.6. Hydrogeological Section: Coastal Plain Province.

Source: *U.S. Geological Survey WRI Report*, 87-4049, 1988. (#40)

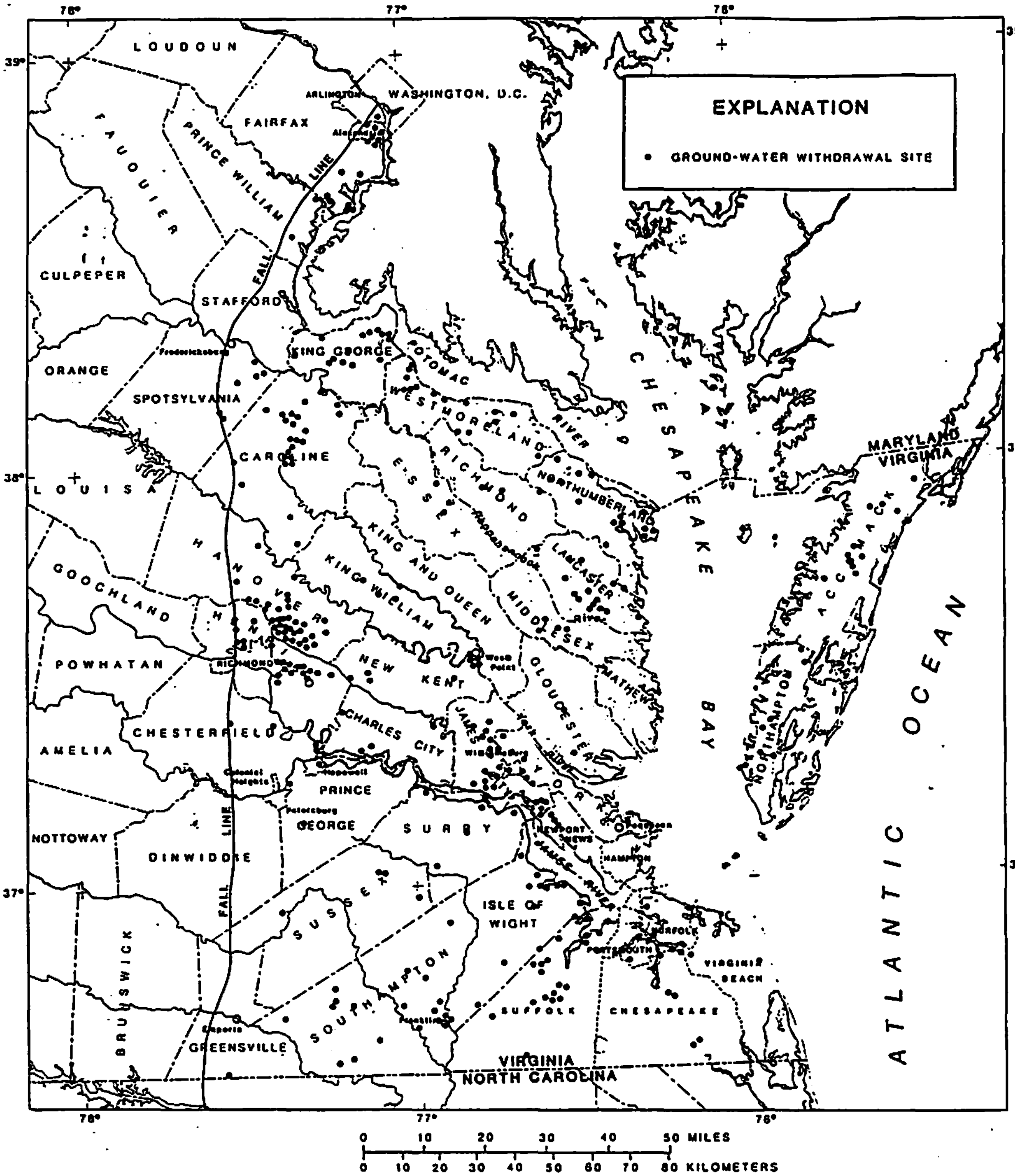

Figure 3.7. Location of withdrawal sites in the Coastal Plain of Virginia, 1983.

Source: *U.S. Geological Survey WRI Report 87-4049*, 1988. (#40)

Piedmont Physiographic Province

The western portion of the basin lies within the Piedmont physiographic province. Given its rural nature, ground water has historically supplied the basic need for water to much of the Piedmont province[38] **Figure 3-8** presents a schematic diagram of the hydrologic cycle throughout the Piedmont province.

The general geologic conditions throughout the Piedmont consist of a weathered horizon of surface soils over a thick layer of decomposed rock called saprolite[46] **(Figure 3-9)** Precipitation percolates through this zone until it reaches impermeable igneous and metamorphic rock where it forms the water-table aquifer[38]. It is estimated that 10 to 12 inches of precipitation per year recharge the water table of the Piedmont region[38]. The remaining precipitation is lost to surface runoff or evapotranspiration.

Water in the crystalline intrusives and metamorphic rocks of the Piedmont is found in fractures within the rocks as well as within the small spaces left in the saprolite[38]. Little if any water moves from within the impermeable layer of hard bedrock. In the sedimentary rocks of the Piedmont water moves through spaces among the particles within the rock and along fractures[38]. Water movement throughout the aquifer as previously discussed is a multi-directional system of alternating recharge and discharge. Water is lost through evapotranspiration as it moves to the soil surface. It also discharges into streams, lakes, springs, hillsides and is withdrawn from man-made wells.

In comparison to the Coastal Plain province the subsurface geology of the Piedmont province is not as conducive to ground water filtration, storage, and withdrawal. Tapping ground water in the Piedmont province is subjected to more geologic constraints. The

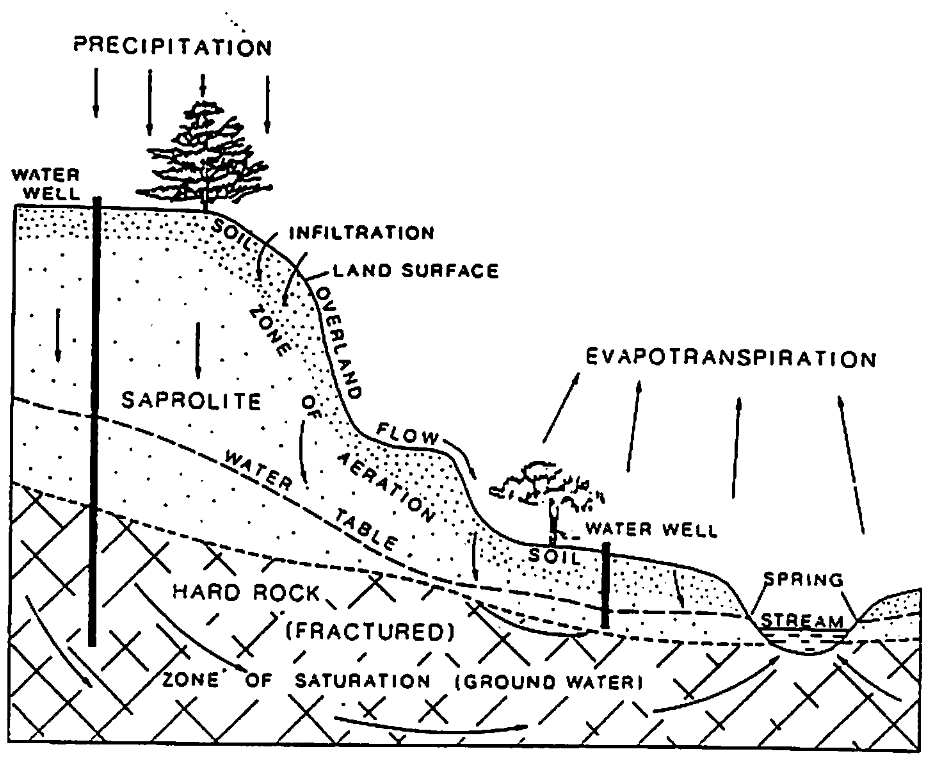

Figure 3.8. Water cycle in the Piedmont Province. (Modified from Richardson, 1982.)
Source: *U.S. Geological Survey WRI Report 85-4235*, 1985. (#38)

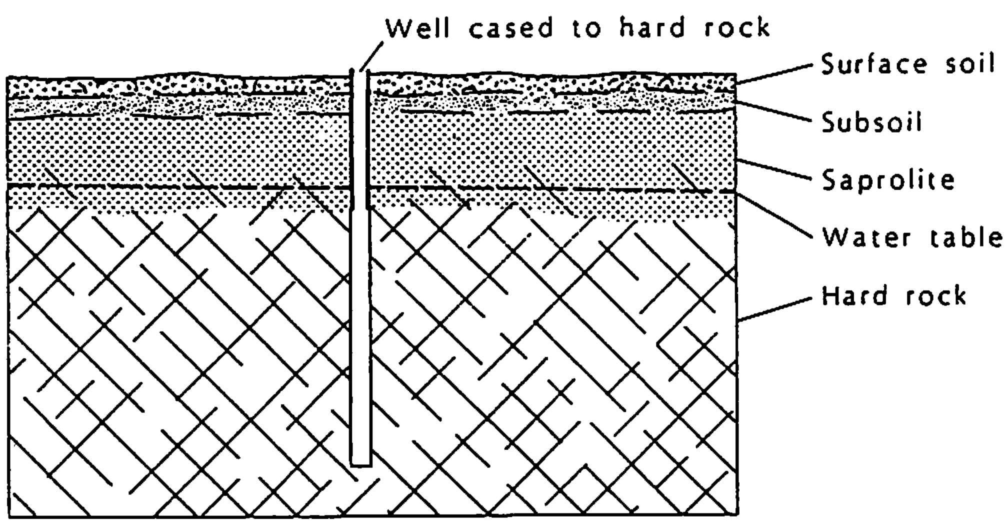

Figure 3.9. Typical subsurface cross section showing the character of materials penetrated by a well in crystalline terrane. (LeGrand, 1960.)
Source: U.S. Geological Survey WRI Report 85-4235, 1985. (#38)

yield of a given well is dependent on the abundance of fractures in subsurface rock and the depth to which these exist[38]. Studies have also shown that the topographic location of a well is a significant factor in relation to its potential yield. Nutter and Otton stated that wells located in valleys can have three to four times the yield at less than 90 percent the depth of hilltop wells[23].

Both shallow bored wells and deeper drilled wells are common in the Piedmont province, however they tap only moderate supplies of ground water in comparison to the wells of the Coastal Plain province[46]. It should be recognized that at present the extent and capacity of ground water resources throughout the Piedmont province in Virginia is unknown. While it is believed that a dependable supply of ground water may exist within the Piedmont, extensive analysis is necessary to confirm more accurate estimates.

Ground water studies indicate that over long periods of time the volume of the water table exists in a state of equilibrium, with recharge equalling discharge[38]. This is only true however if the water table is not subjected to prolonged drought or artificial withdrawal from man made wells. Since there is no way of actually increasing the rate of natural recharge, the total amount of ground water available is essentially limited.

3.8 WATER RESOURCES: INTERRELATIONSHIPS CONCERNING WATER QUALITY

To deal with issues affecting the quality of water resources there are critical links which exist between surface and ground water reserves that need to be recognized. The physical and chemical processes acting on water as it migrates through the hydrologic cycle (in both surface and subsurface regimes), ultimately determine the quality of all water resources. For this reason surface water and ground water need to be considered as one indivisible resource. Thus within this section water resources or water quality will pertain to both surface and ground water.

Water quality is generally evaluated using two basic criteria: the quantity of water which can be removed (without causing an unacceptable decline in its overall water level); and by the actual chemical composition of the water[21]. As previously discussed, the maximum volume of water available in the YRB is primarily limited by the input of precipitation through the hydrologic cycle. It was also recognized that ground water is a major source of water flowing to streams, ponds, and reservoirs through subterranean aquifer connections. Consequently, surface water withdrawals can alter ground water volumes and vice versa. The net result of this suggests that the available water supply within the YRB is one large inter-connected resource.

Two issues of growing concern, minimum in-stream flows and water table drawdown (cones of depression), further illustrate the interrelationship between surface and ground water. Minimum in-stream flow is a principle which aims to define a specific volume of water in a river or reservoir that will sustain water quality to support multiple uses such as recreation, navigation, waste treatment, continued propagation of water associated biota, and public water use. Minimum in-stream flow criteria focusses on the quantity of water left in the river rather than the volume removed. Thus given the known interconnection between ground and surface water, large withdrawals of ground water may alter surface water and salinity levels considerably. Over time this could have an effect on instream plant communities, the composition of vertebrate and invertebrate species, as well as fish species.

Cones of depression result from large volumes of ground water withdrawal from individual wells, which causes the level of ground water to be drawn down[21] **(Figure 3-10)** Over a period of time this can have a profound effect by lowering the natural level of the water table. This can result in land subsidence in certain instances and salt water intrusion of fresh water aquifers. Salt water intrusion into the ground water aquifer can in turn result in an increase in the salinity of surface water sources.

The quality of water is primarily affected by the chemical constituents water (precipitation) interacts with throughout its movement in the hydrologic cycle. Determining the origin, concentration, and distribution of dissolved-chemical constituents and other pollutants in water requires extensive monitoring and complex analysis. Thus general characteristics will be described in lieu of a detailed technical description of water quality. Cooperative efforts between the Virginia State Water Control Board, the U.S. Geological Survey, and the Environmental Protection Agency currently monitor and record water quality in certain locales of the York River Basin. However, comprehensive data on ground and surface water will be necessary in the future if the management of water resources is to become more effective. The data acquired is compiled on a yearly basis by the Virginia State Water Control Board and is available to the public.

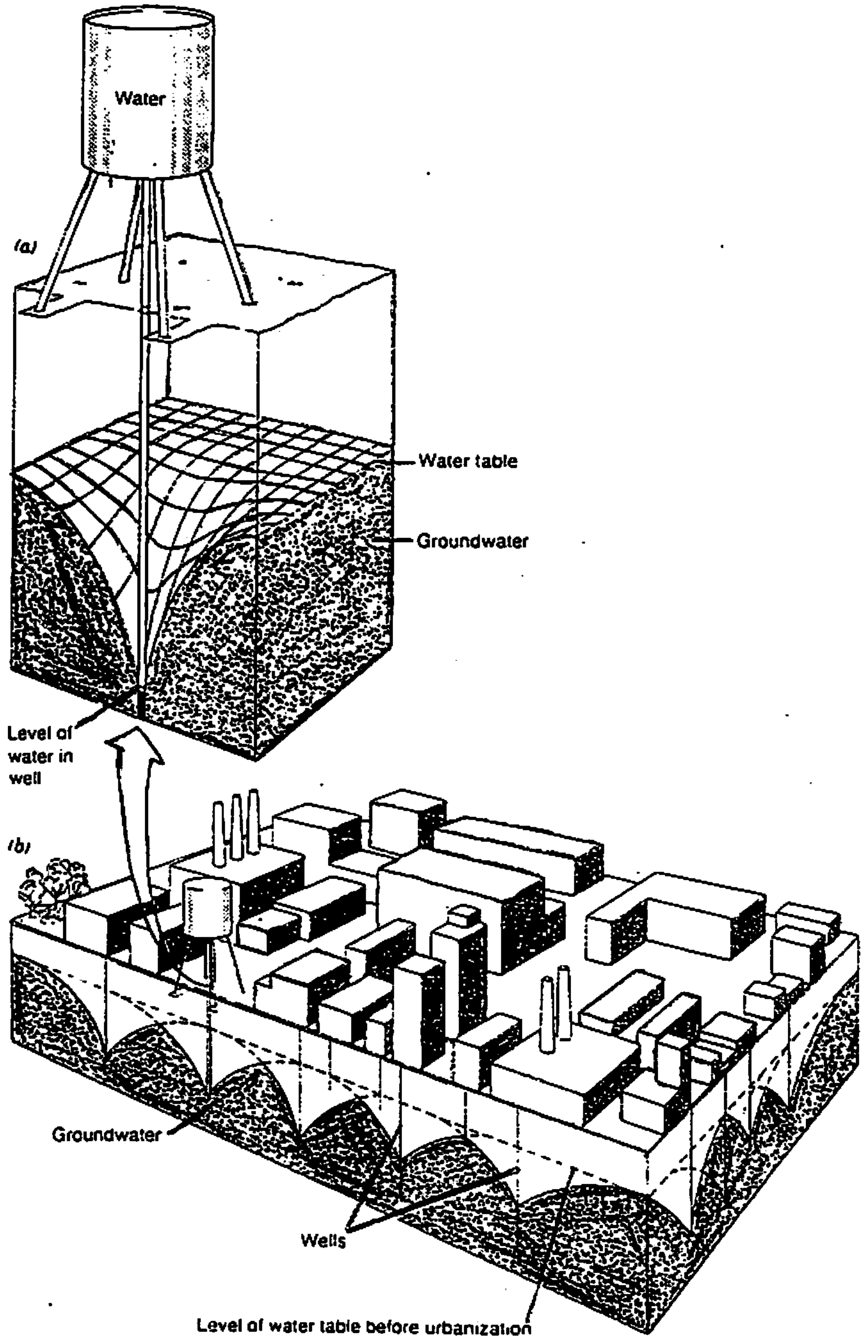

Figure 3.10. Formation of a cone of depression in a water table: (a) around a single well; (b) intersecting cones of depression resulting from many closely spaced wells in an uranized area. Source: Marsh, William M., *Earthscape: A Physical Geography*, 1987. (#21)

Table 3-1 YORK RIVER BASIN
SUMMARY OF GROUND WATER QUALITY PROBLEMS
IN AQUIFERS OF THE YORK-JAMES PENINSULA BY REGION

AQUIFER	WESTERN REGION	CENTRAL REGION	EASTERN REGION
Columbia	Aquifer not present	Aquifer used for domestic supply only	Very hard water
Yorktown-Eastover	Aquifer used for domestic supply only	Moderately hard water	Hard water Calcite precipitation
Chickahominy-Piney Point	Moderately hard water Calcite precipitation	Moderately hard water	Elevated sodium Elevated chloride Elevated dissolved solids Calcite precipitation
Upper Potomac	Aquifer not present	Elevated dissolved solids Elevated flouride	Elevated sodium Elevated chloride Elevated dissolved solids Elevated flouride
Middle Potomac	No apparent problems	Elevated dissolved solids Elevated flouride	Elevated sodium Elevated chloride Elevated dissolved solids Elevated flouride Elevated dissolved iron
Lower Potomac	No apparent problems	Elevated sodium Elevated chloride Elevated dissolved solids Elevated dissolved iron	Elevated sodium Elevated chloride Elevated dissolved solids Elevated dissolved iron Very hard water

Source: Adopted from USGS, Water Resources Investigations Report 88-4059, p. 48, 1988.

**Table 3-2 YORK RIVER BASIN
SUMMARY OF THE GROUND WATER QUALITY
IN THE PIEDMONT PROVINCE**

GEOLOGIC TYPE	TYPICAL WATER QUALITY CHARACTERISTCS
Light colored crystalline metamorphic and igneous rock	Soft water Slightly acidic Low in dissolved solids Low sulfate Moderate levels of chloride
Dark colored crystalline metamorphic and igneous rock	Moderately hard water Slightly alkaline Dissolved solids prevelant Low sulfate concentration Dissolved iron prevelant
Sedimentary rock	Hard water Slightly alkaline High level of dissolved solids Moderate levels of sulfate

Source: Adopted from USGS, Water Resources Investigations Report 85-4235, p. 24-6, 1985.

4.0 INVENTORY OF EXISTING WATER RESOURCES & FACILITIES

4.0 INVENTORY OF EXISTING WATER RESOURCES & FACILITIES

Water supply and service for the population of the York River Basin emanates from a wide variety of locations operated by public and private purveyors. This chapter identifies existing water supply sources utilized throughout the watershed by jurisdiction. The issues associated with calculating the available supply of water resources are also discussed.

4.1 CAROLINE COUNTY

Approximately 90 percent of Caroline County lies within the Coastal Plain physiographic province of Virginia, with the remaining portion occurring in the Piedmont province. Prior to 1990, the county relied primarily on the extensive volume of ground water available from the Coastal Plain aquifers. In 1990, however .744 million gallons per day (mgd) of surface water and .514 mgd of ground water was withdrawn by users within the county. According to the 1987 USGS ground water study, only two aquifers had been tapped by 1983 - the Yorktown-Eastover and Middle Potomac[40]. The following table derived from the 1990 U.S. Census of Population and Housing details the source of water for housing units throughout the county.

Table 4-1

CAROLINE COUNTY: SOURCE OF WATER-1990

Public system or private company	1,937
Individual drilled well	2,960
Individual dug well	2,255
Some other source	140
Total Housing Units	7,292

These figures indicate that 27 percent of the housing units in 1990 were served by a centrally administered waterworks system. The major withdrawal locations in the county are listed in **Table 4-1a**. Nineteen wells are listed with six of those being considered municipal supply systems and the remaining number being self supplied systems. Although branches of the federal government are not required to report water use, Fort AP Hill of the U.S. Army operated 26 wells in 1984, resulting in an estimated ground water withdrawal of .015 mgd. Two surface water systems are utilized, Lake Caroline which is a private reservoir, and a stream intake location along the Mattaponi River for a sand and gravel operation.

Table 4-1a YORK RIVER BASIN
CAROLINE COUNTY
MAJOR WATER WITHDRAWAL LOCATIONS - 1990

OPERATOR	CATEGORY	SOURCE	TYPE	1990 AVER. (MGD)
Town of Bowling Green	Public water system	GW	Well	0.0467
Town of Bowling Green	Public water system	GW	Well	0.0249
Town of Bowling Green	Public water system	GW	Well	0.0453
Town of Bowling Green	Public water system	GW	Well	0.0184
Alpha Water Corporation	Public water system	GW	Well	0.0151
Caroline County	Public water system	GW	Well	0.0328
Caroline County	Public water system	GW	Well	0.0000
Sydnor Hydrodynamics	Public water system	GW	Well	0.0010
Sydnor Hydrodynamics	Public water system	GW	Well	0.0360
Lake Land Utility Co.	Public water system	GW	Well	0.0532
Lake Caroline Water Co.	Public water system	SW	Reservoir	0.3953
Residential Subtotal				0.6687
Commonwealth of VA	Commercial	GW	Well	0.0000
Commonwealth of VA	Commercial	GW	Well	0.0478
Commonwealth of VA	Commercial	GW	Well	0.0000
Commonwealth of VA	Commercial	GW	Well	0.0147
Caroline County	Commercial	GW	Well	0.0054
Caroline County	Commercial	GW	Well	0.0573
Caroline County	Commercial	GW	Well	0.0547
Caroline County	Commercial	GW	Well	0.0437
Foreign & Domestic Inc.	Manufacturing	GW	Well	0.0167
Comm/Inst/Light Ind Subtotal				0.2403
Smith Sand & Gravel	Mining	SW	Stream Intake	0.3486
Heavy Industrial				0.3486
COUNTY TOTAL				1.2576

Source: SWCB VWUDS, 1990.

4.2 GLOUCESTER COUNTY

The entire county of Gloucester is within the Coastal Plain physiographic province. The majority of the county's water needs are supplied by ground water resulting in .214 mgd withdrawn in 1990. According to the USGS ground water study, three aquifers had been tapped by 1983 - the Yorktown-Eastover, Aquia, and Brightseat-Upper Potomac[40]. There are three county operated water systems, the Gloucester Sanitary District #1, the County Water System, and the Beaverdam Swamp Reservoir system[46]. The latter system began delivering water in July of 1990 and replaces the former ground water systems of Gloucester Point Sanitary District, and the Gloucester Court House.

The Gloucester Sanitary District #1 has three water wells and two elevated storage tanks with capacities of 75,000 and 250,000 gallons. The County Water System operates a radial collector well at Ordinary[46]. The County Water System also operates the water treatment facility which has a capacity of .300 mgd. The Beaverdam facility has a new treatment plant with a current capacity to deliver 1.95 mgd. The system was designed with the ability to be expanded to deliver 4.0 mgd of treated water[25]. Gloucester Point Sanitary District owns an elevated water storage tank which has a capacity of 250,000 gallons[46].

The following table derived from the 1990 U.S. Census of Population and Housing details the source of water for housing units throughout the county.

Table 4-2

GLOUCESTER COUNTY: SOURCE OF WATER-1990

Public system or private company	1,897
Individual drilled well	8,877
Individual dug well	1,617
Some other source	60
Total Housing Units	12,451

Only 15 percent of the housing units in 1990 were served by a centrally operated waterworks system. The major withdrawal locations in 1990 are listed in **Table 4-2a.**

Problems and Issues

A variety of concerns surround the existing supply of water resources currently available for Gloucester County. The most significant issues involve the quality and volume of ground water available throughout the county. The County has historically had numerous problems in maintaining water quality standards set by the federal government and the State Health Department. Some of these problems have been alleviated since the completion of the radial collector well at Ordinary.

The eastern portion of Gloucester County must rely on ground water from the Yorktown-Eastover aquifer which has low yield potential[46]. In the eastern areas of the county the deeper high yield aquifers are unusable due to salt water intrusion from the Chesapeake Bay and the Atlantic[40]. In the western portion of the county the deeper aquifers such as the Brightseat-Upper Potomac and the Middle Potomac, are capable of providing a considerable volume of ground water supply. In 1988 the SWCB estimated that these aquifers may be capable of producing 2-5 mgd using properly placed withdrawals of 0.2 mgd per well[46]. However, if an increase in reliance on these aquifers continues the movement of the high

Table 4-2a YORK RIVER BASIN
GLOUCESTER COUNTY
MAJOR WATER WITHDRAWAL LOCATIONS - 1990

OPERATOR	CATEGORY	SOURCE	TYPE	1990 AVER. (MGD)
Gloucester County	Public water system	GW	Well	0.2137
Residential Subtotal				0.2137
COUNTY TOTAL				0.2137

Source: SWCB VWUDS, 1990.

chloride water wedge will progress westward as a result of water table drawdown[46]. While the rate and severity of this process are unknown, it generally suggests that suitable ground water available to Gloucester County is of limited supply. In addition the SWCB stated in 1988 that 'the current municipal water supply systems in Gloucester County are unable to supply future demands which indicates that an expanded County administered system is needed[46].

4.3 HANOVER COUNTY

The entire county of Hanover is within the Coastal Plain physiographic province. The majority of the county's water needs are supplied by surface water reserves. In 1990, 18.91 mgd of surface water, and .423 mgd of ground water were withdrawn. According to the USGS ground water study, two aquifers had been tapped by 1983 - the Yorktown-Eastover, and Middle Potomac[40]. Hanover County has the greatest number of ground water wells in operation of the entire YRB. The following table modified from the 1990 U.S. Census of Population and Housing details the source of water for housing units throughout the county.

Table 4-3

HANOVER COUNTY: SOURCE OF WATER-1990

Public system or private company	11,614
Individual drilled well	6,835
Individual dug well	5,116
Some other source	162
Total Housing Units	23,727

Hanover County has sought to combine numerous individual wells in operation. This has resulted in approximately 50 percent of the housing units being serviced by a public or private water system. The major withdrawal locations in the county are listed in **Table 4-3a.** In 1985, the Mechanicsville Sanitary district consisted of 11 wells with an estimated production capability of 1.25 mgd[12]. The Doswell water system consists of a 2.5 mgd high rate filtration plant using water from the North Anna River[12]. The Doswell system also operates a 1.0 million gallon water storage tank. The Town of Ashland operates a 2.0 mgd water treatment facility on the South Anna River[12]. There are also a host of other individual county operated well systems scattered throughout the county. In addition, there are

Table 4-3a YORK RIVER BASIN

HANOVER COUNTY

MAJOR WATER WITHDRAWAL LOCATIONS - 1990

OPERATOR	CATEGORY	SOURCE	TYPE	1990 AVER. (MGD)
Hanover County	Public water system	GW	Well	0.0711
Hanover County	Public water system	GW	Well	0.0000
Hanover County	Public water system	GW	Well	0.1255
Hanover County	Public water system	GW	Well	0.0125
Hanover County	Public water system	GW	Well	0.0013
Hanover County	Public water system	GW	Well	0.0117
Hanover County	Public water system	GW	Well	0.0136
Hanover County	Public water system	GW	Well	0.0115
Hanover County	Public water system	GW	Well	0.0043
Hanover County	Public water system	GW	Well	0.0000
Hanover County	Public water system	SW	SR	1.8332
Town of Ashland	Public water system	SW	SR	0.9028
Meadow Farm	Public water system	SW	SR	0.0000
Sydnor Hydrodynamics Inc.	Public water system	GW	Well	0.0028
Sydnor Hydrodynamics Inc.	Public water system	GW	Well	0.0141
Sydnor Hydrodynamics Inc.	Public water system	GW	Well	0.0021
Sydnor Hydrodynamics Inc.	Public water system	GW	Well	0.0756
Sydnor Hydrodynamics Inc.	Public water system	GW	Well	0.0055
Sydnor Hydrodynamics Inc.	Public water system	GW	Well	0.0000
Sydnor Hydrodynamics Inc.	Public water system	GW	Well	0.0115
Residential Subtotal				3.0991
Commonwealth of VA	Commercial	GW	Well	0.0196
Commonwealth of VA	Commercial	GW	Well	0.0020
Commonwealth of VA	Commercial	GW	Well	0.0091
Commonwealth of VA	Commercial	GW	Well	0.0128
Commonwealth of VA	Commercial	GW	Well	0.0128
Hanover County	Commercial	GW	Well	0.0003
Hanover County	Commercial	GW	Well	0.0134
Hanover County	Commercial	GW	Well	0.0023
Colesville Nursery	Commercial	SW	Reservoir	0.0311
The Hollows Golf Course	Commercial	SW	Reservoir	0.0220
Comm/Inst/Light Ind Subtotal				0.1254
Bear Island Paper Co.	Manufacturing	SW	Reservoir	0.9946
Bear Island Paper Co.	Manufacturing	SW	SR	0.4624
General Crushed Stone Co.	Mining	SW	SR	0.0049
General Crushed Stone Co.	Mining	SW	Reservoir	0.2558
Feldspar Corporation	Mining	GW	Well	0.0003
Feldspar Corporation	Mining	SW	Reservoir	14.3999
Heavy Industrial				16.1179
COUNTY TOTAL				19.3424

Source: SWCB VWUDS, 1990.

a large number of privately owned and operated water systems which rely primarily on ground water. Currently a small sub-system, the Air Park, purchases water from Henrico County[12].

4.4 JAMES CITY COUNTY

James City County lies within the Coastal Plain physiographic province. The county water needs are supplied entirely by ground water reserves resulting in the withdrawal of .225 mgd of ground water during 1990. The county's reliance on ground water has resulted in withdrawals from all aquifers except the Lower Potomac[40]. The following table modified from the 1990 U.S. Census of Population and Housing presents the source of water for housing units throughout the county.

Table 4-4

JAMES CITY COUNTY: SOURCE OF WATER-1990

Public system or private company	10,799
Individual drilled well	2,873
Individual dug well	607
Some other source	51
Total Housing Units	14,330

These figures suggest that 75 percent of the housing units in 1990 were served by a centrally administered waterworks system. The major reservoirs, stream intakes, and ground water withdrawal locations in the county are listed in **Table 4-4a**. The public water system, the James City Service Authority (JCSA), currently owns 40 wells which serve four service areas and has a capacity of approximately 7.54 mgd[14]. **Table 4-4b** located in Appendix A, compiled by the Regional Raw Water Study Group, lists the wells and storage tanks owned by the JCSA. The county also obtains a portion of its water service from the City of Williamsburg (0.2 mgd) and Newport News Waterworks (7.3 mgd)[18]. Four privately owned well systems with approximately 500 connections permitted by the VDH are also operated within the county[18]. In addition to these systems which supply water specifically to James City county[18]. In addition to these systems which supply water specifically to James City

Table 4-4a YORK RIVER BASIN
JAMES CITY COUNTY
MAJOR WATER WITHDRAWAL LOCATIONS - 1990

OPERATOR	CATEGORY	SOURCE	TYPE	1990 AVER. (MGD)
James City Service Authority	Public water system	GW	Well	0.1656
James City Service Authority	Public water system	GW	Well	0.0009
James City Service Authority	Public water system	GW	Well	0.0013
James City Service Authority	Public water system	GW	Well	0.0382
James City Service Authority	Public water system	GW	Well	0.0003
James City Service Authority	Public water system	GW	Well	0.0056
James City Service Authority	Public water system	GW	Well	0.0044
James City Service Authority	Public water system	GW	Well	0.1073
James City Service Authority	Public water system	GW	Well	0.0044
James City Service Authority	Public water system	GW	Well	0.0059
James City Service Authority	Public water system	GW	Well	0.0015
James City Service Authority	Public water system	GW	Well	0.0730
James City Service Authority	Public water system	GW	Well	0.0139
James City Service Authority	Public water system	GW	Well	0.1701
James City Service Authority	Public water system	GW	Well	0.1954
James City Service Authority	Public water system	GW	Well	0.0146
James City Service Authority	Public water system	GW	Well	0.1562
James City Service Authority	Public water system	GW	Well	0.0003
James City Service Authority	Public water system	GW	Well	0.0036
James City Service Authority	Public water system	GW	Well	0.0139
James City Service Authority	Public water system	GW	Well	0.0391
James City Service Authority	Public water system	GW	Well	0.1161
James City Service Authority	Public water system	GW	Well	0.0058
James City Service Authority	Public water system	GW	Well	0.0285
James City Service Authority	Public water system	GW	Well	0.1115
James City Service Authority	Public water system	GW	Well	0.0081
James City Service Authority	Public water system	GW	Well	0.0763
James City Service Authority	Public water system	GW	Well	0.0020
James City Service Authority	Public water system	GW	Well	0.1935
James City Service Authority	Public water system	GW	Well	0.0061
James City Service Authority	Public water system	GW	Well	0.0255
James City Service Authority	Public water system	GW	Well	0.0010
James City Service Authority	Public water system	GW	Well	0.0480
James City Service Authority	Public water system	GW	Well	0.0205
James City Service Authority	Public water system	GW	Well	0.0356
James City Service Authority	Public water system	GW	Well	0.0014
James City Service Authority	Public water system	GW	Well	0.0039
Sydnor Hydrodynamics, Inc.	Public water system	GW	Well	0.0373
Sydnor Hydrodynamics, Inc.	Public water system	GW	Well	0.0097
Tidewater Water Company	Public water system	GW	Well	0.01
Residential Subtotal				1.7563
COUNTY TOTAL				1.7563

Source: SWCB VWUDS, 1990.

County, there are a number of reservoirs within the county which provide water to the city of Newport News. **Table 4-4c** found in Appendix A identifies various characteristics of these water supply facilities.

4.5 KING AND QUEEN COUNTY

King and Queen County lies within the Coastal Plain physiographic province. The county's water needs are supplied by ground water reserves resulting in .015 mgd of withdrawals during 1990. The following table modified from the 1990 U.S. Census of Population and Housing details the source of water for housing units throughout the county.

Table 4-5

KING AND QUEEN COUNTY: SOURCE OF WATER-1990

Public system or private company	98
Individual drilled well	1,450
Individual dug well	1,143
Some other source	7
Total Housing Units	2,698

Given its predominately rural nature, the county has developed only one public water system, the Walkerton Water System, Inc., which services only four percent of the housing units in the county. In 1990 it provided .015 mgd of ground water to the Walkerton Service Area.

Table 4-5a YORK RIVER BASIN
KING AND QUEEN COUNTY
MAJOR WATER WITHDRAWAL LOCATIONS - 1990

OPERATOR	CATEGORY	SOURCE	TYPE	1990 AVER. (MGD)
Walkerton Water System	Public water system	GW	Well	0.015
Residential Subtotal				0.015
COUNTY TOTAL				0.015

Source: SWCB VWUDS, 1990.

4.6 KING WILLIAM

The entire county of King William is within the Coastal Plain physiographic province. The majority of the county's water needs are supplied by ground water reserves. In 1990, 18.72 mgd of ground water, and .002 mgd of surface water were withdrawn. According to the USGS ground water study, by 1983 the county had tapped all but the Yorktown-Eastover aquifer to meets its needs[40]. Most of the ground water is withdrawn from the Upper, Middle, and Lower Potomac aquifers which provide the greatest quantity of supply[40]. The following table modified from the 1990 U.S. Census of Population and Housing indicates the source of water for housing units throughout the county.

Table 4-6

KING WILLIAM COUNTY: SOURCE OF WATER-1990

Public system or private company	1,200
Individual drilled well	1,916
Individual dug well	1,064
Some other source	13
Total Housing Units	4,193

These figures suggest that approximately 29 percent of the housing units in 1990 were served by a centrally administered waterworks system. The major water withdrawal locations in the county are listed in **Table 4-6a**. Chesapeake Corporation, located in West Point, is the largest single user of ground water in the county with 14 wells in operation. The Town of West Point owns two wells, and a 100,000 and 500,000 gallon storage tank[46]. The lone surface water user was West Point Country Club which uses water primarily for irrigation purposes.

Table 4-6a YORK RIVER BASIN
KING WILLIAM COUNTY
MAJOR WATER WITHDRAWAL LOCATIONS - 1990

OPERATOR	CATEGORY	SOURCE	TYPE	1990 AVER. (MGD)
Town of West Point	Public water system	GW	Well	0.2413
Town of West Point	Public water system	GW	Well	0.1737
Virginia Suburban Water Co.	Public water system	GW	Well	0.0057
Residential Subtotal				0.4207
King William County	Commercial	GW	Well	0.0057
King William County	Commercial	GW	Well	0.0010
West Point Country Club	Commercial	SW	Reservoir	0.0021
Comm/Inst/Light Ind Subtotal				0.0088
Chesapeake Corporation of VA	Manufacturing	GW	Well	0.4191
Chesapeake Corporation of VA	Manufacturing	GW	Well	2.0191
Chesapeake Corporation of VA	Manufacturing	GW	Well	1.0986
Chesapeake Corporation of VA	Manufacturing	GW	Well	1.5059
Chesapeake Corporation of VA	Manufacturing	GW	Well	1.2
Chesapeake Corporation of VA	Manufacturing	GW	Well	2.2082
Chesapeake Corporation of VA	Manufacturing	GW	Well	0.7315
Chesapeake Corporation of VA	Manufacturing	GW	Well	1.7123
Chesapeake Corporation of VA	Manufacturing	GW	Well	2.0794
Chesapeake Corporation of VA	Manufacturing	GW	Well	1.063
Chesapeake Corporation of VA	Manufacturing	GW	Well	0.6301
Chesapeake Corporation of VA	Manufacturing	GW	Well	1.663
Chesapeake Corporation of VA	Manufacturing	GW	Well	1.7123
Chesapeake Corporation of VA	Manufacturing	GW	Well	0.2493
Heavy Industrial				18.2918
COUNTY TOTAL				18.7213

Source: SWCB VWUDS, 1990.

4.7 LOUISA COUNTY

Louisa County lies within the Piedmont physiographic province. The majority of the county's water needs are supplied by surface water reserves. In 1990, 2064.26. mgd of surface water, and .257 mgd of ground water were withdrawn. The following table modified from the 1990 U.S. Census of Population and Housing identifies the source of water for housing units throughout the county.

Table 4-7

LOUISA COUNTY: SOURCE OF WATER-1990

Public system or private company	1,259
Individual drilled well	5,307
Individual dug well	2,225
Some other source	289
Total Housing Units	9,080

Only 14 percent of the housing units are serviced by a public or private water system. The major withdrawal locations in the county are listed in **Table 4-7a.** The majority of Louisa County residents receive water from private wells. There are three separate central water systems in the county[17]. The Louisa County Water Authority controls the reservoir on the Northeast Creek and 5 wells. The water treatment plant for the Northeast Creek reservoir has a capacity of one million gallons per day[17]. The Town of Mineral operates 5 wells and maintains an elevated storage tank which holds 90,000 gallons. Ridge Utilities Inc. provides water to the Blue Ridge Shores Subdivision from its three wells and two 20,000 gallon storage tanks[17].

Table 4-7a YORK RIVER BASIN
LOUISA COUNTY
MAJOR WATER WITHDRAWAL LOCATIONS - 1990

OPERATOR	CATEGORY	SOURCE	TYPE	1990 AVER. (MGD)
Louisa County Water Authority	Public water system	GW	Well	0.0054
Louisa County Water Authority	Public water system	GW	Well	0.0000
Louisa County Water Authority	Public water system	GW	Well	0.0000
Louisa County Water Authority	Public water system	GW	Well	0.0000
Louisa County Water Authority	Public water system	GW	Well	0.0000
Louisa County Water Authority	Public water system	SW	Reservoir	0.1551
Town of Mineral	Public water system	GW	Well	0.0373
Town of Mineral	Public water system	GW	Well	0.0043
Town of Mineral	Public water system	GW	Well	0.0091
Town of Mineral	Public water system	GW	Well	0.0089
Town of Mineral	Public water system	GW	SP	0.0189
Metro Mobile Parks	Public water system	GW	Well	0.0113
Ridge Utilities Inc.	Public water system	GW	Well	0.0471
Ridge Utilities Inc.	Public water system	GW	Well	0.0000
Residential Subtotal				0.2974
Virginia Power	Nuclear Power	GW	Well	0.0000
Virginia Power	Nuclear Power	GW	Well	0.0032
Virginia Power	Nuclear Power	GW	Well	0.0084
Virginia Power	Nuclear Power	GW	Well	0.0282
Comm/Inst/Light Ind Subtotal				0.0398
Kloeckner-Pentaplast America	Manufacturing	GW	Well	0.0000
Kloeckner-Pentaplast America	Manufacturing	GW	Well	0.0673
Kloeckner-Pentaplast America	Manufacturing	GW	Well	0.0073
Kloeckner-Pentaplast America	Manufacturing	SW	Reservoir	0.0000
Heavy Industrial				0.0746
Virginia Power (a)	Nuclear Power	SW	Reservoir	1120.6850
Virginia Power (a)	Nuclear Power	SW	Reservoir	943.4246
Nuclear Power Subtotal				2064.1096
COUNTY TOTAL				2064.5214

(a) -- 99% of water use is considered non-consumptive, thus demand is listed seperately.

Source: SWCB VWUDS, 1990.

4.8 NEW KENT COUNTY

All of New Kent County lies within the Coastal Plain physiographic province. The county's water needs are satisfied entirely by ground water, resulting in .014 mgd withdrawn in 1990. According to the USGS ground water study, two aquifers had been tapped by 1983 - the Brightseat-Upper Potomac, and the Middle Potomac, which are of the upper artesian aquifer[40].

The following table modified from the 1990 U.S. Census of Population and Housing indicates the source of water for housing units throughout the county.

Table 4-8

NEW KENT COUNTY: SOURCE OF WATER-1990

Public system or private company	1,018
Individual drilled well	2,125
Individual dug well	781
Some other source	44
Total Housing Units	3,968

These figures indicate that 26 percent of the housing units in 1990 were served by a centrally administered waterworks system. The majority of New Kent County residents receive water from private wells. The major withdrawal locations in the county are listed in **Table 4-8a.**

Table 4-8a YORK RIVER BASIN
NEW KENT COUNTY
MAJOR WATER WITHDRAWAL LOCATIONS - 1990

OPERATOR	CATEGORY	SOURCE	TYPE	1990 AVER. (MGD)
Alpha Water Corporation	Public water system	GW	Well	0.0084
New Kent County	Public water system	GW	Well	0.0046
New Kent County	Public water system	GW	Well	0.0010
Residential Subtotal				0.0140
COUNTY TOTAL				0.0140

Source: SWCB VWUDS, 1990.

4.9 ORANGE COUNTY

The southeastern half of Orange County falls within the YRB. The remaining portion is part of the Rappahannock River Basin. The entire county lies within the Piedmont province of Virginia. Historically, much of the county has relied on ground water reserves. Unfortunately, little information is available on the extent, capacity, and quality of ground water in Orange County.

The following table modified from the 1990 U.S. Census of Population and Housing details the source of water for housing units throughout the county.

Table 4-9

ORANGE COUNTY: SOURCE OF WATER-1990

Public system or private company	4,186
Individual drilled well	3,907
Individual dug well	730
Some other source	215
Total Housing Units	9,038

These figures indicate that 46 percent of the housing units were served by a centrally administered waterworks system in 1990. The main water demand centers (Town of Orange and Gordonsville) which are in the Rappahannock River Basin currently obtain water from the Rapidan River[24]. The Town of Orange operates a water treatment plant which has a capacity of 2.0 mgd[24]. The Town of Gordonsville obtains its supply of water from the Rapidan Service Authority who purchases water from the Town of Orange[24]. Operating 14 of 40 wells Lake of the Woods in the northeast corner of the county obtains 100 percent of its water needs from ground water. The Rapidan Service Authority also operates an elevated water storage tank with a capacity of 500,000 gallons near Lake of the Woods[24].

Table 4-9a YORK RIVER BASIN
ORANGE COUNTY
MAJOR WATER WITHDRAWAL LOCATIONS - 1990

OPERATOR	CATEGORY	SOURCE	TYPE	1990 AVER. (MGD)
Rapidan Service Auth.	Public water system	GW	Well	0.0188
Residential Subtotal				0.0188
COUNTY TOTAL				0.0188

Source: SWCB VWUDS, 1990.

4.10 SPOTSYLVANIA COUNTY

The eastern corner of Spotsylvania County is within the Coastal Plain province with the majority of the county occurring in the Piedmont province. The majority of the county's water needs are supplied by surface water reserves. In 1990, 2.32 mgd of surface water, and .074 mgd of ground water were withdrawn. The following table modified from the 1990 U.S Census of Population and Housing identifies the source of water for housing units throughout the county.

Table 4-10

SPOTSYLVANIA COUNTY: SOURCE OF WATER-1990

Public system or private company	11,480
Individual drilled well	6,092
Individual dug well	2,820
Some other source	91
Total Housing Units	20,483

These figures suggest that approximately 56 percent of the housing units in 1990 were served by a centrally operated public or private water system. The major water withdrawal locations in the county are listed in **Table 4-10a.** The Ni River Reservoir has an estimated safe yield of 4.0 mgd[32].

Table 4-10a YORK RIVER BASIN
SPOTSYLVANIA COUNTY
MAJOR WATER WITHDRAWAL LOCATIONS - 1990

OPERATOR	CATEGORY	SOURCE	TYPE	1990 AVER. (MGD)
Spotsylvania County	Public water system	GW	Well	0.0106
Spotsylvania County (a)	Public water system	SW	Reservoir	2.3193
Residential Subtotal				2.3299
Po River Water & Sewer Co.	Commercial	GW	Well	0.0191
Po River Water & Sewer Co.	Commercial	GW	Well	0.0271
Po River Water & Sewer Co.	Commercial	GW	Well	0.0168
Comm/Inst/Light Ind Subtotal				0.0630
COUNTY TOTAL				2.3929

(a) – Water is withdrawn from the Ni Reservoir and transferred to Rappahanock River Basin.

Source: SWCB VWUDS, 1990.

4.11 YORK COUNTY

York County lies entirely within the Coastal Plain physiographic province. The majority of the county's water needs are supplied by surface water reserves from other jurisdictions. According to the USGS ground water study, four aquifers had been tapped by 1983 - the Chickahominy-Piney Point, Aquia, Brightseat-Upper Potomac, and the Middle Potomac[40]. The following table modified from the 1990 U.S. Census of Population and Housing identifies the source of water for housing units throughout the county.

Table 4-11

YORK COUNTY: SOURCE OF WATER-1990

Public system or private company	13,453
Individual drilled well	1,541
Individual dug well	271
Some other source	19
Total Housing Units	15,284

Based on these figures 88 percent of the housing units were served in 1990, by a centrally administered waterworks system. The major reservoirs, stream intakes, and ground water withdrawal locations in the county are listed in **Table 4-11a. Table 4-11b** found in Appendix A, lists the public and private water service companies that provide water to York County.

The majority of York County's water supply needs are met by the Newport News Waterworks and City of Williamsburg water systems[18]. Newport News Waterworks supplies water to York County and the county in turn sells this water to private water companies[18]. York County operates three wells, three 15,000 gallon storage tanks, and one 30,000 gallon storage tank[18]. The system's permitted design capacity is 120,000 gallons per day[18].

Table 4-11a YORK RIVER BASIN
YORK COUNTY
MAJOR WATER WITHDRAWAL LOCATIONS - 1990

OPERATOR	CATEGORY	SOURCE	TYPE	1990 AVER. (MGD)
York County	Public water system	GW	Well	0.0198
York County	Public water system	GW	Well	0.0180
York County	Public water system	GW	Well	0.0131
U.S. Government	Public water supply	SW	Reservoir	0.1027
Residential Subtotal				0.1536
Mecca Leisure	Commercial	GW	Well	0.0574
Comm/Inst/Light Ind Subtotal				0.0574
Amoco Oil	Manufacturing	SW	SR	61.8772
Heavy Industrial				61.8772
Virginia Power (a)	Power Generation	SW	SR	765.1715
Power Generation Subtotal				765.1715
COUNTY TOTAL				827.2597

(a) -- 99% of water use is considered non-consumptive, thus demand is listed seperately.

Source: SWCB VWUDS, 1990.

There are four military stations in York County which use significant volumes of water. Newport News Waterworks also supplies water to two military stations: the U.S. Coast Guard Reserve Training Center which utilizes a 100,000 gallon storage tank , and the Yorktown Naval Weapons Station, which has ten storage facilities with a capacity of 1.5 million gallons[18]. Camp Peary obtains its water from Williamsburg and utilizes a 150,000 gallon storage tank and two on site emergency wells[18]. The Cheatham Annex Naval Supply Center obtains water from Jones Pond, which is located within the Center.

4.12 CITY OF WILLIAMSBURG

Williamsburg lies entirely within the Coastal Plain physiographic province. The majority of the county's water needs are supplied by surface water reserves from Waller Mill Reservoir which is owned by the city[18]. According to the USGS ground water study, two aquifers had been tapped by 1983 - the Aquia, and the Brightseat-Upper Potomac[40]. The following table derived from the 1990 U.S. Census of Population and Housing details the source of water for housing units throughout the county.

Table 4-12

CITY OF WILLIAMSBURG: SOURCE OF WATER-1990

Public system or private company	3,915
Individual drilled well	31
Individual dug well	14
Some other source	0
Total Housing Units	3,960

Based on these figures, 99 percent of the housing units were served in 1990, by a centrally administered waterworks system. The major reservoirs, stream intakes, and ground water withdrawal locations in the county are listed in **Table 4-12a.** In addition to the Waller Mill Reservoir, the city also obtains water from a well and raw water purchases from Newport News Waterworks[46]. The Waller Mill Reservoir in York County, has a total storage capacity of 1.42 billion gallons with an estimated safe yield of 3.5 mgd[44]. The well has a pumping capacity of .72 mgd and is used primarily to feed the reservoir. The city owned and operated water treatment plant at Waller Mill Reservoir has a capacity of 7.0 mgd[46]. The City of Williamsburg also owns five storage facilities with a combined storage capacity of 3.5 million gallons[44]. **Table 4-12b** in Appendix A lists an historical record of water losses incurred by the Williamsburg Water Treatment Plant.

Table 4-12a YORK RIVER BASIN
CITY OF WILLIAMSBURG
MAJOR WATER WITHDRAWAL LOCATIONS - 1990

OPERATOR	CATEGORY	SOURCE	TYPE	1990 AVER. (MGD)
City of Williamsburg	Public water system	GW	Well	0.3413
City of Williamsburg	Public water system	SW	Reservoir	3.4983
Residential Subtotal				3.8396
COUNTY TOTAL				3.8396

Source: SWCB VWUDS, 1990.

4.13 SAFE YIELD CONCEPTS

To provide better capabilities to manage water resources during drought periods, Virginia has established regulations addressing the safe yield of a given water reserve. Safe yield is defined as "the quantity of water which may be withdrawn from a water source during some critical dry period without depleting the source"[18]. The Virginia Department of Health (VDH) defines safe yield for surface water as:

"The safe yield of the source should be determined as follows:

1. Simple intake (free flowing stream) - The safe yield is defined as the minimum withdrawal rate available during a day and recurring every 30 years (30-year 1-day low flow or 1Q30). To generate the report for this , a 50-year period of data is to be used. If actual gage records are not available for this, gages are to be correlated from similar watersheds and numbers are to be synthesized for the 50 year period.

2. Complex (impoundments in conjunction with streams) - The safe yield is defined as the minimum withdrawal rate available to withstand the worst drought of record in Virginia since 1930. If actual gage records are not available, correlation is to be made with a similar watershed and numbers are to be synthesized in order to develop the report." (VDH Water Works Regulations 8.02.01)

Calculating the safe yield of water reserves is limited by technology and availability of historical data and is essentially a best guess. It must compensate for losses due to evaporation, transmission loss, and seepage[18]. In their report for the Regional Raw Water Study Group (RRWSG) Malcolm Pirnie acknowledges that "safe yields are based on a management decision as to the reliability, confidence, and resiliency of the system to respond during critical dry periods and the level of risk willing to be accepted by the decision makers"[18].

The in depth 1991 study of Newport News Waterworks (NNW), completed by Malcolm Pirnie for the RRWSG, offers a thorough analysis of some of the shortcomings of traditional methods of calculating safe yield volumes. The study points out the following concerns:

> "To some, the term safe yield may imply that a system will always be able to provide this quantity. This is not the case. The safe yield is 100 percent certain only if: 1) No low flow periods occur in the future which are more extreme than those which occurred in the historic record, and 2) the maximum rated source pump capacities and transmission capacities are available when required"[18].

Neither of these statements can be acknowledged as absolute, so in fact there is some probability that safe yield estimates using the VHD criteria can not be guaranteed in any future year. The report goes on to point out:

- A 60-year hydrological record was used to determine the drought of record to estimate safe yield for Newport News Waterworks. However, a significant probability exists that a worse drought will occur in the future at a time when demand will be even greater.

- In the past, many reservoirs have been designed with about 10 percent of the reservoir volume reserved for dead storage. However, for operational and planning purposes, more than 10 percent of total reservoir storage should be reserved to:1) Protect environmental features including water quality, fisheries, wetlands, and recreational use; 2) allow for future reservoir volume losses through siltation.

- Future land development can deplete the volume of water available to current sources by disrupting overland runoff.

- NNW has experienced significant water quality problems in its reservoirs when they have been drawn down significantly primarily because reservoirs are excellent sinks for nonpoint pollution such as phosphorous, nitrates and sediments[18].

The cumulative effect of these concerns can have a significant impact on the actual volume of surface water consistently available to meet future demand. Derivations of these concerns also effect the availability and reliability of safe yield estimates for ground water reserves. In addition, since there is no accurate method for analyzing ground water resources, estimating the safe yield of ground water reserves is even more difficult[18]. Due to the high level of uncertainty regarding the volume and location of aquifers, jurisdictions are becoming hesitant to rely completely on ground water resources. This attitude is particular prevelant in the eastern portions of the YRB. In total these issues may suggest that more conservative estimates should be considered when quantifying the safe yield of regional water resources. Despite the limited capacity for accuracy, setting safe yields for water resources is an essential component of the equation involving water resource management. **Table 4-13** summarizes the current safe yields estimated for the jurisdictions of the YRB.

Table 4-13 YORK RIVER BASIN
ESTIMATED SAFE YIELDS OF EXISTING WATER SOURCES FOR YEAR 2000

JURISDICTION	WATER SOURCE	SAFE YIELD (MGD)	REFERENCE
Caroline County	Ground Water	0.388	SWCB
	Reservoir		
	Stream Intake		
Gloucester County	Ground Water	0.300	SWCB
	Reservoir	2.000	
Hanover County	Ground Water	2.870	SWCB
	Stream Intake	6.100	
James City County	Ground Water	6.910	RRWSG
	Transfer from NNW	7.000	
King William County	Ground Water	0.680	SWCB
King & Queen County	Ground Water	0.090	*
Louisa County	Ground Water	0.418	SWCB
	Reservoir	2.770	
New Kent County	Ground Water	0.042	*
Orange County	Ground Water	0.057	OCPC
	Stream Intake	2.000	
Spotsylvania County	Reservoir	4.000	SWCB HSMM
York County	Ground Water	0.650	RRWSG
	Transfer from NNW	6.000	
City of Williamsburg	Ground Water	0.720	RRWSG
	Reservoir	3.500	SWCB
	Transfer from NNW	5.000	RRWSG
TOTAL		51.495	

SWCB - State Water Control Board, 1988.

RRWSG - Malcolm Pirnie, Regional Raw Water Study Group, 1991.

HSMM - Hayes, Seay, Mattern & Mattern, Inc., 1989

OCPC - Orange County Planning Commission, 1990.

* - Ground water provides entire supply; extent of resource unknown. For estimating purposes 1990 demand was tripled due to the large amount of ground water available in aquifers.

4.14 EXISTING WATER SUPPLY: AREAS OF CONCERN

A variety of natural and anthropogenic factors can have a significant impact on the basin's available water supply (safe yield). Precipitation is the most critical natural factor. As the original source of all surface and ground water, prolonged periods of drought can diminish a water supply. The unpredictability of drought occurrence and longevity are difficult to plan for.

Another natural factor that must be acknowledged is supply distribution, which is primarily a function of the physical geography of the basin. Planning at the watershed scale recognizes that the "available supply" is not adequately distributed throughout the entire basin, whether it be surface or ground water. The amount of available supply is defined as the amount of long-term average water available for withdrawal[31]. Most often, calculations defining the total "available supply" of surface water are taken at or near the mouth of the basin[31]. The SWCB calculated the annual average water supply available in the York River to be 2049.73 mgd[46]. This available volume is used in their analysis of the basin for both the calendar year 1984 and 2030. USGS estimates for available ground water are 1.5 billion gallons per square mile in the Piedmont province, and higher yet in the Coastal Plain province[38]. However, these numbers represent average gross volumes based on estimated constants. The demand for water resources is an ever changing number subject to differing population densities and multiple withdrawal points throughout the YRB. Therefore, the sum of withdrawals, basin wide, could exceed the available supply at a given point in the watershed[46].

A brief analysis of various anthropogenic factors which have a significant impact on water, exposes other complexities involved with the protection of the region's water supply. Many of these complexities result from the fact that while water resources may have jurisdictional boundaries attached to them, the human impacts affecting water resources have no specific boundaries. Water supplies are susceptible to contamination from expanding land development. Pollution in a variety of forms from both point and nonpoint sources can contaminate both surface and ground water. Large ground water withdrawals from aquifers at West Point have resulted in a lowering of the water table causing cones of depression. These impacts are caused by human activities and typically have negative implications on water supply which are not localized. As a result of water quality problems and the possibility of overdrawing ground water resources, many communities may place a stronger emphasis on the development of surface water sources to meet future demand[38]. Because the migrating properties of water contamination and aquifer drawdown do not correspond to jurisdictional boundaries, efforts must be targeted to address these issues at a watershed scale.

Other issues which the YRB must consider include water storage technology, and inter-basin water transfers. Storage facilities and water distribution infrastructure must be improved, retrofitted, and maintained to minimize the amount of water loss (unaccounted for water) thereby increasing available supply. Controversies surrounding inter-basin water transfers continue to escalate often sending water projects to the courts to be resolved through costly litigation. Analysis and control of the "available supply" on a river basin scale can provide the foundation necessary for regional management regulations that will control inter-basin transfers.

5.0 WATER DEMAND

5.0 WATER DEMAND

This chapter summarizes information available on the demand for surface and ground water for the base year 1990 and several preceding years. Accurate monitoring and documentation of water consumption is essential to efforts aimed at improving methods for projecting future water demand. A critical factor that must be recognized throughout this report is the potential disparity caused by the differences between jurisdictional boundaries (county or city) and basin or watershed boundaries. Data within this report represents water demand totals for an entire jurisdiction (county or city) regardless of the where point of demand (withdrawal) recorded lies within the York River Basin. For consistency all water demand withdrawals presented in this chapter were obtained from the SWCB.

5.1 RAW WATER DEMAND

In March, 1982 the SWCB adopted "Regulation 11" requiring that all raw water withdrawals greater than 10,000 gallons per day (gpd) during the peak month be reported to the State[18]. In 1991 the State also began requiring all irrigation use greater than 1,000,000 gallons per month to be reported. Any ground water in excess of 300,000 gallons per month within a state designated Ground Water Management Area must also be permitted and recorded. The data presented in this chapter is based on these recordings which are compiled by the SWCB under the Virginia Water Use Data System (VWUDS)[18]. Inferences have also been derived from the *York Water Supply Plan (Planning Bulletin 343)* and the James Water Supply Plan (Planning Bulletin 337) published by the SWCB in 1988.

The following tables summarize annual raw water withdrawals recorded by the SWCB throughout the York River Basin for the years 1982, 1984, 1986, 1988, and 1990. In 1990, an average of 107.757 million gallons per day (mgd) were withdrawn for residential, commercial, industrial, manufacturing, mining, and institutional uses. This excludes 2.319 mgd exported to the Rappahannock River Basin, and cooling water for thermoelectric power generation which amounted to 2829.282 mgd. Approximately 79 percent of the 1990 demand relied on surface water and the remaining 21 percent utilized ground water. **Table 5-1** provides figures for total annual withdrawal of both surface and ground water by jurisdiction as recorded by the SWCB.

Table 5-2 outlines total annual water withdrawal by land use within each jurisdiction recorded by the SWCB. The Virginia Power plants in Louisa and York County are the largest individual users of water in the YRB. As a result, the Heavy Industry category places the largest demand on water resources in the YRB. This type of land use required 96.71 mgd or approximately 90 percent of the total 1990 demand.

As discussed in Chapter 4, water was supplied by a variety of systems, purveyors, and sources. **Table 5-3** indicates that about half of the overall water demand was provided by self-supplied sources (wells) and the other half was provided by a public system or private company.

Table 5-1 YORK RIVER BASIN
AVERAGE ANNUAL WATER WITHDRAWALS - GROUND WATER (GW) & SURFACE WATER (SW) (MGD)

JURISDICTION	1982		1984		1986		1988		1990		1990	PERCENT OF
	GW	SW	GW	SW	GW	SW	GW	SW	GW	SW	GW+SW	1990 TOTAL
Caroline County	0.182	0.058	0.207	0.688	0.294	0.000	0.374	0.101	0.514	0.744	1.258	1.17%
Gloucester County	0.291	-	-	-	-	-	-	-	0.214	-	0.214	0.20%
Hanover County	0.249	4.750	0.295	3.440	0.321	16.720	0.361	17.350	0.436	18.910	19.346	17.95%
James City County	0.052	-	0.050	-	0.051	-	1.741	-	1.756	-	1.756	1.63%
King & Queen Cou	-	-	0.021	-	0.011	-	0.016	-	0.015	-	0.015	0.01%
King William Count	14.280	-	14.800	-	17.690	0.009	15.960	-	18.720	0.002	18.722	17.37%
Louisa County	0.250	0.008	0.283	0.050	0.175	0.209	0.189	0.214	0.257	0.155	0.412	0.38%
New Kent County	-	-	-	-	0.011	-	0.006	-	0.014	-	0.014	0.01%
Orange County	-	-	-	-	-	-	-	-	0.019	-	0.019	0.02%
Spotsylvania Count	0.077	1.600	0.032	1.860	0.027	2.270	0.102	2.050	0.074		0.074	0.07%
York County	0.046	0.161	0.072	0.233	0.105	0.105	0.074	66.730	0.108	61.980	62.088	57.62%
Williamsburg	-	3.087	-	3.156	0.173	3.668	0.266	3.280	0.341	3.498	3.839	3.56%
SUBTOTALS	15.427	9.664	15.760	9.427	18.858	22.981	19.089	89.725	22.468	85.289	107.757	
PERCENT OF TOT	61.48%	38.52%	62.57%	37.43%	45.07%	54.93%	17.54%	82.46%	20.85%	79.15%	100.00%	100.00%

MISCELLANEOUS WITHDRAWALS

	1982	1984	1986	1988	1990
Louisa County (1)	1654.488	134.870	1847.751	2066.575	2064.110
Spotsylvania County (2)	1.600	1.863	2.268	2.046	2.319
York County (1)	632.150	655.000	783.918	1134.119	765.172
SUBTOTALS	2288.238	791.733	2633.937	3202.740	2831.601

	1982 GW	1982 SW	1984 GW	1984 SW	1986 GW	1986 SW	1988 GW	1988 SW	1990 GW	1990 SW	1990 GW+SW
PLANNING AREA GRAND TOTALS	15.427	2297.902	15.760	801.160	18.858	2656.918	19.089	3292.465	22.468	2916.890	2939.359

(1) - Figures represent Virginia Power Plant withdrawals in Louisa and York County. Water is considered non-consumptive because water is only used for cooling and is returned to source.
(2) - Water is withdrawn from the Ni Reservoir and transferred to the Rappahannock River Basin.

Source: SWCB (VWUDS), 1990.

Table 5-2 YORK RIVER BASIN
AVERAGE ANNUAL WATER (SURFACE AND GROUND) WITHDRAWALS
BY LAND USE (MGD)

JURISDICTION	1982	1984	1986	1988	1990
Caroline County					
Residential	0.144	0.150	0.222	0.391	0.669
Comm/Inst/L. Industry	0.038	0.066	0.072	0.084	0.240
Heavy Industrial	0.058	0.688			0.349
Gloucester County					
Residential					0.214
Hanover County					
Residential	3.526	2.402	2.682	3.095	3.099
Comm/Inst/L. Industry	0.040	0.041	0.093	0.111	0.125
Heavy Industrial	1.435	1.298	14.268	14.508	16.118
James City County					
Residential	0.052	0.050	0.051	1.741	1.756
King & Queen County					
Residential		0.021	0.011	0.016	0.015
King William County					
Residential	0.376	0.376	0.391	0.441	0.421
Comm/Inst/L. Industry	13.902	14.420	17.304	0.006	0.009
Heavy Industrial				15.512	18.292
Louisa County					
Residential	0.215	0.249	0.293	0.302	0.297
Comm/Inst/L. Industry	0.043	0.028	0.024	0.031	0.040
Heavy Industrial		0.055	0.065	0.070	0.075
Power Generation/Other	1654.488	1340.870	1847.751	2066.575	2064.110
New Kent County					
Residential			0.011	0.006	0.014
Orange County					
Residential					0.019
Spotsylvania County					
Residential	0.016	0.010	0.012	0.021	0.011
Comm/Inst/L. Industry	0.061	0.022	0.015	0.081	0.063
Power Generation/Other	1.600	1.863	2.268	2.046	2.319
York County					
Residential	0.046	0.267	0.149	0.152	0.154
Comm/Inst/L. Industry		0.038	0.061	0.042	0.057
Heavy Industrial				66.653	61.877
Power Generation/Other	623.150	655.000	783.918	1134.119	765.172
Williamsburg					
Residential	3.087	3.156	3.841	3.506	3.840
TOTALS	2302.277	2021.070	2673.502	3309.508	2939.355

Source: SWCB (VWUDS), 1990

Table 5-3 YORK RIVER BASIN - 1990
PERCENTAGE OF HOUSING UNITS SERVED BY CENTRALLY SUPPLIED SYSTEM

JURISDICTION	TOTAL HOUSING UNITS	HOUSING UNITS ON CENTRAL SYSTEM	NET PERCENTAGE SERVED BY CENTRAL SYSTEM
Caroline County	7,292	1,937	26.56%
Gloucester County	12,451	1,897	15.24%
Hanover County	23,727	11,614	48.95%
James City County	14,330	10,799	75.36%
King & Queen County	2,698	98	3.63%
King William County	4,193	1,200	28.62%
Louisa County	9,080	1,259	13.87%
New Kent County	3,968	1,018	25.66%
Orange County	9,038	4,186	46.32%
Spotsylvania County	20,483	11,480	56.05%
York County	15,284	13,453	88.02%
City of Williamsburg	3,960	3,915	98.86%
TOTALS	126,504	62,856	49.69%

Source: U.S. Bureau of the Census, 1990 Census of Population and Housing

5.2 AREAS OF CONCERN

Comprehensive monitoring and documentation of water use on a continual basis is critical to the development of an effective water management plan. The techniques used for determining water use and the availability of data have a direct impact on the planning methods used to project future water resource demand. Consistent methodology is necessary for the collection, processing, and storage of water consumption data. The current breakdown of surface and ground water use by volume, location, and land use type provided by the SWCB is vital to efforts aimed at projecting future water use. The newly adopted regulation by the SWCB requiring large scale irrigation use to be reported is an appropriate measure in the right step.

The York and James Water Supply Plans compiled by the SWCB, focus their analysis on water system withdrawals using over 300,000 gallons per month[46]. Monitoring and documenting all water use throughout the YRB is difficult and can become cost prohibitive. Furthermore, current methods for metering commercial and multi-family residential development vary throughout the YRB. However, strengthening regulations to require a broader approach to water use monitoring and better accountability of unaccounted-for water will provide an expanded data base which will improve methods for water planning and management. Expanded monitoring and documentation of water quality and flow levels through the addition of stream gauges should also be considered as the demand increases along the major tributaries in the basin.

Water resource planners and managers also need to consider developing predictive strategies aimed at projecting the rate and scale at which future residential users become incorporated into centrally supplied water systems. Given the rural nature of the YRB and the fact that approximately 50 percent of the residents obtain water from centrally supplied systems. Thus a significant portion of water use is not being recorded as part of the overall supply and demand equation. Expanding publicly supplied water service to meet future demand can result in improved management of ground and surface water resources. However, expanding public water service will involve a number of significant issues at the local and regional level. As population continues to grow and spread throughout the YRB, the economic, political and environmental costs of water supply and delivery will increase.

6.0 PROJECTIONS: POPULATION TRENDS AND WATER DEMAND

6.0 PROJECTIONS: POPULATION TRENDS AND WATER DEMAND

Effective planning and management of water resources is largely dependent on the acceptance of reliable methodology used to predict population growth and future water demand. This chapter summarizes population trends and water demand projections of the York River Basin for the planning period 1990 to 2030. A number of miscellaneous issues which should be considered when developing methodology for population and future water demand projections are also discussed.

6.1 POPULATION PROJECTIONS

Projecting population growth rates and distribution within the YRB is recognized as one of the most critical steps in the development of a long term plan for the effective management of water demand. A brief review of population statistics throughout the YRB indicates a continuos linear pattern of growth for all jurisdictions during the planning period. The growth rate of the YRB is expected to exceed that of the state over the next 40 year period. Based on figures from the U.S. Bureau of the Census, the 1990 population for the watershed was 328,261. This number includes the total population of all jurisdictions in the York River Basin regardless of the portion of the jurisdiction occurring within the watershed. (For an in depth analysis of population trends on a county by county basis refer to *York River Watershed: Economic Analysis.*)

Table 6-1 provides a comparison of population projections to the year 2030 completed by the State Water Control Board (SWCB), and the Virginia Employment Commission (VEC). The figures from both sources predict that the YRB will out pace state growth rates over the next three decades. Regional growth rates for the YRB are projected to exceed 10 percent each decade of the planning period. Furthermore, over the next 40 years, the

Table 6-1 YORK RIVER BASIN
POPULATION PROJECTIONS FOR THE YORK RIVER BASIN - 1990-2030

		2000	2010		2020		2030	
JURISDICTION	1990(a)	VEC	VEC	SWCB	VEC	SWCB	VEC	SWCB
Caroline County	19,217	20,503	21,702	26,800	22,901	29,000	24,100	31,200
Gloucester County	30,131	39,042	46,049	35,700	53,056	39,600	60,063	43,500
Hanover County	63,306	77,978	93,491	78,000	109,004	84,000	124,517	90,000
James City County	34,859	44,273	54,004	32,300	63,735	34,100	73,466	35,900
King & Queen County	6,289	6,696	6,997	7,200	7,298	7,500	7,599	7,800
King William County	10,913	12,686	14,127	13,600	15,568	14,500	17,009	15,400
Louisa County	20,325	22,591	24,409	25,600	26,227	27,700	28,045	29,800
New Kent County	10,445	12,597	14,533	17,100	16,469	19,000	18,405	20,900
Orange County	21,421	24,407	27,009	27,800	29,611	30,000	32,213	32,200
Spotsylvania County	57,403	76,002	89,004	81,300	102,006	93,000	115,008	104,700
York County	42,422	49,494	56,000	51,000	62,506	54,100	69,012	57,200
City of Williamsburg	11,530	12,564	13,221	11,600	13,878	12,000	14,535	12,400
REGION TOTALS	328,261	398,833	460,546	408,000	522,259	444,500	583,972	481,000

(a) - U.S. Bureau of the Census, 1990 Census of Population and Housing

VEC - Virginia Employment Commission Population Projections 2010, 1993

SWCB - State Water Control Board, 1988

equivalent rate of growth for the entire Basin is estimated to be 78 percent. All of the jurisdictions except Caroline, Louisa, King & Queen, and the City of Williamsburg are predicted to experience at least a 10 percent or greater rate of growth over each of the next three decades. A detailed breakdown of future population growth rates for the jurisdictions in the YRB are shown in **Table 6-2**. The VEC has projected a basin wide population of 583,972 by the year 2030, as compared to the 481,000 SWCB projection. As indicated by these figures it is readily apparent that population projections can vary greatly from source to source.

6.2 POPULATION PROJECTION ISSUES

Future water demands facing any jurisdiction are determined by population growth and distribution. As coastal regions continue to experience growth, jurisdictions will be faced with planning for and providing the public service demands generated by new businesses and residents. Methods for predicting future population growth and distribution are often inconsistent due to numerous variables that must be taken into account. During the data collection phase of this report it became apparent that for any given area, population projections varied widely from publication to publication. As an illustration, certain jurisdictions cited their disagreement with population projections developed by state agencies as a specific reason for not approving the 1988 SWCB York and James Water Supply Plan reports[46]. Furthermore, the longer time period population projections attempt to cover, the more potential there exists for error.

A variety of methodologies can be used to determine population projections, each of which may provide a different result. In the Lower Virginia Peninsula Regional Raw Water

Table 6-2 YORK RIVER BASIN
FUTURE POPULATION GROWTH RATES -- 1990-2030

JURISDICTION	1990-2000	2000-2010	2010-2020	2020-2030	1990-2030
Caroline County	0.07	0.06	0.06	0.05	0.25
Gloucester Count	0.30	0.18	0.15	0.13	0.99
Hanover County	0.23	0.20	0.17	0.14	0.97
James City Count	0.27	0.22	0.18	0.15	1.11
King & Queen Co	0.06	0.04	0.04	0.04	0.21
King William Cou	0.16	0.11	0.10	0.09	0.56
Louisa County	0.11	0.08	0.07	0.07	0.38
New Kent County	0.21	0.15	0.13	0.12	0.76
Orange County	0.14	0.11	0.10	0.09	0.50
Spotsylvania Cou	0.32	0.17	0.15	0.13	1.00
York County	0.17	0.13	0.12	0.10	0.63
Williamsburg	0.09	0.05	0.05	0.05	0.26
REGION	**0.21**	**0.15**	**0.13**	**0.12**	**0.78**
VIRGINIA	**0.11**	**0.08**	**0.07**	**0.07**	**0.38**

Source: Calculated from VEC projections shown in Table 6-1

Supply Plan 1990-2040 (1991), the Regional Raw Water Study Group described four possible projection techniques:

- Comparative Population Ratio Model: This model asserts that the population growth that takes place within a community is highly dependent on what happens to the population within the surrounding community.

- Linear Projection Model: This method accepts the assumption that past growth trends will continue in a similar straight line fashion.

- Comparative Employment Ratio Model: This model asserts that there is a dependent relationship between the population of the community and the employment and labor force characteristics of its residents.

- Virginia Population Projections, 2010: These projections were developed and published by the Virginia State Data Center of the Virginia Employment Commission. This method uses a cohort component which evaluates birth, death, and migration rates. The projections from the Year 2010 to the Year 2030 are a linear extension of the 2000 through 2010 data.

On a broader scale regional characteristics can have a significant impact on estimating future population projections. Issues of specific concern in developing projections for the YRB include:

- Coastal regions, which most of the YRB is defined as, are experiencing some of the fastest growth rates in the entire nation.

- Faced with future cuts in the national defense budget, Federal military installations and their support services may not be as strong of an employment magnet for the eastern portions of the YRB as they traditionally have been.

- The Chesapeake Bay Preservation Act may also begin to reduce the rate and amount of development in some of the coastal counties which could alter the population distribution.

- Between 1980 and 1990 various indicators show a continual increase in residential growth, and a decrease in agricultural and forested lands. If the needs of future populations perpetuate this trend, water demand rates could be significantly altered in both time and location.

To contend with these complex issues, consistent methods for predicting growth and development are necessary. Planning for the effective management water supply and demand is in large part dependent on the accuracy, consistency, and acceptance of local and regional population projections. Coordinating and sharing of information at all levels of government is necessary to initiate techniques to develop watershed scale population projections. The relationships between population growth and distribution must be analyzed in greater detail at the watershed scale. This will provide better identification of potential conflicts between upstream and downstream users within the YRB. More importantly, it will provide valuable information necessary for predicting relationships between future water demands and the carrying capacity of water resources on a basin by basin scale. This is not a simplistic task for it would also require an approach to analyzing and predicting land use trends at a regional level.

6.3 WATER DEMAND PROJECTION ISSUES

There are a variety of other variables that must be analyzed when attempting to improve the accuracy of projecting future water demand. Irrigation and unaccounted-for water (UAW) losses in rural areas are two factors of particular importance. Irrigation for agriculture and golf courses, and unaccounted-for water should be included in future demand projections.

Between 1962 and 1982 the acreage of large scale irrigation use in Virginia increased by more than 150 percent[29]. Given the importance of agriculture throughout the YRB the potential for large volumes of water use for irrigation is significant. This burden of meeting this potential demand will fall primarily on surface water sources such as the Mattaponi and Pamunkey Rivers. An expansion of riparian-based irrigation could lead to water shortages during drought periods in some areas[41]. Both agricultural and golf course irrigation create a critical conflict for water management since their peak demand periods coincide with prolonged drought periods. Thus, implementing requirements for monitoring, documenting and estimating water use for large scale irrigation would improve the accuracy of calculating water demand in the YRB.

Prior to 1991 water use for agricultural purposes was exempt from reporting the amount of withdrawal to the SWCB. As a result, little empirical evidence is available to analyze irrigation use in the YRB. Estimating the quantity of water used for irrigation is complicated by several variable factors including acreage irrigated, water volume applied, the type of crop, and the type of irrigation system used[46]. Based on data compiled by the SWCB, **Table 6-3** provides a rough estimate of the potential demand for irrigation water in the YRB.

Table 6-3

SWCB Estimated Irrigation Water Demands in the York River Basin

YEAR	AGRICULTURAL IRRIGATION (MGD)(a)
1990	4.844
2000	6.512
2010	8.180
2020	8.180
2030	8.180

(a) Based on application rate of 8" of water per year.
Source: SWCB, York and James Water Supply Plan, 1988.

For simplicity these figures are considered typical for a normal rainfall year. Furthermore, for the purposes of this report it was assumed that the demand for agricultural irrigation would stabilize by the year 2010 due to limitations on available agricultural land. While it is acknowledged that a these figures are subjected to a great number of variables, the gross volume of demand indicates that water for irrigation use could result in significant quantities. It should be recognized however, that irrigation use may decline in counties which experience the greatest growth as agricultural land is lost to accommodate development. Further studies are necessary to improve predictions concerning the impact of future irrigation use on the water resources of the YRB.

Water losses are caused by a variety of factors in all water supply systems. System age, operating pressures, metering inaccuracies, leakage, unaccounted-for water usage, and spillage are some of the most significant examples of unaccounted-for water[18]. Unaccounted-for water is typically defined as the difference between a water utility's finished water production and all metered water usage[18]. Estimates of UAW vary from the national average of 11.4 percent to 5 percent reported by James City County[18]. To define an approximate quantity of unaccounted-for water, this report has adopted a straight average of these two figures which is approximately 8 percent. For the purposes of this report it is assumed that this percentage of unaccounted-for water will not increase over the life of the planning period due to improved technology and management of water distribution. Allowing a water loss rate cushion of more than 8 percent creates an unnecessary attitude of justifying greater losses before they occur. **Table 6-4** itemizes UAW based on the projected demand for each decade. By 2030 it is estimated that UAW could possibly be as high as 14.447 mgd - a significant volume of water.

Another variable affecting water demand which is becoming increasingly controversial in Virginia is inter-basin water transfers. As population centers, both urban and rural, outside of the watershed continue to grow they may look to the water resources of the YRB to meet some of their needs. Numerous proposals have recently been studied involving water transfers from various tributaries in the YRB to jurisdictions outside of the YRB. Most of these would require the construction of a reservoir within the YRB and the subsequent delivery of water to users outside of the watershed.

Table 6-4 YORK RIVER BASIN
PRESENT (1990) AND FUTURE WATER DEMAND PROJECTIONS -- 1990-2030 (MGD)

DEMAND CATEGORY	1990	2000		2010		2020		2030	
		65 gpcpd	100 gpcpd	65 gpcpd	100 gpcpd	65 gpcpd	100 gpcpd	65 gpcpd	100 gpcpd
Residential (a)(b)	10.509	15.555	23.930	20.955	32.238	27.157	41.781	34.162	52.557
Comm/Inst/Light Ind (a)	0.535	0.647	0.647	0.744	0.744	0.841	0.841	0.942	0.942
Heavy Industry (c)	96.710	101.546	101.546	106.623	106.623	111.954	111.954	117.552	117.552
Federal Installations (d)	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740
Estimated Irrigation (e)	4.840	6.510	6.510	8.180	8.180	8.180	8.180	8.180	8.180
SUBTOTAL	113.334	124.998	133.373	137.242	148.525	148.872	163.496	161.576	179.971
Unaccounted-for Water	9.067	10.000	10.670	10.979	11.882	11.910	13.080	12.926	14.398
Water Basin Transfers	2.319	2.500	2.500	4.000	4.000	4.000	4.000	4.000	4.000
TOTAL DEMAND	124.720	137.498	146.543	152.222	164.407	164.782	180.576	178.502	198.368
Power Generation	2829.280		2829.280		2829.280		2829.280		2829.280

(a) - 1990 demand derived from Table 5-2.
(b) - Demand for yrs. 2000-2030 based on adopted population figures from Table 6-5; 10% increase in population served each decade
(c) - 1990 demand derived from Table 6-6; estimated 5% increase in water use each decade.
(d) - Source: Malcolm Pirnie, RRWSG, 1991.
(e) - Derived from Table 6-3.
(f) - Estimated at 8.0% of the Subtotal Demand for each decade.
(g) - Water is withdrawn from the Ni Reservoir and Transferred to Rappahanock River Basin, SWCB 1988.

As **Table 6-5** shows, the recent water source alternatives which are receiving the most serious attention include:

Table 6-5

WATER SOURCE ALTERNATIVE	PROPOSED LOCATION	ESTIMATED SAFE YIELD SOUGHT FOR TRANSFER
Ware Creek Reservoir w/ Pumpover from Pamunkey	James City County	24.1 mgd
Black Creek Reservoir w/ Pumpover from Pamunkey	New Kent County	21.3 mgd
King William Reservoir w/ Pumpover from Mattaponi	King William County	26.4 mgd

Source: Malcolm Pirnie, Regional Raw Water Study Group, 1993.

These alternatives have been identified by the RRWSG as practicable options to meet the projected water demands of the Lower York-James Peninsula through the year 2040. While a portion of the safe yield noted would be allocated to meet the future needs of York County, James City County, Williamsburg, and King William or New Kent County, the majority of this water would be transported outside of the YRB to meet the future needs of the growing Newport News area. Inter-basin water transfers must be recognized as part of the overall supply and demand equation at the watershed scale. Legislative changes would need to be considered to improve the effectiveness of watershed based planning and control the management of inter-basin water transfers.

6.4 WATER DEMAND PROJECTIONS

The final variable that must be determined in the water supply and demand equation is the volume of water needed by the projected population growth. During the data collection and analysis phase of this report it became clear that numerous different methods have been developed to determine water demand projections. Each method established its own set of assumptions, however, most methods attempted to utilize historical records of water use to define differences in consumption based on different user groups. Different user groups might include residential, commercial, industrial, power generation, and federal installations. For obvious reasons these user groups experience different growth rates, and require different quantities of water use. The following list adopted from Malcolm Pirnie's 1991 report for the RRWSG differentiates the demand characteristics of the user groups:

- Residential: This is the water demand of the general population living in the areas served.

- Commercial, Institutional, and Light Industrial: This is the water demand created by employment at the work place in the jurisdictions served. This category also includes light industrial establishments whose water use is similar to commercial demands, with little to no process water usage. For the purposes of this study this would include the commercial/institutional, mining, and manufacturing categories used in the SWCB Virginia Water Use Data System (VWUDS).

- Heavy Industrial: Distinctions between Light Industry and Heavy are related to the intensity of the business. Heavy Industrial users are water intensive users.

- Federal Installations: This is the demand imposed by Federal installations. It covers demand for installations serviced by a master meter and includes all uses at these locations, regardless of usage category[18].

- Power Generation: For the purposes of this report, this includes all power generation categories used in the SWCB VWUDS. However, because this water is recircualted through the power plant and back to the reservoir, this demand is considered non-consupmtive and thus is not included as a fugure in the total water demand summary.

Irrigation and unaccounted-for water (UAW) are two other categories contributing to water demand which have already been analyzed.

Comprehensive water conservation programs can also have a significant impact on water demand projections. However, data related to the potential volume of water conserved is not readily available for the variety of water conservation programs in use throughout the nation. As a result this report does not incorporate possible yields obtained from water conservation measures into the water supply and demand equation.

The water demand projections for the YRB are presented in **Table 6-4** and disaggregated into eight major demand categories: Residential, Commercial/Institutional/Light Industrial, Heavy Industry, Federal Installations, Estimated Irrigation, Unaccounted-for Water (UAW), Water Basin Transfers, and Power Generation. All water use values presented are based on average day demands. The following list describes the various assumptions used to determine the aggregate water demand presented in **Table 6-4**:

1. Residential: Residential demand is based on regional population figures and the percentage of that population estimated to be served by a central water system. As previously indicated in **Table 5-3**, approximately 50 percent of the YRB is serviced by a publicly supplied water system. For the purposes of this report it was asssumed that an additional 10 percent of the regional population each decade would be provided water through a centrally supplied system. Thus by the year 2030, 90 percent of the YRB population would be provided residential water as a public service. **Table 6-6** provides the adopted population figures used to calculate the projected residential water demand shown in **Table 6-4**.

   In **Table 6-4** two different consumption rates were used to calculate demand - 65 gallons per capita per day (gpcpd) and 100 gpcpd. Due to the rural nature of the YRB and that a significant portion of the population is on private water wells, rates of consumption vary significantly from one locale to another. Consequently, for the purposes of this study,the selection of one value for a gallons per capita per day use could be somewhat misleading. The lower value of 65 gpcpd is representative of water consumption habits involving comprehensive water conservation measures[1]. Determing a high and low range of residential demand provides an opportunity for planning strategies to consider a best and worst case scenario.

2. Commercial/Institutional/Light Industrial: As a residual category, for the purposes of this report it includes the commercial/institutional, and any mining, manufacturing, or power generation withdrawals under 50,000 gallons per day listed in the SWCB Virginia Water Use Data System (VWUDS). The demand from this category is essentially the most difficult to calculate. Water consumption rates can vary greatly among these different users. Projecting the growth rate and distribution of these types of user groups is also difficult. As a result this report assumes that commercial employment will increase in direct proportion to the civilian population. Using the regional growth rates from **Table 6-2**, the 1990 demand for this category was increased by the population growth rate corresponding to each successive decade.

3. Heavy Industrial: For the purposes of this report, this category includes any mining, manufacturing, or power generation withdrawals over 50,000 gallons per day listed in the SWCB Virginia Water Use Data System (VWUDS). The total withdrawals are listed in **Table 6-7** and do not include power generation withdrawals considered non-consumptive (See No. 8 Power Generation Category below).

   This category also is subject to wide variability in terms of gallons per day consumption. As a result a linear projection was chosen to provide estimates for the potential demand of heavy industrial users. In **Table 6-4** Heavy Industrial demand is estimated to increase 5 percent each decade using the total demand in 1990 as the base figure.

4. Federal Installations: The 1990 water demand of federal facilities in York County and Williamsburg totaled .74 mgd based on Malcolm Pirnie's 1991 report[18]. This figure was held constant throughout the planning period based on the fact that these federal facilities do not anticipate expansion in the future.

5. Estimated Irrigation: Calculations for projecting agricultural irrigation demand were discussed in 6.3 of this report (**See Table 6-3**). For the purposes of this report it was assumed that the demand for agricultural irrigation would stabilize by the year 2010 due to limitations on available agricultural land.

6. Unaccounted-for Water: Calculations for projecting UAW were discussed in 6.3 of this report. Eight percent of the estimated total demand each decade was utilized during the entire planning period.

7. Water Basin Transfers: Various localities in the Rappahannock River Basin have contracted with Spotsylvania County to transfer water from the Ni Reservoir throughout the entire planning period. The 1990 demand was

recorded by the SWCB. The subsequent years are based on projections listed by the SWCB.

8. Power Generation: In 1990 the SWCB recorded 2829.28 mgd of withdrawal for power generation in the YRB. This demand was held constant for the duration of the planning period. Due to the fact that 99 percent of this water use is considered non-consumptive, the quantity is listed seperately from the total regional demand.

Table 6-6 YORK RIVER BASIN
ADOPTED PROJECTIONS: REGIONAL TOTAL POPULATIONS AND PERCENTAGE OF POPULATION SERVED BY CENTRAL WATER SYSTEM - 1990-2030

CATEGORY	REGIONAL POPULATION PROJECTIONS	ADOPTED REGIONAL POPULATION PROJECTIONS	CATEGORY
1990 Population	328,261	164,131	50% of 1990 Population served by central system
2000 Population	398833	239299.8	60% of 2000 Population served by central system
2010 Population	460546	322382.2	70% of 2010 Population served by central system
2020 Population	522259	417807.2	80% of 2020 Population served by central system
2030 Population	583972	525574.8	90% of 2030 Population served by central system

(a) -- Source: U.S. Bureau of the Census, 1990 Census of Population and Housing.
(b) -- Source: VEC Population Projections 2010, 1993.

Table 6-7 YORK RIVER BASIN
HEAVY INDUSTRIAL WATER DEMAND (>50,000 g/d) - 1990 (mgd)

OPERATOR	CATEGORY	SOURCE	TYPE	1990 AVER. (MGD)
CAROLINE COUNTY				
Smith Sand & Gravel	Mining	SW	Stream Intake	0.3486
Heavy Industrial				0.3486
HANOVER COUNTY				
Bear Island Paper Co.	Manufacturing	SW	Reservoir	0.9946
Bear Island Paper Co.	Manufacturing	SW	SR	0.4624
General Crushed Stone Co.	Mining	SW	SR	0.0049
General Crushed Stone Co.	Mining	SW	Reservoir	0.2558
Feldspar Corporation	Mining	GW	Well	0.0003
Feldspar Corporation	Mining	SW	Reservoir	14.3999
Heavy Industrial				16.1179
KING WILLIAM COUNTY				
Chesapeake Corp. of VA	Manufacturing	GW	Well	0.4191
Chesapeake Corp. of VA	Manufacturing	GW	Well	2.0191
Chesapeake Corp. of VA	Manufacturing	GW	Well	1.0986
Chesapeake Corp. of VA	Manufacturing	GW	Well	1.5059
Chesapeake Corp. of VA	Manufacturing	GW	Well	1.2
Chesapeake Corp. of VA	Manufacturing	GW	Well	2.2082
Chesapeake Corp. of VA	Manufacturing	GW	Well	0.7315
Chesapeake Corp. of VA	Manufacturing	GW	Well	1.7123
Chesapeake Corp. of VA	Manufacturing	GW	Well	2.0794
Chesapeake Corp. of VA	Manufacturing	GW	Well	1.063
Chesapeake Corp. of VA	Manufacturing	GW	Well	0.6301
Chesapeake Corp. of VA	Manufacturing	GW	Well	1.663
Chesapeake Corp. of VA	Manufacturing	GW	Well	1.7123
Chesapeake Corp. of VA	Manufacturing	GW	Well	0.2493
Heavy Industrial				18.2918
LOUISA COUNTY				
Kloeckner-Pentaplast America	Manufacturing	GW	Well	0
Kloeckner-Pentaplast America	Manufacturing	GW	Well	0.0673
Kloeckner-Pentaplast America	Manufacturing	GW	Well	0.0073
Kloeckner-Pentaplast America	Manufacturing	SW	Reservoir	0
Heavy Industrial				0.0746
YORK COUNTY				
Amoco Oil	Manufacturing	SW	SR	61.8772
Heavy Industrial				61.8772
REGION TOTAL				96.7101

Source: SWCB VWUDS, 1990; totals derived from Chapter 4.

7.0 YORK RIVER BASIN SUMMARY

7.0 YORK RIVER BASIN SUMMARY

This chapter summarizes the relationships between and variables associated with estimating population growth, water demand, and water supply for the entire YRB. The information presented in Chapter 5 and Chapter 6 are aggregated for the entire planning region (YRB) to contrast projected water demand with available supply. Potential problems and issues affecting planning methodologies used for projecting the future use of water resources in the YRB are also discussed. These issues suggest the need for pursuing alternative methods to managing water supply and demand which are discussed in more detail in Chapter 8.

7.1 GENERAL ASSUMPTIONS

Chapter 4 through Chapter 6 pointed out that a number of parameters affect each of three main variables - safe yield, water demand, and population growth - used in the equation to project the potential of a future water deficit occurring. These parameters are further complicated by attempting to expand planning methodologies at a watershed scale. During the data collection and analysis phase of this project it was evident that a number of different methodologies were used to calculate safe yield, water demand, and population growth within the region. Each methodology incorporated different assumptions which altered the outcome of these three main variables.

A number of assumptions were also made in this report to develop water demand projections as discussed in Chapter 6. The assumptions made attempted to simplify safe yield, water demand, and population projections in aggregate form using primarily linear projections. This was explained in Chapter 6 in greater detail for **Tables 6-4** and **6-6.**

The summaries presented in **Tables 6-4, 6-6, 7-1** and **7-2** were computed at the watershed scale to show that taken collectively the potential for demand placed on the fixed water resources of the YRB could result in significant deficits over the next forty years. The summation of the existing supply and projected demand for all jurisdictions in the YRB makes the assumption that the worst case conditions could occur simultaneously. This is a reasonable assumption given the interrelationships of watershed hydrology and the basic acceptance that the region will experience positive growth rates. This assumption applies to estimates of peak demand, due to the fact that a severe drought would most likely impact the entire YRB at the same time.

Parameters affecting population projections must also be considered. The utilization of regional population totals projected by the VEC depicts the case scenario for growth and consequently water demand because their figures are higher than those projected by the SWCB (**Table 6-1**). Furthermore, the jurisdictions will differ in their volume and rate of growth and thus demand will vary in time and scale over the course of the planning period. Closely related to this concern is the rate at which the jurisdictions are able to incorporate future growth into centrally supplied water systems (**Table 6-6**). The rate at which the growing population is connected to public water service has a significant impact on planning for future water demands. With these basic parameters established there are various concerns relevant to supply and demand totals which require consideration.

7.2 QUALIFYING AND QUANTIFYING SUPPLY TOTALS

In **Table 7-1** four different scenarios are presented to project a potential water deficit for the YRB over the next forty years. Three different supply values were utilized to create these different years. Three different supply values were utilized to create these different

Table 7-1 YORK RIVER BASIN
COMPARISON BETWEEN REGIONAL WATER DEMAND PROJECTIONS
AND AVAILABLE SUPPLY - 2000-2030 SCENARIOS A & B (MGD)

A	SUPPLY	DEMAND	DEFICIT	SUPPLY	DEMAND	DEFICIT
YEAR	ESTIMATED SAFE YIELD (a)	ANNUAL AVG. DEMAND (b)	SURPLUS OR (DEFICIT)	ESTIMATED SAFE YIELD (a)	ANNUAL AVG. DEMAND (c)	SURPLUS OR DEFICIT
2000	51.495	137.498	-86.003	51.495	146.543	-95.048
2010	51.495	152.222	-100.727	51.495	164.407	-112.912
2020	51.495	164.782	-113.287	51.495	180.576	-129.081
2030	51.495	178.502	-127.007	51.495	198.368	-146.873

B YEAR	DROUGHT SUPPLY (d) (1Q30 L.F.)	ANNUAL AVG. DEMAND (b)	SURPLUS OR (DEFICIT)	DROUGHT SUPPLY (d) (1Q30 L.F.)	ANNUAL AVG. DEMAND (c)	SURPLUS OR DEFICIT
2000	29.45	137.498	-108.048	29.45	146.543	-117.093
2010	29.45	152.222	-122.772	29.45	164.407	-134.957
2020	29.45	164.782	-135.332	29.45	180.576	-151.126
2030	29.45	178.502	-149.052	29.45	198.368	-168.918

(a) - Derived from Table 4-13.
(b) - Derived from Table 6-4, using 65 gpcpd for residential demand.
(c) - Derived from Table 6-4, using 100 gpcpd for residential demand.
(d) - Source: SWCB, York Water Supply Plan, 1988.
(e) - Peak demand is estimated to be 1.5 times the Annual Average Demand for each decade.

Table 7-1 YORK RIVER BASIN (Continued)
COMPARISON BETWEEN REGIONAL WATER DEMAND PROJECTIONS
AND AVAILABLE SUPPLY - 2000-2030 SCENARIOS C & D (MGD)

C	SUPPLY	DEMAND	DEFICIT	SUPPLY	DEMAND	DEFICIT
YEAR	ANNUAL AVG. SUPPLY (d)	ANNUAL AVG. DEMAND (b)	SURPLUS OR (DEFICIT)	ANNUAL AVG. SUPPLY (d)	ANNUAL AVG. DEMAND (c)	SURPLUS OR DEFICIT
2000	2049.730	137.498	1912.232	2049.730	146.543	1903.187
2010	2049.73	152.222	1897.508	2049.73	164.407	1885.323
2020	2049.73	164.782	1884.948	2049.73	180.576	1869.154
2030	2049.73	178.502	1871.228	2049.73	198.368	1851.362

D YEAR	ANNUAL AVG. SUPPLY (d)	PEAK DEMAND (e)	SURPLUS OR (DEFICIT)	ANNUAL AVG. SUPPLY (d)	PEAK DEMAND (e)	SURPLUS OR DEFICIT
2000	2049.73	206.247	1843.483	2049.73	219.8145	1829.9155
2010	2049.73	228.333	1821.397	2049.73	246.6105	1803.1195
2020	2049.73	247.173	1802.557	2049.73	270.864	1778.866
2030	2049.73	267.753	1781.977	2049.73	297.552	1752.178

(a) - Derived from Table 4-13.
(b) - Derived from Table 6-4, using 65 gpcpd for residential demand.
(c) - Derived from Table 6-4, using 100 gpcpd for residential demand.
(d) - Source: SWCB, York Water Supply Plan, 1988.
(e) - Peak demand is estimated to be 1.5 times the Annual Average Demand for each decade.

Table 7-2 YORK RIVER BASIN

INDEPENDENT STUDIES COMPARING WATER DEMAND AND AVAILABLE SUPPLY PROJECTIONS FOR THE YORK RIVER BASIN* - 1990 -2030 (MGD)

JURISDICTION	REFERENCE NO.	2000	2010	2020	2030
CAROLINE COUNTY					
Projected Aver. Demand	NA				
Estimated Available Supply					
Potential Deficit					
GLOUCESTER COUNTY	NA				
Projected Aver. Demand					
Estimated Available Supply					
Potential Deficit					
HANOVER COUNTY	27				
Projected Aver. Demand		8.44	12.4	15.14	18.44
Estimated Available Supply		8.97	8.97	8.97	8.97
Potential Deficit		0.53	-3.43	-6.17	-9.47
JAMES CITY COUNTY	18				
Projected Aver. Demand		3.41	4.24	4.83	5.43
Estimated Available Supply		4.44	6.91	6.91	6.91
Potential Deficit		1.03	2.67	2.08	1.48
KING & QUEEN COUNTY	NA				
Projected Aver. Demand					
Estimated Available Supply					
Potential Deficit					
KING WILLIAM COUNTY	NA				
Projected Aver. Demand					
Estimated Available Supply					
Potential Deficit					
LOUISA COUNTY	NA				
Projected Aver. Demand					
Estimated Available Supply					
Potential Deficit					
NEW KENT COUNTY	28				
Projected Aver. Demand		2.78	3.74	4.86	6.17
Estimated Available Supply		3	3	3	3
Potential Deficit		0.22	-0.74	-1.86	-3.17
ORANGE COUNTY	NA				
Projected Aver. Demand					
Estimated Available Supply					
Potential Deficit					

Table 7-2 YORK RIVER BASIN (continued)

INDEPENDENT STUDIES COMPARING WATER DEMAND AND AVAILABLE SUPPLY PROJECTIONS FOR THE YORK RIVER BASIN* - 1990 -2030 (MGD)

JURISDICTION	REFERENCE NO.	2000	2010	2020	2030
SPOTSYLVANIA COUNTY	13				
Projected Aver. Demand		5	5.8	6.5	7.2
Estimated Available Supply		4	4	4	4
Potential Deficit		-1	-1.8	-2.5	-3.2
YORK COUNTY	18				
Projected Aver. Demand		0.3	0.45	0.53	0.63
Estimated Available Supply		0.65	0.65	0.65	0.65
Potential Deficit		0.35	0.2	0.12	0.02
WILLIAMSBURG	18				
Projected Aver. Demand		4.07	4.28	4.67	5.09
Estimated Available Supply		3.8	3.8	3.8	3.8
Potential Deficit		-0.27	-0.48	-0.87	-1.29

* All numbers derived from existing reports which discuss water supply and demand deficits.

NA - Not available

scenarios. The estimated safe yield - 51.495 mgd- utilized in **Table 7-1** Scenario A is based on the total presented in **Table 4-13** which was derived from the data available defining the existing safe yields of each jurisdiction. Scenario B utilizes the 1Q30 low flow volume - 29.45 mgd - calculated by the SWCB as a safe yield[46]. Scenarios C and D are based on a gross annual average output of the watershed - 2049.73 mgd - calculated by the SWCB[46].

When considering Scenario A the uncertainties associated with calculating safe yield discussed in 4.13 should not be overlooked. Any combination of these uncertainties could reduce current and future safe yields below estimates adopted in this report. The 1Q30 low flow value represents the minimum withdrawal rate available within the York River during a day recurring every 30 years[46]. Of particular concern involving both of these safe yield estimates is the fact that a future drought has a significant probability of being more severe than the drought of record used to calculate these values.

Scenario C and D attempt to present a simplified water supply based on a gross volume of output calculated for the entire watershed. This value is based on a measurement of the outflow of water at the mouth of the York River as an annual average. The major short fall associated with this supply estimate is the obvious fact that this volume of water is not available at every point within the watershed[46]. The withdrawals in a basin do not all occur at the same point and thus this presents an unrealistic relationship between available supply and projected demand. In essence, the sum of the regional demand could exceed the available supply at any given location throughout the basin. Furthermore, this estimated volume of available water does not take into account the limitations that will be created by minimum instream flow requirements necessary to support the wide variety of other demands placed on the water resources of the YRB.

Determining an acceptable method for calculating water supply is critical to the future success of managing water resources. Basic assumptions must be incorporated into the methodology. With a fixed amount of input (precipitation) occurring within the watershed it should be recognized that the removal of ground water or surface water has the same effect on the total available supply[46]. Fluctuations in ground water and streamflow are assumed to balance out in the long term and the water supply is always in equilibrium[46].

Reasonable estimates of water loss from evapotranspiration can be calculated for the watershed. In addition, with very little water being transferred out of the YRB this number can also be subtracted from the overall water budget. The final and most difficult variable in estimating a regional safe yield requires the adoption of acceptable criteria which establishes minimum instream flow values for Virginia's streams and rivers. Thus the following equation represents an effective estimate for the safe yield of a watershed:

Watershed Safe Yield = Annual Precipitation - Evapotranspiration - Out of Basin Water Transfers - Estimated Ground Water Absorption - Water Volume Required By Suggested MIF Criteria

An estimate of the net safe yield for the YRB using this equation is provided in Appendix A (**Table 7-3**). The reader should note that this is only an estimate since minimum instream flow criteria has not been approved for the rivers of the York River Basin.

7.3 QUALIFYING AND QUANTIFYING DEMAND TOTALS

The demand totals used in **Table 7-1** present worst case scenarios for water demand potential using two different calculations. Scenarios A, B, and C are based on the annual average demand projections calculated in **Table 6-4**. Scenario D based on an estimated peak demand, presents the greatest demand of the four scenarios. The peak demand was based on a methodology used by the SWCB which multiplies the annual average demand by 1.5 times[46].

One parameter which should receive special attention from a planning perspective involves the adopted population projections presented in **Table 6-6** which were used to calculate residential demand each decade. Water resource planners, policy makers, and engineers must work with the public and private sector of each jurisdiction to obtain a better understanding of the feasibility and rate at which future water users will be served by publicly operated water systems. While it may be unlikely that the YRB ever supplies public water service to 90 percent of the projected 2030 population, service to 60 or 70 percent of the future population is not unrealistic.

It should be noted that the water demand projections shown do not include water use by those not connected to central water supply systems. Using the same assumptions used to compute centrally supplied residential demand in **Table 6-4**, the percentage of the population not served could result in considerable demand. Forty percent of the projected population for the year 2000 could result in an additional 15.95 mgd based on water use at 100 gpcpd. Ten percent of the projected population for the year 2030 could result in an additional 5.84 mgd based on water use at 100 gpcpd. Planning methods must be implemented to quantify the potential volume of water demand created by those users not connected to central water systems.

7.4 WATER DEMAND VERSUS SUPPLY - 2000-2030

Table 7-1 presents a comparison between regional water demand projections and the estimated available supply for the YRB over the next forty year period. Scenarios A and B suggest significant deficits of water supply over the course of the planning period. While scenarios A and B utilize two different safe yield values, they suggest deficits that range from 86.003 mgd in 2000 to 168.918 mgd in 2030 for the entire YRB.

The primary significance of this range of values lies in the fact that the YRB will be faced with significant demands to provide water service over the next forty years. This report indicates that current supply sources and infrastructure will fall short of meeting the projected demand by the year 2000 even if the best case scenario is projected (using 65 gpcpd for residential consumption). This is also the case even if Commercial/Institutional/Light

Industrial and Heavy Industry experience no growth over the next 10 years. The deficit situation is even more critical if the low flow (1Q30) safe yield is considered.

In reviewing Scenarios C and D a surplus exists in all situations throughout the planning period including the use of a peak demand value. Virginia has long been considered a water rich state. These numbers would seem to support that concept. However, these numbers are somewhat unrealistic with respect to actual water availability throughout the basin as discussed above in section 7.2.

Table 7-2 offers a more localized approach for analyzing the supply and demand of individual jurisdictions. The chart offers a summary of previous technical reports completed by a variety of professional firms commissioned to project potential deficits. These studies indicate that Hanover, New Kent, and Spotsylvania County, and the City of Williamsburg all project potential deficits during the course of the planning period. Spotsylvania and Williamsburg expect to encounter a deficit as early as the year 2000. It should be noted that the studies conducted to develop these projections incorporate different methodologies as previously discussed. Thus it is difficult to make exact comparisons between the supply and demand totals shown in **Table 7-2**. These different studies indicate that those jurisdictions predicting a future deficit in water supply are pursuing alternatives to meet their demand. However, these alternatives may or may not provide multi-jurisdictional benefits.

7.5 REGIONAL TRENDS

Citing regional population projections, significant increases in water demand are evident throughout the YRB. As a region, jurisdictions in the YRB have typically followed localized, individual planning methods in an effort to address water supply and demand issues. Understandably a variety of characteristics have perpetuated this approach.

Historically Virginia has been considered a water rich state. Consequently, water resource planning and management have not been forced to become progressive or innovative. Planning and management of water resources has traditionally been conducted at the county or city level. Each jurisdiction has sought to define their own demand projections and have pursued solutions which would result in the creation or acquisition of their own supply.

The relatively sparse population and rural land uses of the YRB correspond to the facts that only approximately 50 percent of the population is connected with public water service and the regions strong reliance on ground water. Until recently the majority of the YRB relied almost exclusively on ground water reserves to meet their demand. In 1982, 62 percent of the total monitored withdrawals relied on ground water and by 1990 this had fallen to 22 percent.

As ground water resources continue to be degraded as a result of contamination, aquifer drawdown, and lack of regulating withdrawal, many municipalities agree that this trend will continue. One logical conclusion would be that the inevitable result of this type of trend will be greater competition for surface water resources. However, this is an over simplification of the larger problem. This report suggests that from a supply perspective, ground and surface water are regarded as interchangeable and the removal of either one has the same effect on the total available supply for the watershed[46]. Thus it should be recognized that shifting the regional reliance from ground to surface water resources provides no long term solutions and only redirects the inevitable conflicts associated with increasing water demand.

Economic trends have also come to the forefront as an issue to be dealt with. Until recently the jurisdictions in the YRB have not been overburdened by the costs of initiating large scale infrastructure improvements related to water service. A continuous, comprehensive approach to providing public water service to a greater percentage of the future population will involve large capital costs over the next 40 years. Despite this reality regional solutions, incorporating cooperation and shared infrastructure costs, can consolidate and minimize costs over the long term.

Other regional trends that need to be addressed through regional planning and cooperative efforts are jurisdictional differences in demand volume and inter-basin transfers of water. The jurisdictions which are projecting high growth rates will result in greater water demand in a shorter period of time. These jurisdictions will be more aggressive in pursuing solutions to meet their projected demands. In addition, the water resources within the YRB are increasingly being considered as viable alternatives to meet water demands outside of the watershed. To deal with these competing interests, a regional framework should seek to: manage demand within the basin; control the location and distribution of supply; meet long term regional water demands as opposed to short term local needs; and consider the cumulative impacts caused by out of basin water transfers.

8.0 WATERSHED SCALE PLANNING & MANAGEMENT CONCEPTS

8.0 WATERSHED SCALE PLANNING & MANAGEMENT CONCEPTS

Based on the data presented in Chapter 7.0, water shortages are imminent within the YRB. This chapter concludes this report by presenting general concepts and recommendations supporting long term planning and management of water resources at the watershed scale. The interconnection between ground and surface water suggests that water resource management measures are needed which respond to natural and anthropogenic impacts at the watershed scale. Moreover, effective long term planning for the supply and demand of water resources will require improved methods for making projections.

This chapter identifies various institutional changes and water programs which could improve the abilities of the planning area to meet future deficits between water supply and demand. Finally, this chapter offers a general list of benefits which can be realized through watershed scale planning and management and inter-jurisdictional cooperation.

8.1 PROTECTION OF WATER RESOURCES

This report has identified a critical link between ground and surface water resources. It is recognized that these sources of water are interconnected through the physical processes of the hydrologic cycle. Large scale alterations to ground water can have a significant impact on surface water reserves and vice versa. The cumulative impacts of land development and increasing water demand continues to degrade the water resources of the YRB. As discussed earlier the pervasiveness of anthropogenic impacts on water quality ignores jurisdictional boundaries and is determined by the natural processes acting on water resources at the watershed scale.

Despite these characteristics, ground and surface water reserves have long been managed independently. State regulations governing water use are specifically designed to address each water source individually. Furthermore, water withdrawal permits have traditionally been considered on an individual case by case basis, rather than by the cumulative results of numerous withdrawals from the same reserves. Recent groundwater legislation has increased the authority of the SWCB, but does not mandate comprehensive management. Consequently, state regulations managing water use should acknowledge the interconnection between ground and surface water and be restructured to become more scientifically based and watershed oriented.

8.2 IMPROVED PLANNING & MANAGEMENT METHODOLOGY

One of the major goals of this study is aimed at the promotion of methodologies to improve water resource planning and management at the watershed scale. Addressing the carrying capacity of water resources will require cooperation among the jurisdictions within the YRB with a focus on improving planning and management procedures.

Planning Methodology

This report has identified some of the short comings of current water resource planning methods. In response to this, uniform methods to determine and provide consistent data for the computation of water supply and demand projections should seek to meet the following objectives:

1. Obtain a consensus on a methodology for determining *basin wide population growth and distribution projections*;

2. Improve the basin wide *monitoring, collection, and dissemination of all water use (demand) data* with special focus on private ground water use;

3. Develop a *mandatory water conservation program* for the YRB including methods to monitor and quantify the savings in water use realized;

4. Define the *long term safe yield* of the water resources (ground and surface water) within the YRB based on minimum in-stream flows.

The YRB, a predominantly rural river basin, historically has not had much cause for concern regarding the allocation of its water resources primarily due to its sparse population and the perception of water abundance. For the jurisdictions in the YRB, only marginal information is available regarding the use and quality of ground and surface water resources. Consequently, many assumptions were incorporated involving the data used to calculate future demand projections in this report.

However, as water demand continues to grow, methods for water resource planning must seek to minimize the number of assumptions made by pursuing the objectives listed above. Each of the objectives listed need to be approached at the watershed scale which will require inter-jurisdictional cooperation. Scientific research to monitor and analyze the quantity and quality of water resources in the YRB must be funded and made a priority. Specifically, scientific studies should focus on MIF criteria, and the modelling ground water reserves throughout the entire YRB. Determining the future allocation of water resources also depends on the reliability and timeliness of data available to planners and policy makers. In addition, it is necessary to expand the long term management model to accommodate the MIF conditions that could occur when peak use coincides with a drought of record. This would strengthen regional reliance on safe yield calculations for future water availability.

Conventional water resource planning methods typically result in each jurisdiction pursuing its own path to meet its individual water needs. This typically results in proposals for the construction of an impoundment (reservoir) or the installation of ground water wells. Consequently, as each jurisdiction looks to meet the water demands of its future growth potential, numerous conflicting water supply projects may be under consideration concurrently within the YRB at a given time.

It is a well known fact that the regulatory review and approval process associated with a proposal to construct a reservoir has become a lengthy (5 to 10 years), costly, and uncertain process. Municipalities are well aware of the extensive work involved with meeting the requirements of an Environmental Impact Statement and the Section 404 (b)(1) Guidelines of the Clean Water Act. The time and costs associated with land acquisition and the construction of the reservoir can also become extensive.

Ground water withdrawals are also subject to a state permit process which will also continue to come under greater scrutiny as the negative impacts of ground water use are better understood. Competition is vigorous among private water supply developers and local jurisdictions for development of future groundwater supplies. Conflicts over jurisdictional transfers of ground water continue to intensify.

In response to the growing awareness of the need for environmental protection, recent water supply projects have faced increasing scrutiny from both regulatory agencies and the general public. As localities seek to meet their individual water use demands, the criteria for approval from the Environmental Protection Agency, the U.S. Army Corps of Engineers, and other federal and state agencies, are becoming more restrictive and precedent setting. The limits and definitions of guidelines associated with Section 404 of the Clean Water Act, which requires that the least environmentally damaging alternative be presented, continue to be tested and challenged by new water supply projects.

As water demand continues to increase due to the growing population throughout the region, competition for water supplies will continue to increase. This increase in competition will result in conflicts between jurisdictions within as well as outside the planning region as water poor areas are forced to search farther and farther for water supply. Furthermore, the institutional capability and social feasibility of water transfer rights has become a controversial topic throughout Virginia's Tidewater region. The proliferation of recent water resource conflicts between jurisdictions involving the distribution of surface or ground water suggests that the continuation of planning methods focussing only on supply management needs to be reassessed. Methodologies for water resource planning at a regional scale must solve the inconsistencies inherent in current localized approaches and seek to address inter-jurisdictional conflicts.

Demand Management

To combat these costly, time consumptive complications of regulatory review and implementation, future planning and management programs focussing on managing water demand rather than simply providing supply should be aggressively pursued. Demand management entails programs or regulations aimed at achieving a more efficient use of water resources. These strategies usually consist of non-structural solutions, and often lack the negative environmental or economic impacts associated with structural supply-oriented solutions[1]. Demand management can be achieved through a variety of different programs. A wide variety of programs are currently being used throughout the nation. Some of these include:

- Retrofitting Programs: Mandated or voluntary installation of water-efficient plumbing fixtures in residential, commercial, and industrial developments to reduce water consumption. Such a program could require all new construction to install modern water-efficient fixtures through changes in the building code; and phase-in the replacement of fixtures in existing houses and buildings over time.

- System Pressure Reduction: Codes and operating procedures aimed at modifying pumping and delivery apparatus through pressure reduction to reduce water loss.

- Wastewater Reuse: Blending highly treated wastewater with potable raw water supplies which will add to the available supply.

- Wastewater Reuse for Non-Potable Uses: The use of treated wastewater to produce non-potable water suitable for industrial cooling and process use. Also includes recycling of industrial water used for cooling and process use.

- Use Restrictions: Contingency measures beyond routine conservation measures, employed to produce short-term reductions in water demand during water supply shortages. Implemented in tiered fashion as shortage intensifies: Tier 1 - voluntary use restrictions; Tier 2 - mandatory use restrictions; Tier 3 - water rationing, with a gpcpd limit on residential and commercial users and a percent reduction for industrial usage. Several recommendations may be included to ensure successful implementation of use restrictions. First, use restrictions must be clearly differentiated from normal conservation measures. With regard to implementation enforcement, extensive inter-jurisdictional cooperation is recommended, with the development of a single ordinance adopted through consensus by all jurisdictions. Second, the group should be empowered with the ability to penalize users for infractions, either through 1) authorization by special ordinance, or 2) financial penalties for violators through rate structure. Third, enforcement of these provisions would be the joint responsibility of both the jurisdiction and the purveyor. And fourth, public education is vital to the success of effective use restrictions. The potential difficulty of enforcement and maintaining public cooperation over a long period of time should be recognized[1].

- Revised Rate Structures: Excess water consumption can be reduced by requiring water users to pay based on an Increasing Block Rate for each subsequent block quantity of water used. A Seasonal Differential Rate Structure to reduce encourage reduced consumption during peak demand months is recommended in conjunction with this Block Rate structure. Again, regional jurisdictional cooperation is key to successful rate structures that reduce excessive water consumption.

- Public Awareness and Education Programs: Methods of information dissemination to educate the public about techniques which can save water.

- Xeriscaping: The design and installation of landscaping which is not dependent on large quantities of irrigation.

- Improved Infrastructure: Replace and update inadequate infrastructure and system monitoring throughout existing municipal systems. Improvements include metering unmetered uses and connections, correcting system and service line leakage, replace inaccurate meters and inadequate controls (i.e. valves, etc.), and improved meter reading and billing programs.

(Above list adopted from Malcolm Pirnie: RRWSG Report, 1991)

- Growth Management: Growth management by jurisdictions has potential to discourage development in water poor areas, encouraging development in areas which have a water supply system of specified capacity. Jurisdictions may establish policies which encourage growth of non-water dependent industry[1].

- Stricter Water Withdrawal Regulations: Two existing state policies should be targeted for revision: the minimum instream flow requirements, and the ground water management areas. Revisions to state water policies could be aimed at limiting the volume of withdrawal from riparian waters and the ground water aquifers. By limiting supply on a state wide river watershed basis, more stringent demand management measures would be necessary to meet MIF regulations, and ground water limitations. The net effect would be a reduction in the demand deficit for the planning area.

The comprehensive implementation of these types of programs can have an impact on the overall consumption of water use. The benefits of implementing demand management programs are directly proportional to the scale and enforcement of the programs chosen. At a watershed scale significant savings in water use could be achieved if water authorities and purveyors implement and enforce demand management measures. Certain municipalities within the YRB are currently operating certain water conservation programs. Inter-jurisdictional cooperation should be sought to reach a consensus on the combination of programs which could maximize benefits and increase implementation efficiency.

8.3 INSTITUTIONAL CHANGES

Institutional revisions are necessary to require comprehensive water resource planning and management methods at the river basin scale. Institutional changes are also the foundation from which many of the benefits of inter-jurisdictional cooperation can be realized.

Minimum In-stream Flow Regulations

In 1989, the Virginia General Assembly granted the State Water Control Board (SWCB) the authority to protect minimum instream flows. The concept of minimum instream flow (MIF) is a complex and somewhat controversial idea based on multiple use demand management for water resources. Minimum instream flow is a value established to set a maximum allowable withdrawal from a given stream to protect beneficial instream and offstream uses.

Riparian waters are subjected to multiple use demands placed by competing interests. Examples of these multiple use demands placed on water resources include potable water supply, power generation, waste assimilation, navigation, irrigation, water based recreation, and the protection of fisheries, and aquatic flora and fauna. These different instream and offstream uses are dependent on different levels of water quality and stream flow to meet their needs. In addition, impacts from upstream uses must be considered in relation to downstream uses when dealing with MIF measures.

With so many competing interests, controversy revolves around the criteria used to establish a MIF. The most difficult question to be solved is: How low can water levels and quality be allowed to decline and for how long of a period, to meet the variety of offstream demands and still support the instream uses of the water body?

Because there are so many variables which affect water quantity and quality associated with each river in the state, reaching a consensus on an acceptable MIF policy has proven to be difficult. The success of any such state policy would be largely dependent on:

- improved scientific data from which to make better policy decisions;
- the political will to develop a stringent state MIF policy;
- the conversion of water resource planning and management methods throughout the state to a watershed scale approach.

The 1989 legislative authority given to the SWCB to implement a state MIF policy has had little effect on water use. The regulatory measures to date are not restrictive enough to accommodate the protection necessary for aquatic environments. The existing MIF regulations have little or no focus on establishing regional water demand and supply management or use restrictions during drought periods. The determination of what MIF restrictions should be is implemented on a case by case basis, independent of basin wide activities and demand. In addition, the permit process developed by the SWCB is quite lenient and numerous uses in existence prior to July 1989 were grand-fathered.

Despite these current political realities, the concept of a more restrictive water resource policy based on MIF may be the single most powerful demand management concept. Depending on the strength, legality, and coverage of the policy, it would be the foundation from which to reverse current institutional methods of water resource allocation. By limiting the available supply of water resources, jurisdictions would be forced to implement comprehensive demand management measures. It would alter the perception that water resources in Virginia are available in a limitless supply. To meet the needs of the multiple conflicting demands placed on water resources, regional cooperation based on better defined MIF regulations are necessary.

Growth Management

Management of demand by encouraging land development in water rich areas and discouraging it in water poor areas is a regional approach that may require future consideration. Growth management can be achieved in part by adoption of comprehensive plans and regulations which protect water sources from degradation, limit development in areas where water and public utilities are unavailable and undesirable, and encourage clustering and high-density in water rich areas[1]. Along with comprehensive plan modifications, jurisdictions can market themselves to industries that are not water-intensive[1]. Such industries increase the tax base but do not place excessive burden on the water resources of the planning area.

In Virginia, growth management is extremely difficult to impose. Because of the Dillon Rule, these decisions must be within the powers expressly delegated to local governments (i.e. zoning powers, comprehensive plans). Localities may not legally prevent development of specific properties due to the inadequacy of the current infrastructure. However, growth management is not a foreign concept. York County has previously discussed reducing density through its comprehensive plan[50]. Legislation directed at sustainable growth can induce orderly growth which protects the quality of the environment, while ensuring adequate economic development in areas that need it and are able to support it. These are the principles used to guide the development of the new state initiative, the Growth Strategies Act, proposed by the Commission on Population Growth and Development[9]. These conditions would necessitate express commitment from the state at all levels for responsible regional cooperation, as opposed to further local political decision-making[1].

Providing Incentives and Authority

In order to develop a comprehensive water management strategy, attitudes must be changed from the idea of rights directly connected to the adjacent land to an awareness of water as a common resource needing broad management[1]. All levels of government need to be involved in cooperative management. Good faith negotiations between competing localities require shared information, a common objective, and a mechanism to facilitate a planning process for regional water resource allocation. This would require a great deal of inter-jurisdictional cooperation, as well as additional mandatory incentives or mechanisms on behalf of the state.

Institutional changes will be necessary to initiate and enforce most water demand management strategies[1]. Water resource regulatory agencies need to be legally restructured and granted enforcement capabilities to succeed. Changes in the permitting policy need to provide for monitoring and evaluation of water resources. In Virginia, water demand management strategies will be more effective if institutional changes are adopted simultaneously. Virginia needs to develop a strong and enforceable, comprehensive and long-range management policy towards its water resources. The implementation and enforcement of regulations based on watershed management criteria can successfully expand Virginia's ability to mitigate its water allocation problems.

8.4 BENEFITS OF A WATERSHED SCALE STRATEGY FOR WATER RESOURCES

Based on these opportunities and constraints, this report has identified various benefits that can be realized from the initiation of a watershed scale strategy for the planning and management of water resources.

- Efficient utilization of available supply - Balanced power and allocation between water poor and water rich areas.
- Minimize adverse environmental impacts.
- Regional water allocation authority can transcend inefficiencies and conflicts of current institutional methods and provide a forum for dispute resolution.
- Shared costs associated with planning process, construction implementation, operations, and enforcement.
- Management of groundwater and surface water as a single resource at the watershed scale will improve water quality, prevent exploitation of ground water, and allow consistent criteria for minimum instream flow requirements.
- Improved monitoring, assessment, and distribution of water resources and data.
- Improved predictive capability to meet projected demands.
- Improved decisions can be made through shared scientific research efforts.
- The general public can be better educated to view water as a shared common resource.
- Equitable sharing of the costs and responsibilities associated with establishing comprehensive water demand management programs.

9.0 APPENDICES

APPENDIX A

SUPPORTING INFORMATION

Table 4.4b
JAMES CITY SERVICE AUTHORITY WELLS

Well (Tank) Name	Depth (ft)	Approximate Historical Measured Yield (gpm)	SWCB Permitted Withdrawal (gpm)	Actual Pump Capacity (gpm)	1991 VDH Recognized Capacity (gpm)	Storage Tank Capacity (gal)	HPNT[1] Capacity (gal)
Owens-Illinois	286	375	375	375	375	250,000	10,000 10,000
Toano	270	175	85	85	120	30,000	5,000
Lake Toano	270	135	105	105	75		5,000
Williamsburg Pottery	282	268	268	268	268	500,000	10,000
Ewell Hall	330	168	161	161	155	20,000	5,000
Olde Town Road	288	318	302	302	300		
Windsor Forest	302	265	215	215	265		5,000
Lafayette H.S.	398	300	161	161	150		
Season's Trace	402	300	157	157	150	Elevated	
Colby Road	282	132	114	114	100		10,000
Forest Glen	282	210	210	210	120	50,000	5,000
Powhatan Secondary	310	50	57	57	50	20,000	5,000
St. George's 100	400	180	180	180	130		5,000
Shellbank Woods Tank						20,000	5,000
Jamestown 1607 #1 Jamestown 1607 #2	414 409	230 240	171 -	170 153	110 110	40,000	5,000
Raleigh Square	204	28	28	28	20		2,000
Gatehouse Farms Tank						20,000	5,000
Powhatan Shores #1 Powhatan Shores #2	385 396	250 240	150 190	150 190	75 70	 20,000	2,000 2,000
The Colony	206	28	20	20	28		2,000
Lakewood	255	105	92	92	105	30,000	5,000
Canterbury Hills #1 Canterbury Hills #2	 280	Out of Service 120	 160	 160	24 45	 10,000	 5,000

Table 4.4b (continued)

JAMES CITY SERVICE AUTHORITY WELLS

Well (Tank) Name	Depth (ft)	Approximate Historical Measured Yield (gpm)	SWCB Permitted Withdrawal (gpm)	Actual Pump Capacity (gpm)	1991 VDH Recognized Capacity (gpm)	Storage Tank Capacity (gal)	HPNT[1] Capacity (gal)
Carriage Road #1	328	240	209	153	100	30,000	10,000
Carriage Road #2	328	170		163	100		
Norge #1	280	65	87	65	65		
Norge #2	280	58		58	58		5,000
Norge School	301	100	57	100	50		10,000
*Racefield	228	124	48	48	–	20,000	5,000
*Glenwood	272	47	47	48	–	20,000	5,000
*Kings Village	250	60	56	56	–	20,000	5,000
199 Storage Tank						1,000,000	15,000
Ford's Colony	306	235	256	256	225		10,000
Williamsburg West	290	118	118	118	0		8,000
*Upper County Park	263	150	150	75	–		5,000
*Ware Creek Manor #1	275	50	53	50	–	20,000	5,000
Ware Creek Manor #2	280	50		50	–		
Kristiansand #1	280	125	126	125	0	30,000	5,000
Kristiansand #2	280	69		69	0		
James Shire	260	34	34	34	0		5,000
Chickahominy Rd #1	270	186	600	150		25,000	10,000
Chickahominy Rd #2	725	500		210		25,000	
Magruder Heights[2]	435	65	65	65			
Governor's Land[3]	–	1200	500/300	–	–	–	–

Table 4.4b (concluded)

JAMES CITY SERVICE AUTHORITY WELLS

Well (Tank) Name	Depth (ft)	Approximate Historical Measured Yield (gpm)	SWCB Permitted Withdrawal (gpm)	Actual Pump Capacity (gpm)	1991 VDH Recognized Capacity (gpm)	Storage Tank Capacity (gal)	HPNT[1] Capacity (gal)
Toano El. Tank						100,000	
Season's Trace El. Tank						250,000	
Eastern State El. Tank						500,000	
TOTALS		6,681 gpm 9.62 mgd	5,497 gpm 7.92 mgd	5,235 gpm[5] 7.54 mgd	3,443 gpm[4] 4.96 mgd	3,050,000	211,000

* Independent wells not connected to main system.

1 HPNT - Hydropnuematic Tank

2 Well on stand-by due to poor water quality.

3 Governor's Land well is public/private joint venture, SWCB permitted withdrawel is 500 gpm for private irrigation and 300 gpm for public water supply. Well is currently not in use.

4 3,443 gpm recognized well capacity results in a VDH permitted design capacity of 1,913 gpm (2.7544 mgd).

5 Assuming the current ratio of VDH recognized well capacity versus permitted design capacity remains constant, the actual pump capacity of 5,233 gpm would result in a permitted design capacity of 2,907 gpm (4.19 mgd).

Source: JCSA Well Data Bank, confirmed by personal correspondence October 1991.

Source: Malcolm Pirnie, Regional Raw Water Study Group, 1993. (#18)

Table 4.4c

EXISTING RAW WATER SOURCE CHARACTERISTICS

NEWPORT NEWS WATERWORKS

Chickahominy River

- 41 mgd capacity pump station at Walkers Dam
- 301 square mile drainage area at the intake
- 206.0 mgd estimated average daily flow at the intake (48 years of record)
- Pumping Rules:
    - A minimum of 10 cfs flow downstream from Chickahominy Reservoir (i.e., Walkers Dam) must be maintained at all times.
    - When water surface elevation upstream of Walkers Dam is ≤3.0 feet MSL, cannot pump to Little Creek Reservoir.
    - Chloride Action Plan recommends that pumping stop when chloride levels exceed 100 mg/L at the intake, or if chloride levels are between 70 and 100 mg/L for a week (self-imposed).

Reservoirs	Drainage Area (sq.mi.)	Total Storage (BG)	Water Surface Area (Acres)
Diascund Creek	44.6	3.49	1,100
Little Creek	4.3	7.48	947
Skiffes Creek	6.0	0.23	94
Lee Hall (Terminal)	16.0	0.90	493
Harwood's Mill (Terminal)	8.5	0.85	265
TOTALS	79.4	12.95	2,899

Sources: CDM, 1986
CDM, 1989
Malcolm Pirnie, Regional Raw Water Study Group, 1993. (#18)

Table 4-11b

WATER SUPPLY COMPANIES SERVICING YORK COUNTY

<u>Supplier/Area</u>

Newport News Waterworks

York County
- Banbury Cross/Skimino
- Hubbards Lane, Queenswood, Royal Grant,
- Queens Lake Section (water from Williamsburg)
- Springfield terrace (water from Newport News Waterworks)

Williamsburg
- Bypass Road, Green Springs, Middletown Farms
- Bruton High School/Camp Peary

James City Service Authority
- Mooretown Road/Ewell Industrial Park

Sydnor Hydrodynamics
- Queens Lake (water from Williamsburg)
- Nelson Park York Terrace (water from Newport News)
- Charleston Heights (water from Newport News Waterworks)
- Parkway Estates (water from Williamsburg)
- Carver Gardens (water from Newport News Waterworks)

York Public Utilities
- Carver Gardens (water from Newport News Waterworks)

Source: York County Environmental Services, Newport News Waterworks

Table 4.12b

WATER LOSSES AT WILLIAMSBURG WATER TREATMENT PLANT

JANUARY 1984 - DECEMBER 1990)

Year	Withdrawals At Waller Mill Reservoir (mg)	Pumpage To Distribution System From WTP (mg)	WTP Losses As % Of Withdrawals
1984	1151.2	1108.3	3.7
1985	1250.5	1215.2	2.8
1986	1340.7	1308.2	2.4
1987	1229.0	1189.4	3.2
1988	1289.2	1255.4	2.9
1989	1324.9	1285.5	3.0
1990	1275.5	1236.7	3.0
Average WTP Losses			3.0
Source: City of Williamsburg Water Treatment Plant production records.			

Source: Malcolm Pirnie, Regional Raw Water Study Group, 1993. (#18)

Table 7-3 YORK RIVER BASIN

METHODOLOGY FOR CALCULATING SAFE YIELD OF A WATERSHED

PROPOSED EQUATION:

Watershed Safe Yield = Annual Precipitation - Evapotranspiration - Out of Basin Water Transfers - Ground Water Absorption - Water Volume Suggested by MIF Criteria

DESCRIPTION	SQ MI	AC/SQ MI	ACRES		
Area	2,661	640	1,703,040		
	FT/YR	ACRES	AC-FT/YR	DAYS	AC-FT/DAY
Annual Precipitation - 44" per yr.	3.67	1,703,040.00	6,248,453.76	365.00	17,119.05
	MGD				
326,000 gal. = Acre foot	5,577.86				
Estimated Evapotranspiration 25% of annual precipitation	1,394.47				
Out of Basin Water Transfers	4.00				
Estimated Ground Water Absorption 12.5 inches or 28% of annual precipitation (38,39)	1,561.80				
SUBTOTAL - ANNUAL FLOW	2,617.60				
Water Volume Required By Suggested MIF Criteria (8) Tennant Method = 30% of annual flow	785.28				
ESTIMATED WATERSHED SAFE YIELD	1,832.32				

APPENDIX B

SUMMARY OF FEDERAL, STATE, AND LOCAL WATER REGULATIONS

SUMMARY OF FEDERAL, STATE, AND LOCAL WATER REGULATIONS

The following section gives general descriptions of the federal, state, and local regulations that may have a bearing on any project involving the use or distribution of water resources in the Virginia. The list is an excerpt from a report titled *Regional Water Supply Plan: 1990-2040*, written by graduate students in the Department of Urban and Environmental Planning at the University of Virginia[1].

I. Legal Issues

Riparian Doctrine: Owners of property adjacent to a waterbody or stream flow have the right to the use of water or to the flow of water, provided that the flow is not unreasonably diminished for other downstream riparian landowners. The "natural flow doctrine" maintains that a downstream user has the right to prevent an upstream user from unreasonably diminishing the natural flow in the stream. Under the "reasonable use doctrine", a downstream landowner must show actual injury to institute legal action upon the upstream user. Riparian water rights are not subject to loss for nonuse.

Inter-jurisdictional Transfers: Inter-jurisdictional transfers are not recognized as a riparian right under the riparian doctrine. However, municipalities may enter into agreements with other jurisdictions for joint water supply projects.

II. Federal Laws (US Code)

- **Clean Water Act (Federal Water Pollution and Control Act) U.S.C. 33 §§ 1251 et seq, FWCPA §§ 101 et seq .**: The Clean Water Act (CWA) is implemented by Virginia's permitting system. In U.S.C. 33 § 1251, Congress states the national goals and recognizes that states have authority over waters in their jurisdictions. The Administrator of the EPA, unless otherwise provided, oversees the enforcement of the law. Section 401 provides states with the authority and duty to certify projects within their jurisdictions so that projects comply with the provisions within the Act. Section 404 mandates permits for the disposal of dredged or filled material into US waters and such permits are issued by the US Corps of Engineers. This section also allows states the opportunity to administer their own permitting programs which must comply with § 404. The CWA is applied to "all waters of the United States" including inundated wetlands, navigable waterways, inland lakes and rivers, mud flats, sand flats, etc. Because of this expansive definition, any surface water supply project in VA will trigger federal permitting requirements.

- **National Environmental Policy Act of 1969 (NEPA) as amended, 42 U.S.C. §§ 4321-4326:** In § 4321, Congress declares the national policy "which will encourage productive and enjoyable harmony between man and his environment" and "to promote efforts which will prevent or eliminate damage to the environment.." NEPA provides that agencies of the federal government shall prepare a detailed statement (an Environmental Impact Statement) assessing the long-term impacts of a federal project or federal action (such as approval of a permit by a federal agency) upon the environment. This statement must evaluate the direct and indirect effects of the project on the environment as well as conflicts with land use plans, natural resource requirements, historic and cultural resources, and socio-economic conditions.

- **The Endangered Species Act (ESA) 16 U.S.C §§ 1531 et seq.):** The ESA prohibits any federal agency from permitting any action "authorized, funded or carried out by such agency" to jeopardize the continued existence of any endangered or threatened species. States may enact mini-versions of the ESA provided that they do not "permit what is prohibited by this Act or prohibit what is authorized via an exemption or permit." The ESA empowers a seven person committee (sometimes referred to as the "God Squad") to grant exemptions for otherwise lawful activities.

- **The Fish and Wildlife Coordination Act 16 U.S.C. §§ 661 et seq.:** This act declares that fish and wildlife conservation will be coordinated with other features of water resource programs. In addition, §§ 662 and 663 declare that whenever a waterway is impounded, diverted, or controlled by a federal agency or an agency under a federal permit, the U.S. Fish and Wildlife Service as well as the agency administering the wildlife conservation for the state must be consulted.

- **The National Historic Preservation Act of 1966. 16 U.S.C. §§ 470 et seq.:** Section 470 (f) states that the head of any federal agency with jurisdiction over a proposed project or having authority to grant a license or permit for such an undertaking must take into account the effects of such an undertaking upon historic properties prior to the issuance of the license or permit. In addition, the said agency head must afford the Advisory Council on Historic Preservation the opportunity to comment on such an undertaking.

- **Rivers and Harbors Act 30 U.S.C:** The Rivers and Harbors Act (RHA) applies to all US waters that are navigable in the traditional sense (i.e. may be used for interstate commerce). Section 9 of the act prohibits construction of a dam or dike in these waters without the approval of Congress (or of the state legislature in which the structure is located) and the Secretary of the Army. Section 10 of the Act also requires approval by the Army Corps of Engineers for any structure that will obstruct the navigable capacity of any US waters.

- **Safe Drinking Water Act U.S.C. 42:** The purpose of the SDWA is to ensure that the public is provided with an adequate quantity of safe drinking water. It is administered by the EPA.

Federal Executive Orders

- **Executive Order 11990:** This order mandates the leadership by federal agencies to minimize the destruction of wetlands in carrying out the agency's responsibilities. The instructions in this order apply to "federal activities and programs affecting land use including but not limited to water and land related resources planning, regulating, and licensing activities." Section 2 of the order mandates that federal agencies shall avoid undertaking construction in wetlands ("construction" includes dredging and filling) unless "(1)there is no practicable alternative to such construction and (2) the proposed action includes all practicable measures to minimize harm to wetlands which may result from such use." In doing so, the agency head may take into account "economic, environmental, and other pertinent factors."

III. State Laws (VA Code)

- **State policy as to waters. § 62.1-11:** The Commonwealth has the power to protect water within its jurisdiction to from "waste and unreasonable use". "Beneficial uses" allowed must be reasonable. In addition, the policy states that the interests of the citizens of the state require the proper "development, wise use, conservation and protection of water resources together with protection of land resources.."

- **State Water Control Law § 62.1-44.2:** The purpose of the water control law is to protect high quality water and restore other waters to purity supportive of aquatic life within the Commonwealth's jurisdiction, prevent increase of pollution in the state's waters, and promote their proper use and management.

- **Powers and duties of the State Water Control Board. § 62.1-44.4;** The State Water Control Board (SWCB) has the authority to enforce water control law. The most relevant powers are as follows:
  · "to study and investigate methods, procedures,.. and technologies which could assist in water conservation or water reduction consumption,
  · to coordinate its efforts toward water conservation with other persons or groups within or outside of the Commonwealth,
  · to.. formulate recommendations based upon ..water

conservation studies to assure that present and future water needs of the citizens of Virginia are met,

· to issue certificates for ...the alteration..of the physical, chemical, or biological properties of state waters under prescribed conditions and to revoke or amend such certificates."

· to establish policies or programs for effective area-wide or basin-wide water quality control and management."

- **Chesapeake Bay Preservation Act Chapter 21 § 10.1 et seq. of Title 10.1:** In 1988, the Virginia General Assembly enacted the Chesapeake Bay Preservation Act (CBPA). This Act is based on the principle that healthy state and local economies are integrally related to each other and to the environmental health of the Chesapeake Bay. The CBPA recognizes the Chesapeake Bay as a valuable natural resource which provides a sound economic base for the region. The CBPA is designed to encourage the preservation of environmentally sensitive areas, while encouraging growth and development within appropriate regions. The CBPA mandates all local governing bodies in Tidewater Virginia to amend their comprehensive or zoning ordinances to accommodate the Chesapeake Bay Preservation Act. This applies to the localities in the York River Basin.

  The desire to protect both the Chesapeake Bay and the region's economy is not the sole motivation behind the Act. The CBPA is also designed to protect and promote the public health, safety and welfare. The Act is intended to:

  (1) protect existing high quality state waters, and restore all other state waters to a quality that will permit all reasonable public uses, and which will support the propagation and growth of all relevant aquatic life,

(2) protect clean state waters from pollution,

(3) prevent any increase in pollution,

(4) reduce existing pollution in the water and,

(5) promote water resource conservation.

- **Groundwater Management Act. §§ 62.1-254 - 270:** The Groundwater Management Act provides state authority to "protect and beneficially utilize" the groundwater of the state. Accordingly, the SWCB has the power to create "groundwater management areas" to protect the supply of groundwater. Within these areas, groundwater withdrawal requires a permit from the SWCB (withdrawals less than 300,000 gallons/month and for agricultural and livestock uses are exempt from this requirement). In addition, the Act provides guidance for; users requiring permits prior to the adoption of the 1992 version of the act, current permit holders who require additional amounts of groundwater to acquire permits, the criteria for issuance of permits, and requirements for drought relief wells. § 62.1-264 also provides authority for the SWCB to set maximum daily withdrawal limits for public water supply projects and requires that the Board consult with the State Health Department.

- **Surface Water Management program. §§ 62.1-242 - 253 (see regulations below):** These provisions allow for the SWCB to create surface water management areas for the protection of levels of surface water. Within these areas, withdrawal of water is prohibited without a SWCB issued permit unless included in an exempt category (including but not limited to withdrawals less than 300,000 gallons/month, non-consumptive uses, etc.). During low-flow periods, withdrawal limitations may be activated to maintain the flow of natural surface water at acceptable levels. In evaluating applications, the SWCB shall balance instream and offstream uses as well as consult the Department of Game and Inland Fisheries, the Dept. of Conservation and Recreation, the Virginia Marine Resources Commission, the Department of Health, the Department of Agriculture and Consumer Services, and any other interested parties and state agencies.

- **Scenic Rivers Act:** The Virginia Scenic Rivers Act provides for the designation by the General Assembly of rivers or portions of rivers to be protected and preserved based upon their scenic, recreational, and historic qualities. Evaluation and recommendation of scenic rivers are made to the Governor and the General Assembly by the Department of Conservation and Recreation. Once designated, no dam or structure impeding the natural flow of the river may be constructed without authorization by the General Assembly.

IV. Federal Permitting Requirements

- **Army Corps of Engineers Public Interest Review:** Corps regulations require a "public interest review" prior to the issuance of a permit which includes an evaluation of all possible impacts of the proposed project upon the public interest. Included in the Corps regulations are provisions for the considerations of wetlands, historic properties, fish and wildlife, flood hazards, land use, socio-economic concerns, water supply and conservation, and other factors related to the "needs and welfare of the people".

- **Clean Water Act § 404 guidelines:** In determining the appropriate action on a permit application, the Corps of Engineers must follow the § 404 guidelines established by the EPA. These guidelines evaluate factors including wetland destruction and the primary and secondary impacts of dredging and filling upon an aquatic ecosystem. Under § 404, the EPA has the power to override a Corps decision regarding a permit and may require additional conditions to be imposed.

- **Clean Water Act § 401 Certification:** Under the provisions of the Clean Water Act, the SWCB has been designated the agency responsible for the certification of federally permitted projects in Virginia. In doing so, the SWCB must ensure that the project complies with the provisions of the CWA as well as state water quality requirements.

V. State Permitting Requirements

- **Virginia Water Protection Permits. § 62.1-44.15:5:** For activities requiring § 401 certification under the CWA, a Virginia Water Protection Permit must be obtained from the SWCB. This process is to ensure the preservation of instream flow levels, the protection of fish and wildlife, and the maintenance of recreational, cultural, and aesthetic values. In evaluating applications, the SWCB shall balance the instream and offstream uses as well as consult the Department of Game and Instream Fisheries, the Department of Conservation and Recreation, the Virginia Marine Resources Commission, the Department of Health, the Department of Agriculture and Consumer Services, and any other interested parties. Under this provision, the SWCB is required affirmatively to consider and act upon permit applications for state waters, and to give priority to instream uses. In addition, the SWCB is authorized to limit the volume of any withdrawals requiring a permit.

- **Surface Water Withdrawal Permits Regulations. VR 680-15-03 (See Surface Water Management Programs above for statutory authority):** A Surface Water Withdrawal Permit from the SWCB is required to withdraw surface water for beneficial uses such as water supply projects. Because these permits are granted on a priority basis, the Board encourages and recognizes voluntary agreements between users.

- **Groundwater Withdrawal Permits (see Groundwater Management Act):** A groundwater withdrawal permit from the SWCB is required to withdraw groundwater for beneficial uses from within Groundwater Management Areas. Withdrawals of less than 300,000 gallons per month are exempt from this requirement.

- **State Corporation Permits. § 62.1-83:** This section mandates that a permit be obtained by the State Corporation Commission (SCC) prior to the construction of a dam in or across any state waters. This permit is required for all navigable waters eligible for use for interstate commerce. For waters that do not fall in this category, an SCC permit is required for projects utilizing a hydroelectric generating component. Because the permit criteria used by the SCC differs from that of the SWCB, the Board's permit authority would supersede that of the SCC in a conflict between the two groups.

- **Virginia Marine Resources Commission requirements:** Under the VA Code, the VMRC has the authority to require a permit for activities encroaching upon subaqueous beds owned by the state. Projects authorized by the "proper authority" (i.e by statute, a state agency with jurisdiction to authorize such a project, or a Circuit Court) would not require a VMRC permit. However, locally authorized projects such as for pipelines or intake structures, would require a permit by the VMRC.

- **State Health Department Requirements:** Any water supply project in the state requires a permit from the State Commissioner of Health designating the capacity of the waterworks, the permitted source of water, the manner of storage, purification, and the treatment of the water supply. Any change in the conditions allowed by the permit must be amended by a new permit from the Department.

VI. Local Permitting Requirements (as provided in VA Code)

- **§ 15.1-37.1:** This provision authorizes the states to construct dams on state-owned bottoms. If in another political jurisdiction, approval by the local governing body of the host jurisdiction must be obtained.

- **§ 15.1-332.1:** This section prohibits the impoundment of water by a county or municipality without the consent of the local jurisdiction within which the impoundment facility is located. In addition, such projects must comply with the local zoning ordinance and comprehensive plan.

- **§ 15.1-456:** Prior to the construction of any public utility facilities, the Planning Commission of the locality within which the facility is located must approve that the facilities are in compliance with the adopted comprehensive plan.

- **Sewer and Water Authorities;** Under the VA Code, Water and Sewer Authorities are entitled to construct water systems in or out of their political boundaries by action of the governing body or bodies creating the authority. In addition, these authorities are empowered to use the beds of state waters to develop water supply projects.

APPENDIX C

LIST OF CONTACTS AND REFERENCES

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REFERENCES

1. Arnn, Matthew et al., *Regional Water Supply Plan: 1990-2040*, Charlottesville, VA: Department of Urban and Environmental Planning, University of Virginia, May 1993. (Unpublished Paper)

2. Bender, M.E., "The York River: A Brief Review of its Physical, Chemical, and Biological Characteristics," Gloucester Point, VA: Virginia Institute of Marine Science, June 1987.

3. Berman, Marcia, Natashia Petrackis, and Carl Hershner, *Current and Projected Land Use in the York River Basin*, Gloucester Point, VA: Virginia Institute of Marine Science, March 1993.

4. Berman, Marcia, Kathy Corish, and Carl Hershner, *York River Watershed: Economic Analysis*, Gloucester Point, VA: Virginia Institute of Marine Science, May 1993.

5. Camp Dresser & McKee, *Spotsylvania County Water/Sewer Master Plan*, Draft Report, Annandale, VA: CDM, December 1991.

6. Camp Dresser & McKee, *Pamunkey River Basin Projected Water Demand through Year 2030*, Draft Report, Annandale, VA, May 1984.

7. Caroline County Planning Commission, *Caroline County Comprehensive Plan Update*, Caroline County, VA, February 1987.

8. Collins, Michael C., *Minimum Instream Flow Methodology and Implications in Virginia*, Charlottesville, January, 1990.

9. Commission on Population Growth and Development, "House Document No. 72," Richmond, VA, 1993.

10. Cox, William E., and Leonard A Shabman, "A Proposal for Improved Management of Interjurisdictional Water Transfer," Special Report No. 19, Blacksburg, VA: Virginia Polytechnic Institute and State University, September 1985.

11. The Cox Company, *Comprehensive Plan Williamsburg*, Virginia 1989.

12. Hanover County Planning Department, *Hanover County Virginia Comprehensive Plan Update*, Hanover County, VA, May 1991.

13. Hayes, Seay, Mattern, & Mattern, Inc., *Environmental Impact Report: Po River Reservoir*, Spotsylvania County, VA, April 1989.

14. James City County Planning Department, *1991 James City County Comprehensive Plan*, James City County, VA, 1991.

15. King and Queen County Planning Commission, *King and Queen County Comprehensive Plan 1990*, King and Queen County, VA and The Cox Company (Charlottesville, VA), 1990.

16. King William County Planning Department, *Comprehensive Plan for King William County Virginia 1991*, King William County, VA, 1991.

17. Louisa County Planning Commission, *Louisa County Comprehensive Plan*, Louisa County, VA, March 1985.

18. Malcolm Pirnie, *Lower Virginia Peninsula Regional Raw Water Supply Plan 1990 - 2040: Water Supply, Demand, and Deficit Projections* Report B, Newport News, December 1991.

19. Malcolm Pirnie, *Lower Virginia Peninsula Regional Raw Water Supply Plan 1990 - 2040: Water Supply, Demand, and Deficit Projections*, Raw Water Study Group, Newport News, April 1992.

20. Malcolm Pirnie, "Alternatives Assessment Briefing," *Lower Virginia Peninsula Regional Raw Water Supply Plan & Environmental Report 1990 - 2040*, Newport News, VA: Raw Water Study Group, October 1992.

21. Marsh, William M., *Earthscape: A Physical Geography*, New York: John Wiley & Sons, 1987.

22. National Oceanic and Atmospheric Administration, *50 Years of Population Change along the Nation's Coasts, 1906-2010*, Rockville,MD: Strategic Assessments Branch, 1990.

23. Nutter , L.J. and E. G. Otton, *Ground Water Occurrence in the Maryland Piedmont*, Maryland Geological Survey Report of Investigations No.10, 1969.

24. Orange County Planning Commission, *Orange County Comprehensive Plan*, Orange County,VA

25. Redman/Johnston Associates, Ltd., *Comprehensive Plan Gloucester County Virginia*, September 1991.

26. Richmond Regional Planning District Commission Staff, *Draft Comprehensive Land Use Plan New Kent County 1991*, Richmond, VA, February 1991.

27. Richmond Regional Planning District Commission, *Interim Regional Water Resources Plan for Planning District 15,* Draft Version, Richmond, September 1992.

28. Richmond Regional Planning District Commission, & Roy F. Weston, *New Kent County Water Supply Feasibility Study*, Richmond, VA, September 1981.

29. Ross, B.B., V.O. Shanholtz, N.L. Powell, and F.S. Wright, "Status of Irrigation Development in Virginia," Department of Agricultural Engineering File Report, Blacksburg, VA: Virginia Polytechnic Institute and State University, 1982.

30. Ruehrmund, James C. Jr., ed., *Virginia: 1992 Facts & Figures,* Commonwealth of Virginia, 1992.

31. Shabman, Leonard, and William E. Cox, "Costs of Water Management Institutions: The Case of Southeastern Virginia," *Scarce Water and Institutional Change,*

32. Spotsylvania County Planning Commission, *Comprehensive Plan for Spotsylvania County Virginia*, Spotsylvania County, VA, 1987.

33. Taylor, D.B., B.B. Ross, G. Vellidis, & A.B. Lanier, *Assessing the Feasibility and Potential Expansion of Large-Scale Riparian Irrigation in Virginia,* Blacksburg, VA: Virginia Water Resources Research Center, Bulletin 146, September 1985.

34. U.S. Department of Commerce, Bureau of the Census, *1970 Census of Population,* Washington, DC.

35. U.S. Department of Commerce, Bureau of the Census, *1980 Census of Population,* Washington, DC.

36. U.S. Department of Commerce, Bureau of the Census, *1990 Census of Population and Housing,* Washington, DC.

37. U.S.Environmental Protection Agency, "Final Determination of the U.S. Environmental Protection Agency's Assistant Administrator for Water Pursuant to Section 404(c) of the Clean Water Act Concerning the Proposed Ware Creek Water Supply Impoundment, James City County, Virginia," July 1989. (Government Document)

38. U.S. Geological Survey, *Availability and Quality of Ground Water in the Piedmont Province of Virginia*, Water Resources Investigations Report 85-4235, Richmond, VA, 1985.

39. U.S. Geological Survey, *Ground-Water Resources of the York-James Peninsula of Virginia,* Water Resources Investigations Report 88-4059, Richmond, VA, 1988.

40. U.S. Geological Survey, *Ground-Water Withdrawals from the Confined Aquifers in the Coastal Plain of Virginia 1891-1983*, Water Resources Investigations Report 87-4049, Richmond, VA, 1988.

41. Vellidis,G., B.B. Ross, and D.B. Taylor, "Potential Expansion and Water Demand of Riparian-Based Irrigation," Transactions, Vol. 30: No. 6, Michigan: American Society of Agricultural Engineers, 1987.

42. Virginia Employment Commission, *Virginia Population Projections: 2010*, Richmond, VA: State Data Center, April 1993.

43. *Virginia Review: 1992 Directory of State & Local Government Officials*, 7th ed. Chester, VA: Review Publications, Inc., 1992.

44. Virginia State Water Control Board, *Safe Yield of Municipal Surface Water Supply Systems in Virginia,* Richmond, VA:SWCB Planning Bulletin 335: March 1985.

45. Virginia State Water Control Board, *Virginia Water Quality Assessment for 1992,* Information Bulletin 588: Vol. 2, 1992.

46. Virginia State Water Control Board, *York Water Supply Plan*, Richmond, VA, Planning Bulletin 343: March 1988.

47. Virginia State Water Control Board, *James Water Supply Plan,* Vol. 1 & 2, Richmond, VA: SWCB, Planning Bulletin 337: March 1988.

48. *Virginia Statistical Abstract*, Center for Public Service: University of Virginia, Charlottesville, 1989.

49. Walker, W.R. and P.G. Bridgeman, "A Water Code to Meet Virginia's Needs," Special Report No. 20, Blacksburg, VA: Virginia Polytechnic Institute and State University, October 1985.

50. York County Planning Department, *The County of York Comprehensive Plan*, York County, VA, 1991.