#22

**ACTION ITEM**
**BOARD OF SUPERVISORS**

**DATE:** November 15, 2011

**TO:** Board of Supervisors

**FROM:** Harry L. Critzer
Department of Utilities

**ISSUE:** Adoption of Water Supply Plan

**STAFF RECOMMENDATION:** Approval

**BUDGET IMPACT:** N/A

**TIME SENSITIVITY:** N/A

**ATTACHMENTS:** (5)

[1] Background Report

[2] Water Supply Plan

[3] Va Code Section 62.1-44.38:1

[4] Local and Regional Water Supply Planning Regulations

[5] **Reso/Ord/Proc** # R11-224

**REVIEW:** [X] County Administrator's Office

[X] County Attorney

[ ] **Consent Agenda**
[ ] **Discussion Item**
[ ] **New Business**
[ ] **Other Business**
[ ] **Presentation**
[ ] **Public Hearing**
[X] **Unfinished Business**
[ ] **Work Session**

**PRESENTATION BY:** Harry Critzer
Director of Utilities

**ELECTION DISTRICT:** N/A

Attachment 1
R11-224

# BACKGROUND REPORT

Va. Code, Section 62.1-44.38:1, requires development of a comprehensive state-wide water supply planning process to:

- Ensure that adequate and safe drinking water is available to all citizens;
- Encourage, promote, and protect all other beneficial uses of the Commonwealth's water resources; and
- Encourage, promote, and develop incentives for alternative water sources including, but not limited to, desalination.

The Local and Regional Water Supply Planning Regulations (9 VAC 25-780-10 *et seq.*) established in 2005 require that all counties, cities, and towns in Virginia submit a local water supply plan or participate in a regional planning unit in the submittal of a regional water supply plan, to the State Water Control Board (SWCB) through the Department of Environmental Quality (DEQ). The Water Supply Plan is required to provide information on:

- Existing water sources;
- Existing water uses;
- Existing resource information;
- Water demand management or current conservation practices;
- Drought response and contingency plans;
- Projected water demand information; and
- A Statement of Need (based on the adequacy of existing water resources) to meet current and projected water demand over the planning period (a minimum of 30 years to a maximum of 50 years).

The Regulations required submittal of a draft Water Supply Plan by November, 2008. Stafford County applied for and received a partial grant, and awarded a contract to Draper Aden Associates in April, 2006 to develop a Water Supply Plan in compliance with the SWCB regulations. A draft plan was submitted to DEQ in November, 2006. Over a year later, comments were received from DEQ.

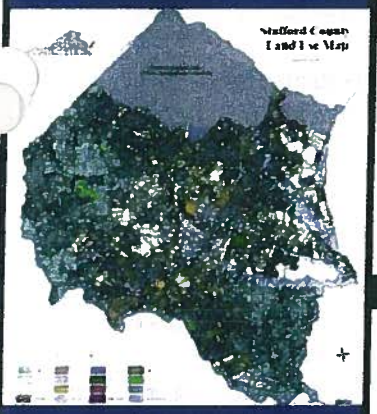
Since that time, staff has worked with DEQ at the Northern Virginia Regional Office to address the comments and provide additional information that was requested. Due to staffing cuts at DEQ, staff has recently been working with DEQ's Blue Ridge Regional Office in Roanoke. This is the first time in Virginia that Water Supply Plans have been required. Once approved, the Plan must be reviewed and revised, if necessary, within five years. The Plan must be reviewed, revised, and resubmitted to DEQ every ten years.

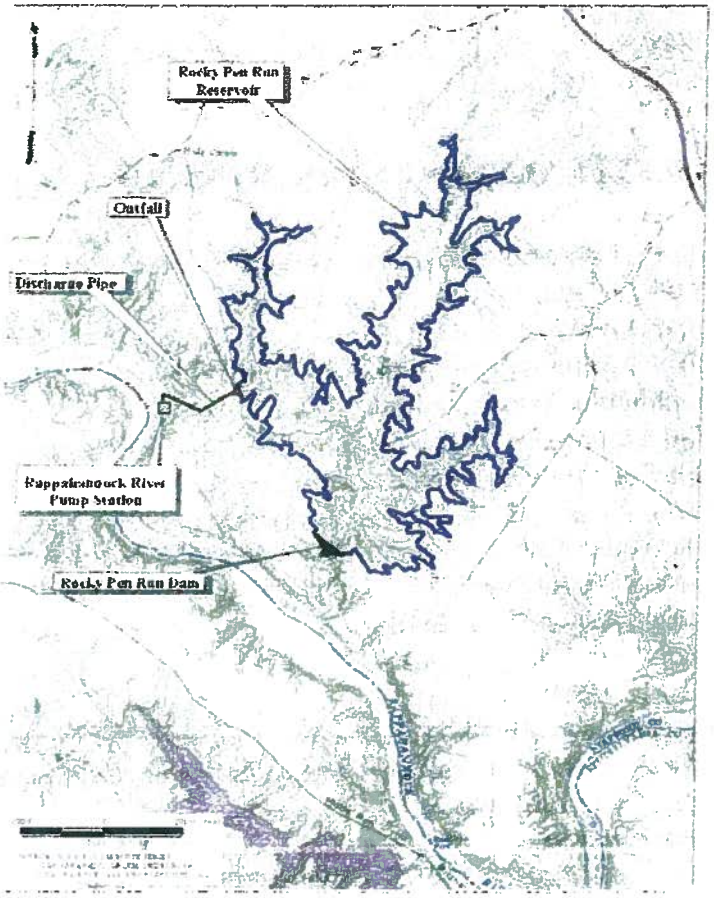
The Water Supply Plan provides a solid foundation upon which future updates can be based. It addresses both surface and groundwater issues and reflects the path which Stafford County has chosen to ensure adequate water supplies for all County residents now and in the future.

A public hearing was held on August 16, 2011. Subsequently, the Board asked for additional time to review the Water Supply Plan.

Staff recommends approval of proposed Resolution R11-224 which adopts a Water Supply Plan for Stafford County.

# WATER SUPPLY PLAN






## Stafford County, Virginia

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MALCOLM PIRNIE

Draper Aden Associates
Engineering • Surveying • Environmental Services



5725-001

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# Chapter 1 INTRODUCTION

## 1.1 Purpose

This Water Supply Plan was developed for Stafford County, Virginia to comply with the State Water Control Board's Regulation 9 VAC 25-780, Local and Regional Water Supply Planning. The purpose of the regulation is to establish a comprehensive water supply planning process for the development of local, regional and state water supply plans. This process is designed to satisfy the following:

- Ensure that adequate and safe drinking water is available to all citizens of Stafford County
- Encourage, promote, and protect all other beneficial uses of Stafford County's water resources, including:
  - Protection of fish and wildlife habitat
  - Maintenance of waste assimilation
  - Recreation, navigation and cultural and aesthetic values
  - Agricultural use
  - Electric power generation, and
  - Commercial and industrial uses
- Encourage, promote, and develop incentives for alternative water sources, including, but not limited to desalination, interconnections, recycling, and reuse.

Stafford County is required to submit its Local Program to the Department of Environmental Quality (DEQ) for review no later than November 2, 2008. The Water Supply Plan document is one component of the overall Local Program that must be developed. Prior to submission of the Local Program to the DEQ for review, a public hearing must be held and the county Board of Supervisors must pass a resolution approving the Plan and any other plans or ordinances that are part of the Local Program.

## 1.2 Background

This Water Supply Plan was developed in accordance with the requirements set forth in 9 VAC 25-780, and has incorporated information from a number of existing sources, including the following:

- **Environmental Impact Report for the Rocky Pen Run Reservoir (Malcolm Pirnie, Inc., October 1999)** – Evaluated Stafford County's water supply needs through the year 2045 and identified a preferred project alternative which will meet the projected needs of the county. Each potential water supply development alternative was evaluated with respect to yield, availability, reliability and cost. A comparison was then made of the potential environmental impacts of the remaining practicable alternatives, and the Rocky Pen Run Reservoir with withdrawals from the Rappahannock River was identified as the practicable alternative with the least environmental impact.

- **Wildlife Habitat Protection Plan (Stafford County, June 2000)** – Developed to discuss previous management programs directed toward the goal of maintaining water quality, providing for future water consumption and expanding recreational opportunities. The plan also recommended additional measures that may be implemented by the county to protect sensitive wildlife habitats and forested areas.

- **Stafford County Needs Assessment (Malcolm Pirnie, Inc., April 2001)** – Provided the estimated safe yield of the existing water supply system, updated population and demand projection estimates, and a comparison of future potable water supply and demand predictions.

- **Land Use Plan (Stafford County, February 2003)** – Developed to manage and direct growth within Stafford County. The Land Use Plan is the basis for the development of other plans which address the environment, transportation, public facilities and public infrastructure. The goal of the plan is to achieve balanced development, phased in conjunction with the provision of adequate public facilities (parks, schools, fire/EMS, etc.) and infrastructure (utilities, roads, etc.).

- **Groundwater Management Plan (Draper Aden, 2004)** – Evaluated the groundwater resource and proposed management strategies to protect both quantity and quality of the resource. Groundwater well data was analyzed with respect to depth, yield, susceptibility and relationship with geologic structure.

- **Stafford County Water and Sewer Master Plan (O'Brien & Gere, March 2005)** – Assessed the Stafford County Department of Utilities' many separate elements and combined these elements into a single plan for the future. This Master Plan serves as a guide to future development and investment decisions for the public water and sewer systems.

- **Stafford County Quarry Evaluation (Draper Aden, June 2005)** – Evaluated the feasibility of utilizing the Vulcan Quarry to provide supplemental capacity for the County's future water storage needs. This report also provides the results of a preliminary geological evaluation of the Vulcan Quarry and concludes that the quarry is not a viable option without further evaluation of the geological conditions.

- **Safe Yield Analysis for Rocky Pen Run Reservoir (Malcolm Pirnie, Inc., March 2006** – Estimated raw water safe yield based on a 97-year simulation period (October 1907 through September 2004).

# Chapter 2 EXISTING WATER SOURCES

## 2.1 Description of Existing Water Supply System

### 2.1.1 County Water System

As of July 2005, the Stafford County Department of Utilities operates a water treatment and supply system serving an estimated 117,300 county residents – whether in their homes (29,116 accounts serving approximately 87,348 residents), in schools or as employees or customers of over 1,000 businesses in the county. In addition, a portion of the Quantico Marine Corps Base that is within Stafford County is served. The county water system also serves non-residents who visit the county for recreation or business. The existing service area includes approximately 50,000 acres along the Interstate 95/Route 1 and Route 17 corridors.

The water distribution system consists of six (6) pressure zones. These zones are identified based upon the overflow elevation of the water tank(s) serving them and include the following:

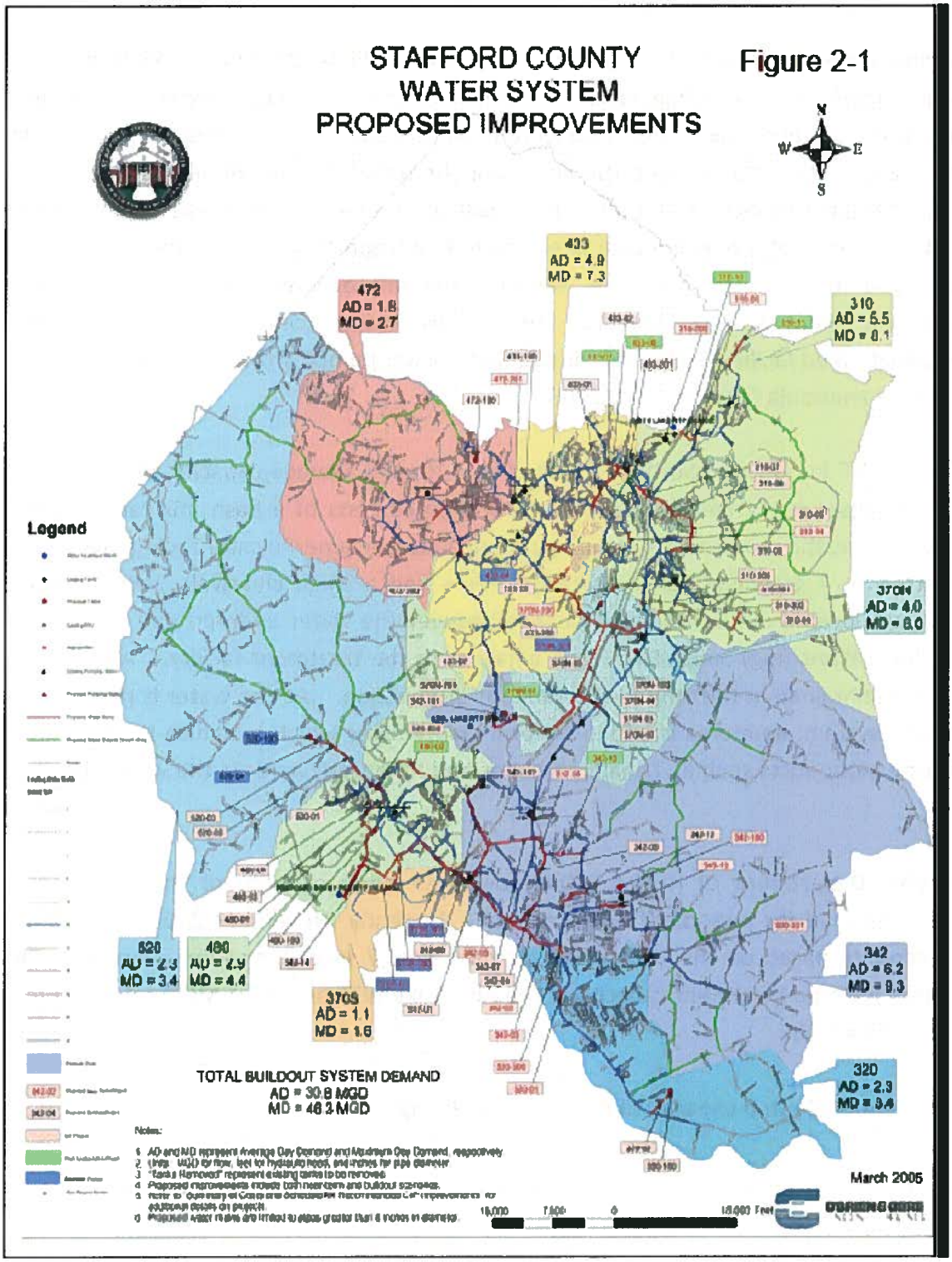
- **310 Pressure Zone** - Serves the area in north Stafford from the Rowser Building on Route 1 north and east of Moncure Elementary School on Route 610
- **320 Pressure Zone** - Serves the area in south Stafford south and east of White Oak Road
- **342 Pressure Zone** - Serves the area in south Stafford from the Rowser Building on Route 1 south and east of I-95
- **433 Pressure Zone** - Serves the area in north Stafford west of Route 1 to Shelton Shop Road
- **472 Pressure Zone** - Serves the area in north Stafford west of Shelton Shop Road
- **503 Pressure Zone** - Serves the area in south Stafford west of I-95 and south of Truslow Road

The existing water supply system is capable of distributing water between pressure zones if necessary. A valve in front of the Rowser Building on Route 1 is normally closed. It can be opened and the M&M Booster Pump Station (on Rt. 1 just south of American Legion Road) and the Potomac Creek Booster Pump Station (on Rt. 1 at Potomac Creek) can be used to pump water north or south depending upon how the valves at each booster pump station are configured. In addition, the Rowser Booster Pump Station can be used to pump water south. A valve on Mt. View Road can also be opened to allow water to gravity feed from the 433 pressure zone in the north to the 342 pressure zone in the south. The Mt. View Road Booster Pump Station can be used to pump water from the 342 pressure zone in the south to the 433 and 472 pressure zones in the north.

The future service area of the Department of Utilities includes all areas within the Urban Service Area identified in the **Stafford County Land Use Plan** (Stafford County Planning Commission, approved 1996, updated in 2003). Figure 2-1 illustrates the existing water supply system and proposed improvements and expansion of the existing system. This map shows both near-term and build-out proposed improvements and is color-coded to illustrate the future pressure zones within the county and the corresponding projected average and maximum day demands for each pressure zone.

The existing Stafford County system consists of two surface water reservoirs (Smith Lake and Abel Lake), two water treatment facilities, five primary pumping stations, 14 potable water storage facilities and over 483 miles of transmission pipeline ranging from 2 inches to 30 inches in diameter. The locations of Smith Lake and Abel Lake are shown on Figures 2-2 and 2-3.

The County operates two water treatment facilities: Smith Lake Water Treatment Facility (WTF) and Abel Lake WTF. The Abel Lake WTF, located in the central portion of Stafford County, supplies up to 6 million gallons per day (mgd) of treated drinking water to customers in the southern portion of the county. The treatment facility, located off of Moorewood Lane, can be accessed from Route 1 by way of Mountain View Road, Enon Road and Hull's Chapel Road (the latter intersects with Moorewood Lane). Treatment at the Abel Lake WTF consists of raw water contact (oxidation), followed by flash mixing, vertical turbine flocculation, clarification, dual media filtration and disinfection. Primary disinfection is accomplished through the use of chlorine (sodium hypochlorite), while secondary (residual) disinfection is accomplished through the use of chloramines (a combination of chorine and ammonia).


STAFFORD COUNTY
WATER SYSTEM
PROPOSED IMPROVEMENTS
Figure 2-1
N
W
E
S
433
AD = 4.9
MD = 7.3
472
AD = 1.8
MD = 2.7
310
AD = 5.5
MD = 8.1
37014
AD = 4.0
MD = 6.0
342
AD = 6.2
MD = 9.3
320
AD = 2.3
MD = 3.4
37015
AD = 1.1
MD = 1.6
480
AD = 2.9
MD = 4.4
520
AD = 2.3
MD = 3.4
Legend
TOTAL BUILDOUT SYSTEM DEMAND
AD = 30.8 MGD
MD = 46.2 MGD
March 2005

The original 2 mgd Abel Lake WTF was completed in July 1982 and included construction of the raw water intake and pumping facilities, flash mix and flocculation facilities, one circular clarifier, four dual media filter (only two were piped up) and finished water pumping facilities. In June 1988, another clarifier and the piping for the remaining two filters were constructed, bringing total plant capacity to 4 mgd. In August of that year, a study was completed which resulted in re-rating of the dual media filters (from 4 to 6 gpm/$ft^2$), bringing the total treatment capacity to 6 mgd. Since that time, various plant improvements have been constructed including the alum storage building (1984), raw water contact tank and potassium permanganate feed facility (1990), raw and finished water pumping facility modifications (1992) and aqueous ammonia feed facilities (2003).

Smith Lake WTF in northern Stafford County has a 10 mgd average capacity and 14 mgd peak capacity and uses two treatment trains. Each train consists of a flash mix tank (for mixing ferric sulfate, caustic soda and potassium permanganate), a SuperPulsator tank (polymer added just upstream), 4 greenleaf sand/anthracite filters and a small clearwell. Low-lift finished water pumps located near each small clearwell convey the water underground outside to the 3.22 million gallons (mg) Smith Lake Tank adjacent to the treatment facility. A free chlorine residual is maintained in the Smith Lake Tank for disinfection. As the water is pumped to the distribution system, ammonia is added to form chloramines which minimize the formation of disinfection byproducts such as Trihalomethanes and Haloacetic Acids in the water distribution system.

The Virginia Department of Health (VDH) combined rated capacity of the two treatment facilities is 20 mgd for periods of high demand. Currently (November 2006), the combined system capacity based on the VDH-issued permits is 13.7 mgd (long-term average). This is based upon a 6 mgd treatment capacity at the Abel Lake WTF and a 7.7 MGD safe yield for the Smith Lake Reservoir.

The VDH combined rated capacity of the system is 20 mgd.

### 2.1.2 Quantico Water System

The Marine Corps Combat Development Command at Quantico comprises the northern twenty percent of the land area of Stafford County. Facilities in this area are served by a VDH District 8-regulated Community Water System: PWSID # 6153060 – "Quantico Marine Corps Base – Camp Barrett" (QMCB-CB). As of September 2006, the QMCB-CB water system is listed with 81 connections serving a "population" of 5,447 persons. It is designated as a "consecutive" water system, because it is supplied entirely by treated surface water that is purchased from the Stafford County water system. Stafford County currently has an open-ended contract with the Quantico Marine Corps Base (QMCB) to supply up to 0.75 mgd of treated water to the Camp Barrett portion of the Base within Stafford County.

In the past, the QMCB-CB water system in Stafford County included a water treatment facility that was supplied by water stored in Lunga Reservoir. Since April 1999, QMCB has discontinued operation of the Lunga Water Treatment Facility and subsequently dismantled it. Lunga Reservoir on Beaverdam Run continues to impound water which is available to augment raw water storage or flow for two water systems that are adjacent to it.

One system is within Stafford County. QMCB has agreed to make releases from Lunga Reservoir, as needed, to compensate for up to 0.75 mgd of treated water which QMCB-CB purchases from the Stafford County water system. This raw water can be released to Beaverdam Run where it flows downstream into Smith Lake to supplement storage there.

The other system is in Prince William County. There, the Quantico Marine Corps Base – Mainside Water System (PWSID # 6153675), also referred to as "Post Camp WTP and Service Area" in the DEQ records, relies on periodic diversions of raw water via pipeline from Lunga Reservoir to supplement storage in Breckenridge Reservoir. From Breckenridge Reservoir in Prince William County, withdrawals are made for the Base's Mainside water treatment and supply system. QMCB relies on diversions from Lunga Reservoir to Breckenridge Reservoir from which withdrawals are made to supplement the Base's supply. Currently, the portion of QMCB within Stafford County is purchasing all of its water from the county water system; and, therefore, has discontinued operation of the Lunga Water Treatment Facility.

### 2.1.3 Ground Water Systems and Self-Supplied Users

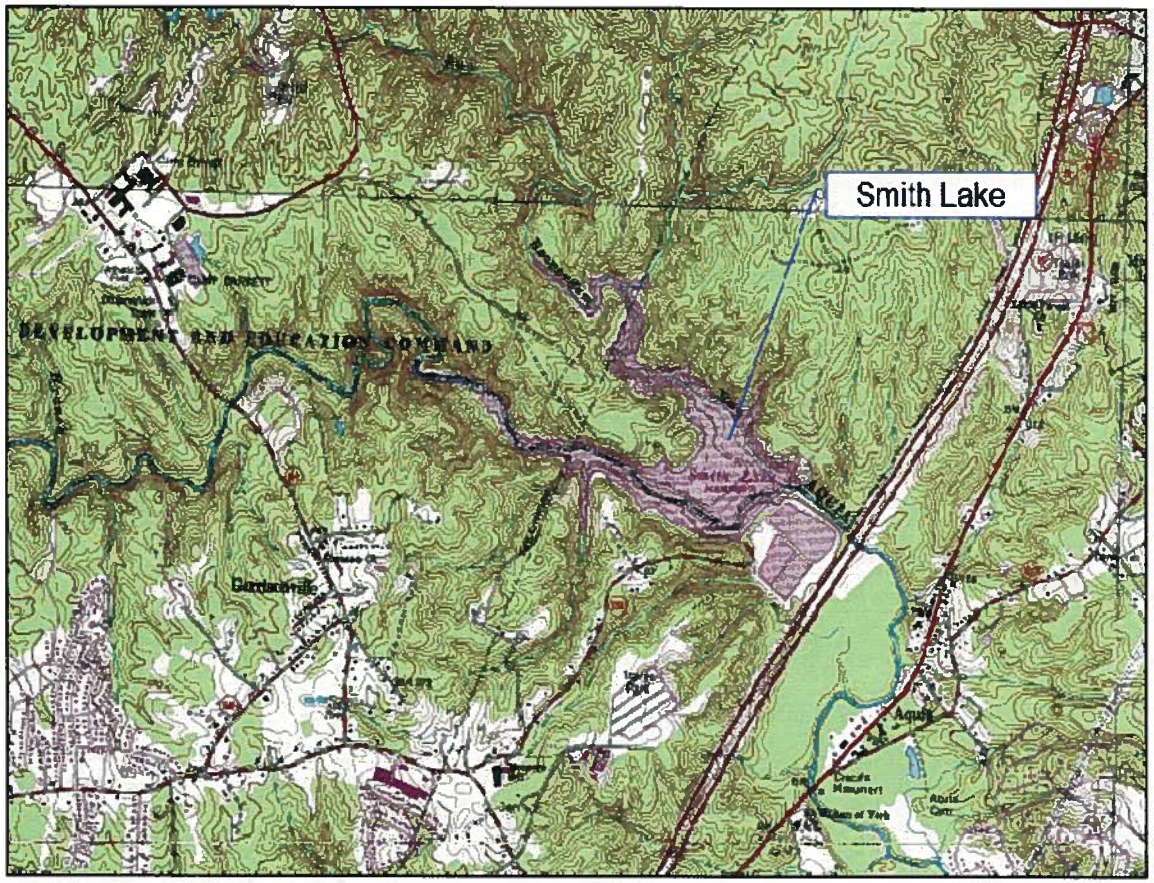
A significant portion of Stafford County residents utilize groundwater as their water supply source. As part of the October 2004 Stafford County Groundwater Management Plan, Draper Aden compiled data for a sampling (approximately 1,669, or 17%) of the County's wells using information provided by the following sources:

- Well logs from the Stafford County Virginia Department of Health (VDH) office
- Well logs from the Culpeper Regional VDH office and the EPA EnviroFacts website
- Well logs from the private driller's records of John Danielson

These well logs were entered into a database and geo-referenced to accurately locate the wells with respect to their horizontal location and well elevation. The locations of these wells are depicted on Figure 2-4. Of these wells, 16 are in privately operated systems using groundwater supplies to serve drinking water to the public at residential, institutional or business facilities. These are recognized and regulated by the VDH Office of Drinking Water, Culpeper Regional Engineering Field Office, District #18 and are discussed in Section 2.1.3.1 for Community water systems and in Section 2.1.3.2 for Non-Community water systems. As of 2005, approximately 9,984 wells that supply potable water to individual private residences are estimated to operate in Stafford County, as discussed in Section 2.1.3.3.

#### 2.1.3.1 Community Water Systems

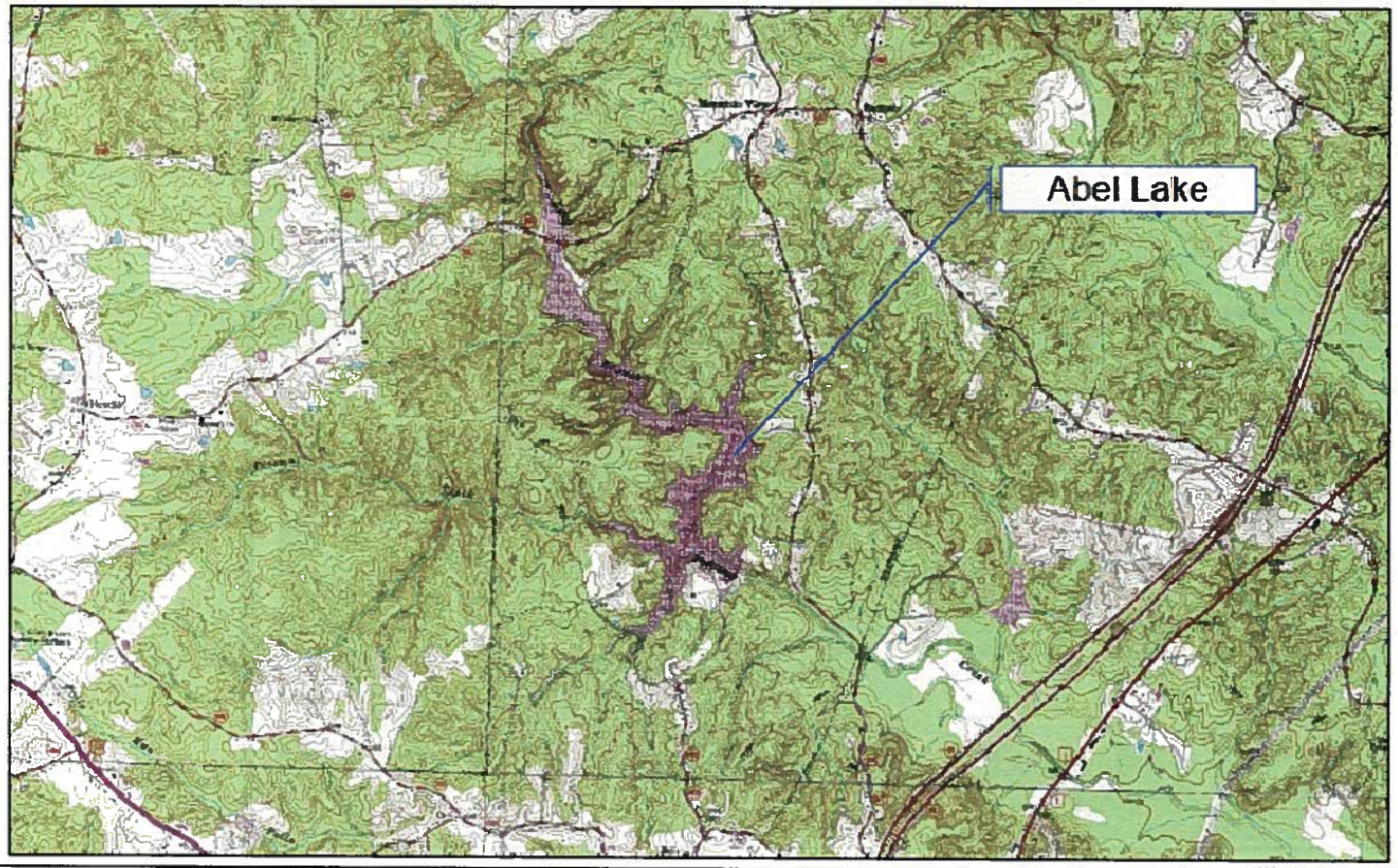
As of 2006, there were four (4) VDH-designated Community Water Systems (e.g., mobile home parks (MHP) and residential assisted living or nursing care facilities) served by groundwater wells: Anne's Mobile Home Park, Hidden Lake Mobile Home Park, Brooke Nursing Center, and Marian Manor. The systems are dispersed along the fringes of the I-95/Route 1 corridor in the north-central portion of the county, as shown in Figure 2-4. Each of the four (4) systems serves, or is permitted to serve, approximately 34 to 110 residents, employees and visitors for a total of approximately 320 people (see Appendix C).




MALCOLM PIRNIE

Smith Lake Site Location Map

FIGURE 2-2




MALCOLM PIRNIE

Abel Lake Site Location Map

FIGURE 2-3

Only limited source description data for these wells was readily available in VDH and DEQ records during searches in 2004 and 2006. This information, i.e., well construction details, well yields and permitted capacities, is given in Appendix C.

### 2.1.3.2 Non-Community Water Systems

For DEQ water planning purposes, these particular twelve (12) facilities in Stafford County in Year 2006 are inventoried as "businesses" that are self-supplied water users of less than 300,000 gallons per month each. Collectively, these systems are permitted to serve up to an estimated 2,400 people daily, with much of the use (i.e., schools, swimming pools, camps) being seasonal.

As of 2006, there were:

- VDH-designated non-transient, non-community systems, e.g. schools - 3
- VDH-designated transient, non-community systems, i.e. businesses and recreational facilities - 9

### 2.1.3.3 Self-Supplied Residential Users

The county estimates the number of households that utilize groundwater well as their water supply source by subtracting the total number of public water supply users from the total county population. The estimated number of households that were on groundwater wells in 2005 is calculated as follows:

117,300 (total population) – (29,116 accounts x 3 people/account) = 29,952 people

29,952 people / 3 people per household = 9,984 households on groundwater wells

## 2.2 Yield of Existing Water Supply System

Safe yield is defined as the quantity of water which may be withdrawn from a water source during some critical dry period without totally depleting or exhausting the source. For systems which depend on surface water sources, calculated safe yields are not absolute values calculated on the basis of exact data. Rather, the calculated safe yields for surface water supply systems in Virginia are linked to levels of risk associated with the probability of occurrence of droughts as or more severe than those on record. Based on VDH regulations, the safe yield of surface water supply systems in Virginia should reflect the worst drought of record since 1930. Safe yield values for surface water systems usually also take into account management decisions as to the reliability and resiliency of the water system to respond during critical dry periods.

### 2.2.1 Raw Water Safe Yields of Reservoirs and Combined County Water Supplies

The safe yield of the existing Stafford County water supply system was calculated by O'Brien & Gere and is described in the report ***Comprehensive Water Supply Study*** (O'Brien & Gere, 1991). The O'Brien & Gere study estimated the raw water safe yield of Abel Lake to be 6.1 mgd at 139 feet normal pool elevation. Safe yield studies for the expansion of Smith Lake were conducted by Woodward-Clyde Consultants (1994). Based on their safe yield modeling for the expanded Smith Lake, its raw water safe yield was estimated at 7.7 mgd.

Woodward-Clyde conducted the safe yield analysis for the Smith Lake expansion in April 1994; therefore, the most recent drought in 1999 to 2002 was not included in their analysis. An evaluation of monthly streamflow data in Aquia Creek near Garrisonville (USGS 1660400 with 34.9 square mile drainage area) was performed by Malcolm Pirnie to determine what if any, effect the more recent drought would have on the existing safe yield analysis. This is the gage that was used by Woodward-Clyde in their safe yield analysis for predicting flows into Smith Lake. The minimum 6-month and 8-month running averages for analysis for streamflow at Garrisonville gaging station occurred in January 1981. The minimum storage level in the Woodward–Clyde safe yield analysis was reached after 6 to 8 months of drawdown; therefore, use of more recent data would not be expected to reduce estimated safe yield. However, safe yield analysis has not been performed to confirm 1980 – 1981 was the most severe drought for Smith Lake. The results of the Aquia Creek streamflow analysis are summarized in Table 2-1.

TABLE 2-1

SUMMARY OF AQUIA CREEK MONTHLY STREAMFLOW ANALYSIS
(ALL FLOW VALUES IN CFS)

| | 1 Month Average | 6-Month Running Average | 8-Month Running Average | 12-Month Running Average | 16-Month Running Average |
|---|---|---|---|---|---|
| Minimum All Month | 0.06 | 2.97 | 4.07 | 7.79 | 7.61 |
| Occurred in Period Ending | Sept 1980 | Jan 1981 | Jan 1981 | Sept 2002 | Oct 2002 |
| Minimum 1980 - 1981 | 0.06 | 2.97 | 4.07 | 7.96 | 10.21 |

The Woodward-Clyde (1994) safe yield study assumed that the Lunga reservoir watershed would not contribute inflows into Smith Lake. This conservative approach was used because of Lunga Reservoir's relatively small drainage area and assumed that very little runoff would reach Smith Lake, particularly during times of drought. Therefore, the discontinuation of daily QMCB withdrawals from Lunga Reservoir should not impact the estimated safe yield of the existing county water system. However – when available and if utilized at key times during low-flow conditions at sufficient flow rates – the agreed upon releases from Lunga Reservoir to Beaverdam Run are intended to sustain, and possibly to marginally increase, the short-term of Smith Lake. This would, at most, be to an extent necessary to offset the up to 0.75 mgd of treated water purchased by QMCB-CB from the county water system. According to these studies, the total long-term raw water safe yield of the existing water supply system is 13.8 mgd.

### 2.2.2 Treated Water Safe Yield – Adjusted for Process and Other Water Losses

To estimate the percentage of water losses in the raw water transmission system and water treatment processes, Stafford County Department of Utilities water treatment facility process water records were reviewed in July 2000. These data are listed in Table 2-2 and indicate that process use has averaged 5.2% of average raw water withdrawals over the period 1991 – 1999 and has been as high as 7.8% on an annual basis. It should be recognized that compliance with increasingly stringent requirements under the Safe Drinking Water Act may result in larger treatment losses. For example, more frequent filter backwashing may be necessary to comply with more stringent turbidity requirements associated with the Interim Enhanced Surface Water Treatment Rule.

TABLE 2-2
PROCESS USE AT STAFFORD COUNTY
WATER TREATMENT FACILITIES

| Year | Process Water (mgd) | Raw Water Withdrawals (mgd) | Process Use as % of Raw Water Withdrawals |
|---|---|---|---|
| 1992 | 0.19 | 4.46 | 4.2 |
| 1993 | 0.31 | 5.10 | 6.1 |
| 1994 | 0.39 | 5.76 | 6.8 |
| 1995 | 0.47 | 6.03 | 7.8 |
| 1996 | 0.29 | 5.92 | 4.8 |
| 1997 | 0.31 | 6.44 | 4.8 |
| 1998 | 0.22 | 6.93 | 3.1 |
| 1999 | 0.28 | 7.61 | 3.7 |
| | | Average 1992-1999 | 5.2 |

Source: Stafford County Needs Assessment, Malcolm Pirnie, April 2001

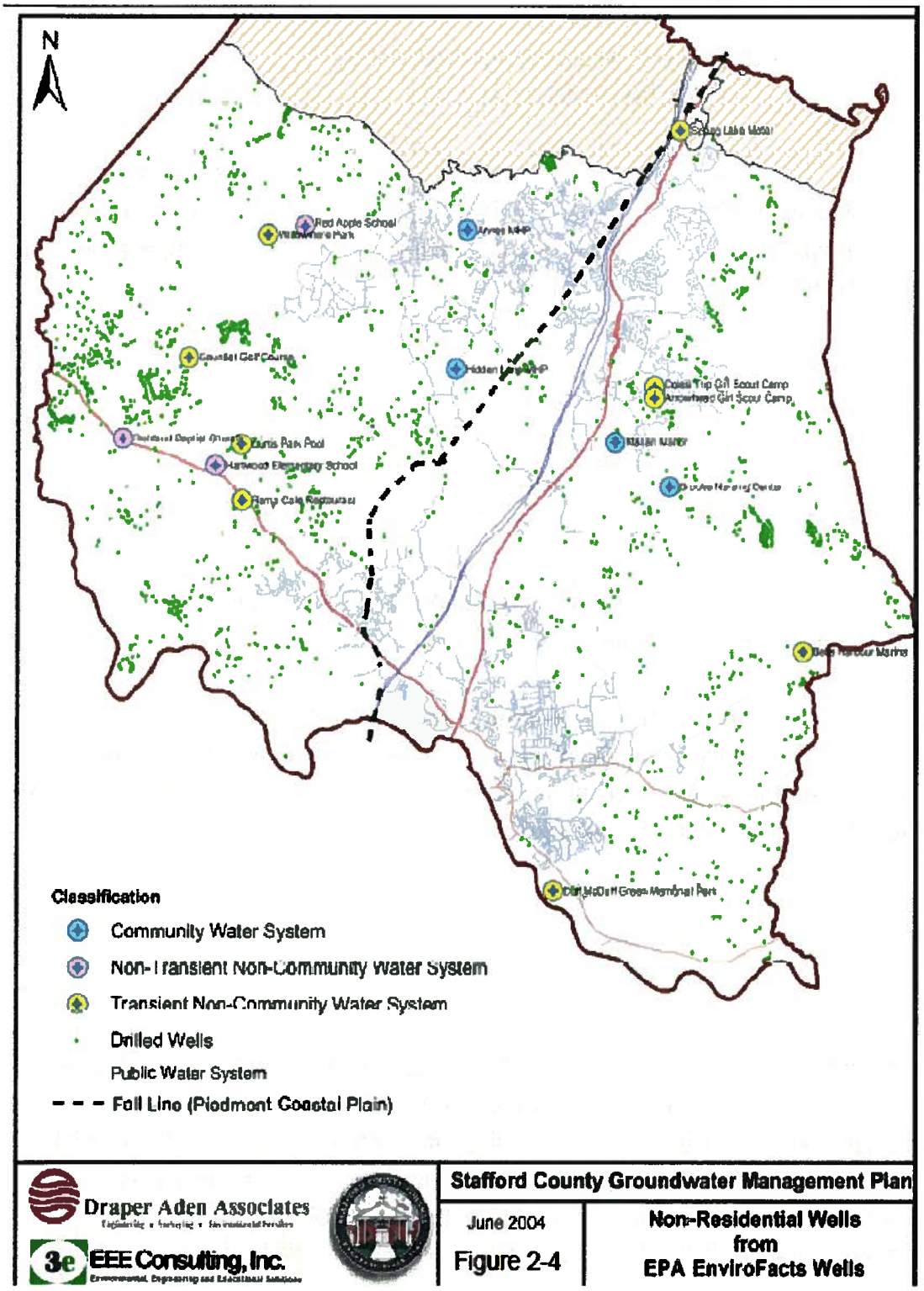
The values in Table 2-2 do not include any potential losses in raw water transmission to the treatment facilities. Consequently, a 6% allowance is made to account for both raw water transmission and treatment losses. Accounting for these losses, the total treated water safe yield of the existing system is approximately 13.0 mgd.

## 2.3 Surface Water Sources

### 2.3.1 County System

The existing Stafford County system consists of two surface water reservoirs, Abel Lake and Smith Lake. Smith Lake has a contributing drainage area of 55.2 square miles and is located on Aquia Creek, approximately 9 miles upstream from its confluence with the Potomac River. The reservoir is impounded by an earthen, roller-compacted concrete embankment and, following a recent expansion from a normal pool elevation of 70 feet to 90 feet, has a capacity of 2.11 BG at full pool elevation and 1.79 BG usable water.

# EXISTING WATER SOURCES



Abel Lake is located on Potomac Creek approximately 10 miles from its confluence with the Potomac River. Abel Lake is impounded by an earthen dam and has a surface area of 185 acres. The reservoir has a contributing drainage area of 30.5 square miles. Normal pool elevation is 139 feet. Total storage capacity is 1.303 BG (O'Brien & Gere, 1991) with a usable capacity of 0.98 BG. The total combined usable storage capacity available for water supply in the two reservoirs is 2.77 BG.

### 2.3.2 Quantico System

Lunga Reservoir is located on Beaverdam Run (a tributary creek) about 3.5 miles upstream from Smith Lake. Lunga Reservoir has a large surface area with a relatively small tributary drainage area. As of 1985, Lunga had an estimated 1.7 BG water storage available under normal conditions. Currently (2005), the stored water remains available for periodic transfer via pipeline to supplement water storage in Breckenridge Reservoir, which the QMCB-Mainside water system in Prince William County relies on for water supply. Also, QMCB has agreed to make releases from Lunga Reservoir, as needed, to compensate for up to 0.75 mgd of treated water that QMCB-CB purchases from the Stafford County water system. This raw water can be released to Beaverdam Run to supplement storage in Smith Lake.

## 2.4 Groundwater Sources

Individuals and communities utilize groundwater wells within Stafford County for their potable water needs. The vast majority of groundwater wells service single family homes. Figure 2-4 illustrates the individual and community groundwater wells within Stafford County. As part of the *Stafford County Groundwater Management Plan (*Draper Aden Associates, October 2004), it was estimated that the 2002 residential groundwater use within the county was 1.75 mgd and agricultural groundwater use was estimated at 800,000 gpd for approximately six months out of the year. This estimate was based on the number of municipal water accounts in the county and the 2002 population, assuming an average of three people per account. The total amount of groundwater users was multiplied by a per capita use rate of 70 gpd, which resulted in the estimate of 1.75 mgd of groundwater being used for residential use.

The County estimate of the 2005 residential ground water use within the County was 2.1 mgd and agricultural and golf course ground water use was estimated at 800,000 gpd for approximately six months out of the year. As discussed in Section 2.1.3, this residential ground water use estimate was based on the number of municipal water accounts in the County and the 2005 population, assuming an average of three people per account. The total amount of ground water users was multiplied by a per capita use rate of 70 gpd, which resulted in the estimate of 2.1 mgd of ground water being used for residential use.

A Groundwater Vulnerability Analysis with respect to both yield and water quality was performed as part of the *Stafford County Groundwater Management Plan*. The analysis determined that the greatest single variable with respect to groundwater supply vulnerability is the nature and depth of individual wells. Shallow wells are often constructed in the Coastal Plain aquifer; these shallow wells are quite susceptible to impacts from surface water contamination, but are largely unthreatened by deeper wells in the Middle Potomac Aquifer. However, shallow wells within the Piedmont region are often protected from surface impacts by a well developed and continuous clay subsoil layer, but they are susceptible to drought and pumping from deeper wells.

The county has adopted the *Stafford County Groundwater Management Plan*. The Plan includes high-level groundwater management strategies, including hydrogeological testing for new development and a groundwater protection overlay zone in the aquifer recharge area. The objective of this Plan is to protect existing groundwater wells, discourage proliferation of development relying on wells and assess existing risks. Hydrogeological testing will be required for new well development to verify the reliability of the water source and the compatibility with existing wells in the area.

As of 2005, in addition to residential, business and agricultural uses, several golf courses, the Vulcan Quarry and Cardinal Concrete have made groundwater withdrawals. Source descriptions can be found in Section 3.2.4 of this document. In addition, limited readily available well construction or capacity data can be found in Appendix C.

## 2.5 Future Water Sources – Rocky Pen Run Reservoir and Rappahannock River Withdrawals

A third water supply reservoir is being developed in southern Stafford County. The Rocky Pen Run Reservoir, located between Route 17 and the Rappahannock River west of Interstate I-95, is planned to open by the spring of 2012. The reservoir surface area will cover 503 acres and hold 5.29 BG of water. The reservoir has a drainage area of 5.18 square miles and will draw water from the Rappahannock River. This project is currently under design and major permits are in place. A description of the project is given below, and the location of the reservoir and system components is depicted on Figure 2-5.

### 2.5.1 Operational Summary

The Rocky Pen Run Reservoir will be operated as an off-stream raw water storage reservoir. Because of its small drainage area (5.18 square miles), the yield from this project will come primarily from water pumped from the Rappahannock River. River withdrawals will be restricted by the permitted minimum in-stream flow (MIF) levels. Raw water will be withdrawn from the reservoir and treated as required to meet system treated water demands. When the reservoir level drops below the normal pool, and as permitted by the MIF levels, water will be withdrawn from the Rappahannock River and pumped to the reservoir. Additional details regarding the permitted water withdrawal conditions for the Rappahannock River are discussed in Section 2.5.4 and Section 7.2.

### 2.5.2 Reservoir Pool

The 503-acre Rocky Pen Run Reservoir will store a total of 5.29 BG at a normal pool elevation of 230 feet msl. The reservoir drainage area of 5.18 square miles is generally bounded by State Route 655 to the northwest, U.S. Route 17 to the northeast, State Routes 654 and 656 to the east, and State Route 654 also to the west. Route 654 crosses the reservoir pool area approximately 3,000 feet upstream of the dam site. It will be flooded to a maximum depth of approximately 116 feet by the normal reservoir pool level at 230 msl.

The reservoir will contain three major arms. The main arm will be formed along Rocky Pen Run. A smaller arm will branch to the west at the Route 654 crossing of Rocky Pen Run. A large peninsula will be formed between these arms. The smallest arm will branch to the east and wrap around Route 654, forming a peninsula with the road along its center.

### 2.5.3 Rappahannock River Withdrawals

Stafford County does not have community systems that rely directly on stream intakes. The Rocky Pen Run Reservoir will be filled by a combination of runoff from the reservoir watershed and water pumped from the Rappahannock River. A 40-mgd Rappahannock River Pump Station will be located on the north shore of the river at river mile 118.6, approximately 10,000 feet upstream of the mouth of Rocky Pen Run. This pump station will draw water from the river and pump it to an outfall on the proposed reservoir shoreline through a 48-inch diameter, 2,600-foot raw water pipeline.

### 2.5.4 Safe Yield Analysis of Rocky Pen Run Reservoir

Methodology

The Rocky Pen Run Reservoir safe yield model was used to develop raw water safe yield estimates based on a 97-year simulation period (October 1907 through September 2004). A monthly time step was used for water balance calculations, with a separate linked daily simulation nodule to first compute allowable monthly Rappahannock River withdrawals between January 1961 and December 1972. The severe early 1930s drought period was excluded from consideration in this analysis; however, a discussion of the safe yield using the 1930s drought is provided later in this section for comparison.

The estimated total volume of the reservoir is 5.29 BG at a normal pool elevation of 230 feet msl based on the results of dimensional analysis performed using detailed 2-foot contour mapping of the reservoir site. All scenarios considered unusable volume to be 25% of the 5.29 BG total volume. The estimated surface area of the reservoir when full is 503.5 acres based on the results of dimensional analysis, and a regression equation was used to relate reservoir surface area to volume in the safe yield model.

The analysis assumed compliance with Rappahannock River minimum in-stream flow (MIF) levels similar to those defined in the Virginia Department of Environmental Quality March 21, 1995 Virginia Water Protection Permit (VWPP) for Spotsylvania County's Hunting Run Reservoir. However, based on the DEQ VWPP that was issued to Stafford County, these MIF levels were modified to incorporate 100 Tennant levels from March through May under normal conditions when the reservoir is nearly full. This change is based on Embrey Dam having now been removed. The MIF levels were further modified by adding a 44 mgd allowance to each monthly MIF level that is based on a 6 mgd water treatment plant capacity for Fredericksburg, plus a 14 mgd maximum Rappahannock River withdrawal for Spotsylvania County. These allowances were made for maximum withdrawals by Fredericksburg and Spotsylvania County to assure that their allowable withdrawals would not be affected by Stafford County's proposed withdrawals. Figure 2-6 illustrates the Rappahannock River allowable pumping rates into the Rocky Pen Run Reservoir.

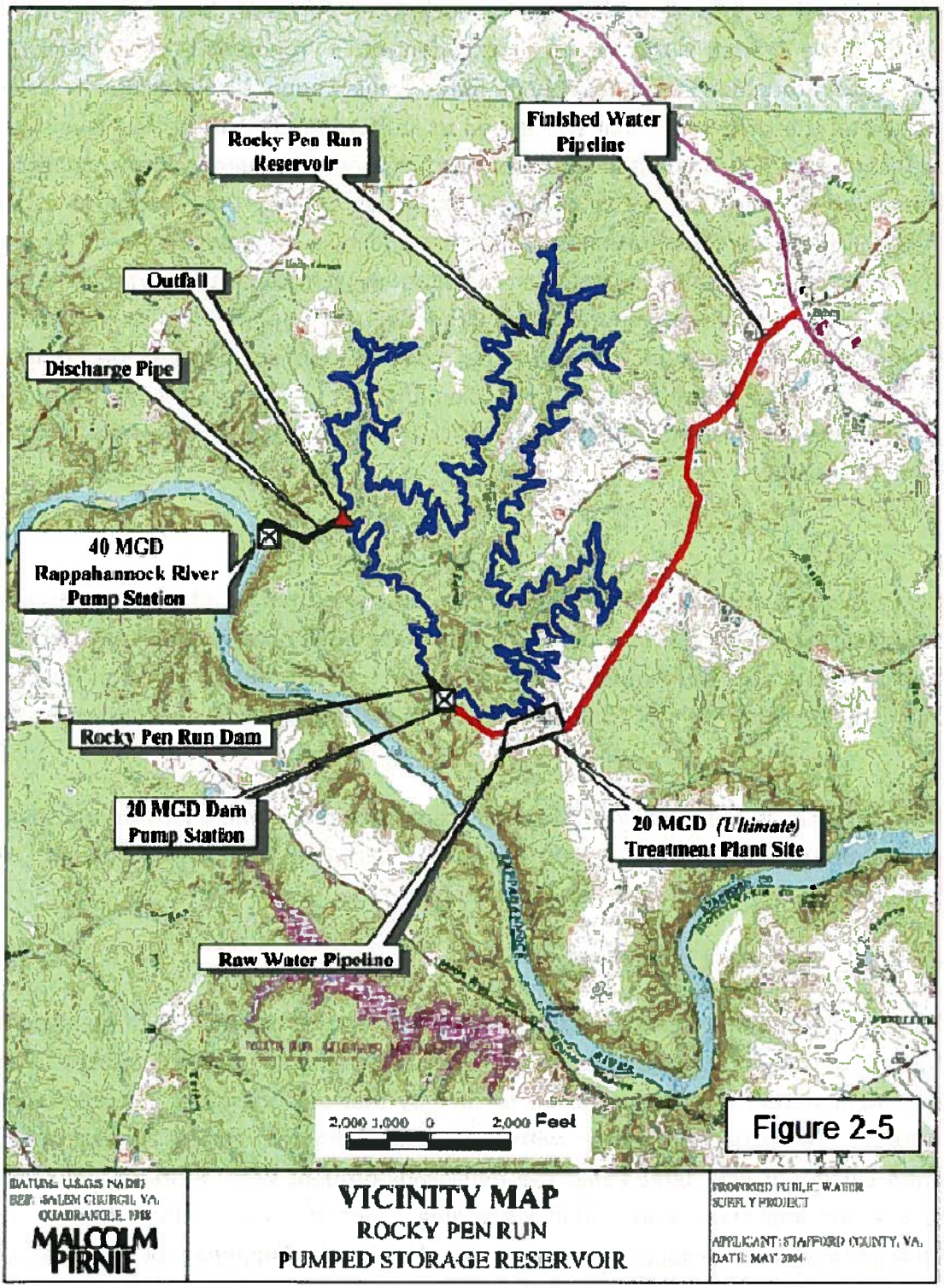
Results

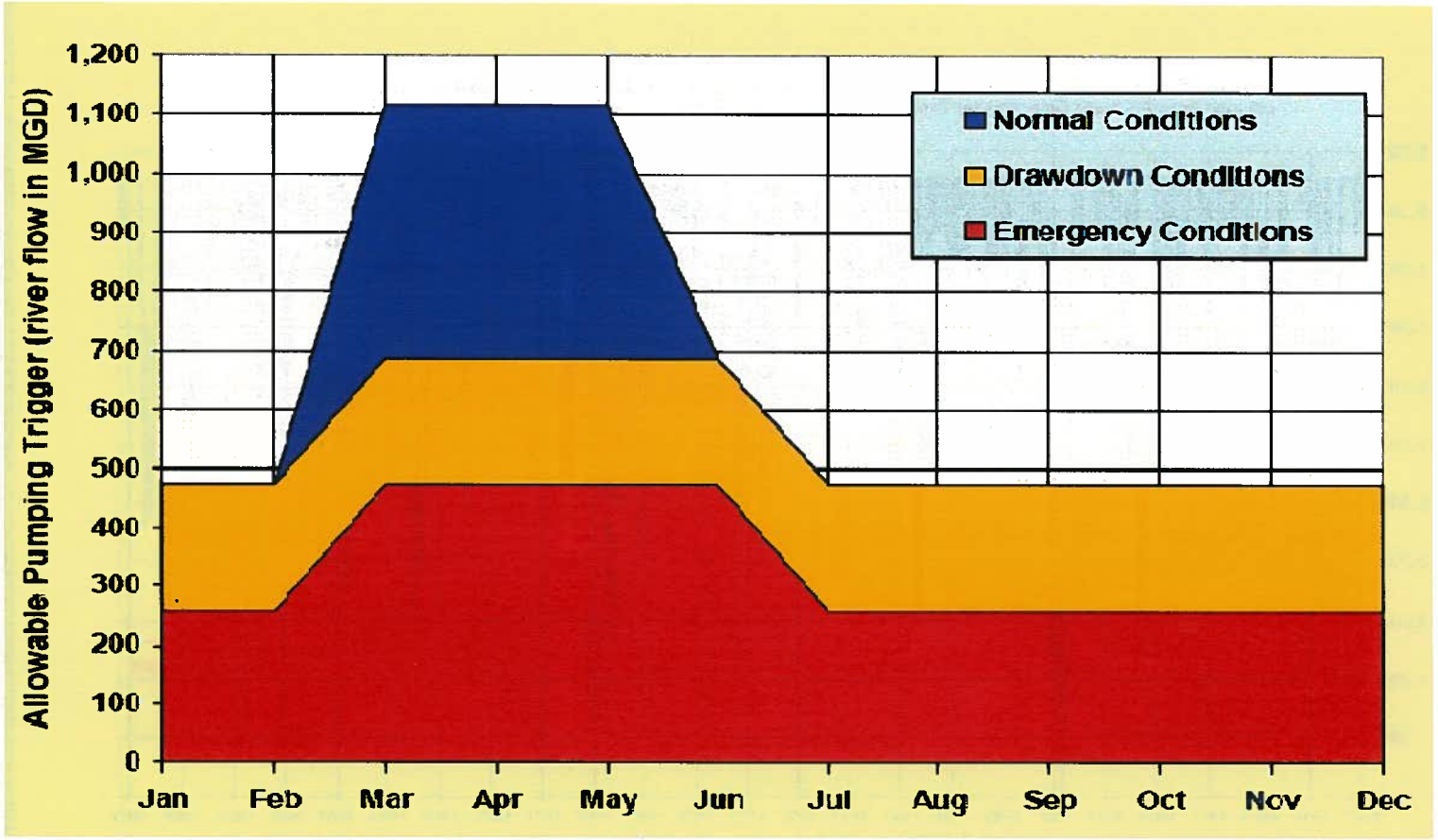
The analysis resulted in a Rocky Pen Run Reservoir safe yield estimate of 13.04 mgd with a normal pool elevation of 230 feet msl and a Rappahannock River withdrawal capacity of 40 mgd. Figure 2-7 illustrates the Simulated Storage History for the Rocky Pen Run Reservoir based on the estimated safe yield of 13.04 mgd and a 40 mgd Rappahannock River withdrawal rate.

As part of this analysis, it was confirmed for each scenario that the mid-1960s drought is the controlling drought when the early 1930s drought is excluded from consideration. The minimum simulated reservoir storage level was in January 1966.

Comparison of Safe Yield Using 1930s Drought

The estimated Rocky Pen Run Reservoir project safe yield for the early 1930s drought period was, for the various scenarios considered, 70 to 80 percent of the safe yield estimated for the mid-1960s drought period that was adopted for use by Stafford County in its water supply planning efforts. Through coordination with and input from the Virginia Department of Environmental Quality, it was agreed that the mid-1960s drought was the more appropriate drought to use for long-term water supply planning, since the early 1930s drought was estimated to have an extremely long recurrence interval within the Rappahannock River basin.


Rocky Pen Run Reservoir
Finished Water Pipeline
Outfall
Discharge Pipe
40 MGD Rappahannock River Pump Station
Rocky Pen Run Dam
20 MGD Dam Pump Station
20 MGD (Ultimate) Treatment Plant Site
Raw Water Pipeline
2,000 1,000 0 2,000 Feet
Figure 2-5
VICINITY MAP
ROCKY PEN RUN
PUMPED STORAGE RESERVOIR
MALCOLM PIRNIE

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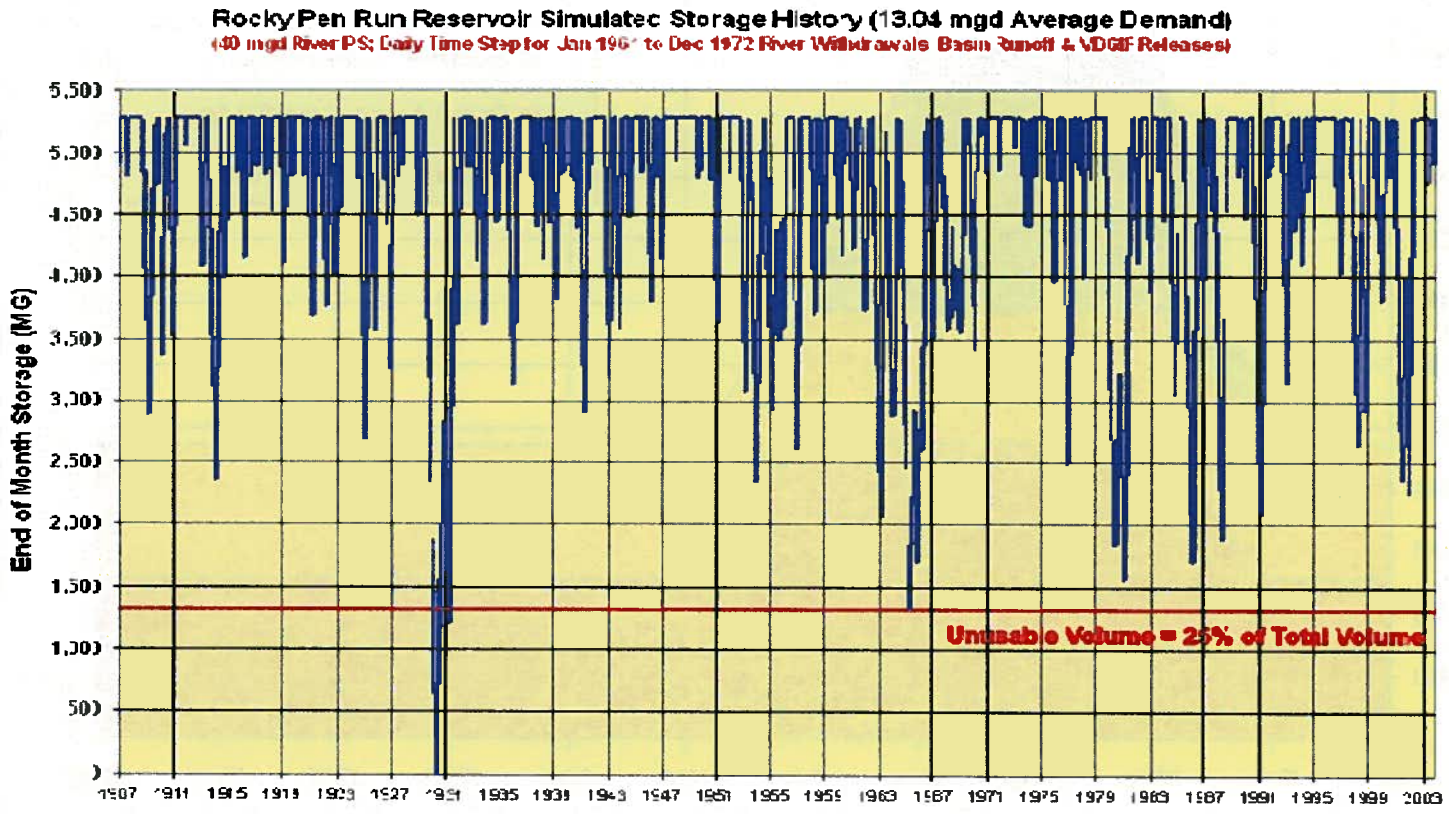
Rappahannock River Allowable Pumping Rules

FIGURE 2-6




MALCOLM PIRNIE

Rocky Pen Run Reservoir Simulated Storage History

FIGURE 2-7

# Chapter 3 EXISTING WATER USE

The following section focuses on the off-stream use and consumption of water within Stafford County. It is acknowledged that there are several other beneficial in-stream uses of the water bodies within Stafford County such as supporting aquatic life, recreation, navigation, and wastewater assimilation.

## 3.1 Customers Served

Stafford County public water system currently serves an estimated 29,116 residential customers (i.e., residential accounts as of 2005), over 1,000 businesses and a portion of the Quantico Marine Corps Base within Stafford County. With its proximity to major industrial and commercial markets and its high percentage of undeveloped land, the county is experiencing rapid residential and commercial development. The service area population and the demand for water and sewer services have approximately quadrupled in the last 20 years and continue to grow. Section 5.1.4 contains additional details regarding the population served within Stafford County.

## 3.2 Raw Water Withdrawals

The Virginia Department of Environmental Quality (VDEQ) adopted "Regulation 11", was initially effective March 1, 1982. A subsequent amended regulation (9 VAC 25-200 - §10 - §50) took effect on December 5, 1990. This regulation requires every water user whose average daily withdrawal of groundwater or surface water exceeds 10,000 gallons per day (gpd) during any single month to report monthly withdrawals to VDEQ annually. However, the reporting requirement applies to water withdrawals for crop irrigation only if the withdrawal exceeds 1 million gallons in any single month. Users exempt from reporting raw water withdrawals include: dry-dock fillings, withdrawals from mines or quarries solely for the purpose of dewatering, and withdrawals made solely for hydropower generation. Although certain self-supported water users operating in Stafford County are exempt from required reporting of raw water withdrawals, or were exempt between 1982 and 1990, estimates and voluntary reports to VDEQ of such withdrawals are available and are discussed in this section.

### 3.2.1 Withdrawals for County Water Supply System

Historical raw water withdrawal data reported under Regulation 11 for the Stafford County public water supply system are presented in Table 3-1. The maximum monthly raw water withdrawal and the month during which it occurred are also included in this table for years 1996 through 2005. These data indicate an 8.2% average annual compound growth rate for raw water withdrawals for the period 1982 – 2005.

**TABLE 3-1**
**AVERAGE ANNUAL RAW WATER WITHDRAWALS**
**Combined Abel Lake and Smith Lake (1982 to 2005)**

| Year | Withdrawal (mgd) | Max. Month Withdrawal (mgd) |
|---|---|---|
| 1982 | 1.66 | - |
| 1983 | 2.00 | - |
| 1984 | 2.09 | - |
| 1985 | 2.30 | - |
| 1986 | 2.58 | - |
| 1987 | 2.76 | - |
| 1988 | 3.26 | - |
| 1989 | 3.83 | - |
| 1990 | 4.10 | - |
| 1991 | 4.43 | - |
| 1992 | 4.46 | - |
| 1993 | 5.10 | - |
| 1994 | 5.76 | - |
| 1995 | 6.03 | - |
| 1996 | 5.92 | 6.81 (August) |
| 1997 | 6.44 | 7.79 (July) |
| 1998 | 6.93 | 8.53 (August) |
| 1999 | 7.61 | 10.16 (June) |
| 2000 | 7.11 | 8.13 (May) |
| 2001 | 7.85 | 9.24 (July) |
| 2002 | 8.53 | 11.35 (July) |
| 2003 | 8.68 | 10.68 (July) |
| 2004 | 9.13 | 10.23 (July) |
| 2005 | 10.16 | 12.93 (June) |

Source: Stafford County Department of Utilities Raw Water Withdrawal Records, 1982 – 2005
1996 – 2005 Maximum month from DEQ raw water withdrawal data

As discussed in Section 5.1.5, residential monthly demand ratios were computed for each of the last 10 years (see Figure 5-7). Based on these ratios, the lowest months of residential use are December through May. In addition, a peak day factor of 1.67 was calculated as part of the Water and Sewer Master Plan (O'Brien & Gere, March 2005) using data from 2002. This peaking factor was derived by dividing the maximum day demand by the average day demand for that year. When applied to the daily average raw water withdrawal for 2005 (10.16 mgd), the total maximum daily withdrawal could approach 17 mgd, which is less than the 20 mgd rated capacity of the water treatment system.

### 3.2.2 Quantico Withdrawals

As discussed in Section 2.1.2, Quantico Marine Corps Base (i.e., QMCB–Mainside water system in Prince William County) utilizes Lunga Reservoir to Breckenridge Reservoir raw water transfers to supplement the Base's supply. Periodic raw water storage transfers from Lunga Reservoir to Breckenridge Reservoir made during July through December 2005 totaled 0.340 BG. For purposes of this water supply plan, this is not considered as Stafford County water use.

The Lunga and Breckenridge reservoirs are not considered potential water supply sources for Stafford County, because water from these reservoirs would primarily be used to supply QMCB-Mainside; except to the extent that Lunga Reservoir releases may be used to augment Smith Lake storage (via Beaverdam Run stream flow) in order to offset QMCB-CB purchases from the Stafford County water system. Since April 1999, no daily withdrawals have been made from Lunga Reservoir to directly supply water to QMCB-CB, the portion of the base within Stafford County. The portion of QMCB within Stafford County now relies solely on the County water supply system for its potable water needs. The Year 2005 treated water bulk sales to QMCB-CB, or military water use, which averaged 0.5 mgd with a maximum of 0.6 mgd, are included in the County water system totals given in Table 3-1 and Table 3-8.

### 3.2.3 Other Surface Water Withdrawals

#### 3.2.3.1 Fredericksburg Sand and Gravel

The Fredericksburg Sand and Gravel (FS&G) Pit is owned by Stafford County and is located near the county's Little Falls Run Wastewater Treatment Facility and the Rappahannock River off Route 3 approximately 4 miles east of Fredericksburg (see Figure 3-1). During operations, FS&G was permitted to withdraw water from the Rappahannock River to be used as process water for their facility. As of October 2002, the FS&G Pit was mined out and the mining company was prepared to initiate the reclamation process that is required by the Virginia Division of Mines, Minerals and Energy; therefore, no surface water withdrawals are currently being made at this quarry. Historic monthly surface water withdrawals for FS&G are presented in Table 3-2. The average annual withdrawal ranges from 0.03 to 0.81 mgd.

**Table 3-2**
**Fredericksburg Sand and Gravel Surface Water Withdrawals**
**(Rappahannock River)**

| | Average Daily Withdrawal (mgd) | | | | |
|---|---|---|---|---|---|
| **Month** | **1996** | **1997** | **1998** | **1999** | **2000** |
| **January** | 0.00 | 0.54 | 0.04 | 0.03 | 0.00 |
| **February** | 0.00 | 0.93 | 0.05 | 0.05 | 0.00 |
| **March** | 0.52 | 1.12 | 0.05 | 0.05 | 0.00 |
| **April** | 0.84 | 0.85 | 0.42 | 0.38 | 0.00 |
| **May** | 0.85 | 1.01 | 0.52 | 0.49 | 0.07 |
| **June** | 0.73 | 0.78 | 0.68 | 0.00 | 0.09 |
| **July** | 0.87 | 0.95 | 0.72 | 0.00 | 0.18 |
| **August** | 0.85 | 0.75 | 0.72 | 0.36 | 0.09 |
| **September** | 0.73 | 0.79 | 0.81 | 0.40 | 0.00 |
| **October** | 0.83 | 0.88 | 0.58 | 0.30 | 0.00 |
| **November** | 0.59 | 0.54 | 0.41 | 0.20 | 0.00 |
| **December** | 0.43 | 0.54 | 0.21 | 0.10 | 0.00 |
| **Average** | **0.60** | **0.81** | **0.43** | **0.20** | **0.03** |

### 3.2.3.2 Vulcan Quarry

Vulcan Materials Company owns and operates the Vulcan Quarry, located in Stafford County west of Garrisonville (see Figure 3-1). During normal mining operations, the quarry withdraws surface water from Aquia Creek to be used as process water at the facility. Table 3-3 summarizes the average monthly surface water withdrawals as reported to DEQ for the years 1996 through 2005. The average annual withdrawal from Aquia Creek ranges from 0.24 to 0.32 mgd. It should be noted that the discharges to Aquia Creek from the groundwater sump withdrawals in the quarry (on the order of 0.33 mgd annual average – see Section 3.2.4.2) are of a similar magnitude as the surface water withdrawals. Over the long term, this may tend to offset impacts of surface water withdrawals on stream flow and on storage in Smith Lake which is downstream.

**Table 3-3**
**Vulcan Quarry Surface Water Withdrawals**
**(Aquia Creek)**

| Month | Average Daily Withdrawal (mgd) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1996 | 1997 | 1998 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
| January | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.07 | 0.07 | 0.06 |
| February | 0.04 | 0.04 | 0.04 | 0.03 | 0.04 | 0.05 | 0.05 | 0.04 | 0.04 |
| March | 0.15 | 0.14 | 0.10 | 0.16 | 0.13 | 0.11 | 0.05 | 0.09 | 0.11 |
| April | 0.33 | 0.35 | 0.30 | 0.31 | 0.32 | 0.30 | 0.25 | 0.26 | 0.35 |
| May | 0.36 | 0.39 | 0.35 | 0.39 | 0.37 | 0.35 | 0.25 | 0.33 | 0.38 |
| June | 0.44 | 0.45 | 0.48 | 0.43 | 0.30 | 0.42 | 0.35 | 0.36 | 0.42 |
| July | 0.35 | 0.39 | 0.48 | 0.41 | 0.31 | 0.43 | 0.31 | 0.45 | 0.49 |
| August | 0.29 | 0.32 | 0.52 | 0.44 | 0.35 | 0.40 | 0.35 | 0.46 | 0.46 |
| September | 0.24 | 0.28 | 0.35 | 0.33 | 0.40 | 0.27 | 0.29 | 0.50 | 0.34 |
| October | 0.27 | 0.30 | 0.36 | 0.37 | 0.44 | 0.29 | 0.41 | 0.44 | 0.25 |
| November | 0.24 | 0.28 | 0.32 | 0.34 | 0.47 | 0.25 | 0.26 | 0.46 | 0.29 |
| December | 0.13 | 0.16 | 0.19 | 0.15 | 0.16 | 0.15 | 0.20 | 0.34 | 0.33 |
| **Average** | **0.24** | **0.26** | **0.30** | **0.29** | **0.28** | **0.26** | **0.24** | **0.32** | **0.29** |

Source: 1996 – 2005 DEQ raw water withdrawal data
Note: No data were reported to DEQ for 1999 withdrawals

### 3.2.3.3 Gauntlet Golf Course

The Gauntlet Golf Course, owned and operated by Golf Course Specialists, Inc., is located approximately 12 miles northwest of Fredericksburg, Virginia (see figure 3-1). The golf course utilizes water from Curtis Lake for onsite irrigation of its courses. The system has a 1,600 gpm capacity. Limiting the number of hours of operation defines the daily withdrawal. The Virginia Department of Game and Inland Fisheries (VDGIF) has placed limitations on withdrawals based on the water surface level in Curtis Lake. The withdrawals made from Curtis Lake, which is on Long Branch Creek, a tributary of Potomac Creek upstream of Abel Lake, as reported to the DEQ in January 2007 for 2006 are presented in Table 3-4. Year 2006 is the first recent year that water withdrawals have been reported for the Gauntlet Golf Course which is the only golf course in Stafford County currently reporting water withdrawals. Up to three additional golf courses were operating as of 2005 – 2006.

For planning and projection purposes, in the absence of better data, the Gauntlet Golf Course year 2006 withdrawals: (a) projected to remain steady at 2006 levels throughout the planning period (Section 5.3.1) and (b) used to estimate (Section 3.2.4.1) or project the water used by other golf courses in the county for 2005 – 2007.

**Table 3-4**
**Gauntlet Golf Course Surface Water Withdrawals**
**(Curtis Lake / Long Branch Creek)**

| Month | Average Daily Withdrawal (mgd) |
|---|---|
| January | 0.000 |
| February | 0.000 |
| March | 0.041 |
| April | 0.055 |
| May | 0.055 |
| June | 0.113 |
| July | 0.107 |
| August | 0.105 |
| September | 0.026 |
| October | 0.008 |
| November | 0.002 |
| December | 0.001 |
| **Average Annual Withdrawal** | **0.043** |
| **Seasonal Average Withdrawal 6 months (April – September)** | **0.077** |

Source: 2006 DEQ raw water withdrawal data

### Section 3.2.3.4 Aquia Harbour Golf & Country Club

Also in the Lower Potomac River – Aquia Creek watershed downstream of Smith Lake, Aquia Harbour G&CC irrigates turf for a 9-hole golf course using a pumped withdrawal from a tributary stream on-site. Aquia Harbour G&CC is estimated to use 0.043 mgd annual average or 0.077 mgd during the April – September peak season.

### Section 3.2.3.5 Cannon Ridge Golf Course at Celebrate! Virginia

This 18-hole golf course withdraws turf irrigation water from an impoundment of minor tributaries of the Rappahannock River. The Year 2005 water use is estimated at 0.092 mgd annual average or 0.161 mgd during the April- September peak season, based on reported withdrawals for the year 2008.

## 3.2.4 Groundwater Withdrawals

In calendar year 2005, groundwater withdrawals averaged 3.01 mgd with a 6-month seasonal peak withdrawal average of 3.89 mgd. Residential potable water usage averaged 2.10 mgd with a 6-month seasonal peak of 2.22 mgd. Non-community business potable water usage averaged 0.04 mgd with a 6-month seasonal peak of 0.08 mgd. Heavy industrial/mining groundwater withdrawals averaged 0.34 mgd with a 6-month seasonal average of 0.56 mgd. Golf course irrigation usage averaged 0.13 mgd with a 6-month seasonal average of 0.231 mgd. Agricultural withdrawals averaged 0.40 mgd with a 6-month seasonal average of 0.8 mgd. These data are summarized in Table 3-9.

### 3.2.4.1 Residential and Agricultural Groundwater Use

Current groundwater use is largely residential in nature, with the majority of wells servicing single family homes. Table 3-7 below presents an estimate of the groundwater demand on a county-wide basis based on residential municipal water accounts, which was developed as part of the Stafford County Groundwater Management Plan. This plan estimated that residential groundwater use in 2002 was approximately 1.75 mgd, using the assumption that there are three users per municipal account with a per capita use rate of 70 gpd. This residential groundwater per capita use rate of 70 gpd is slightly higher than the 68 gpd rate used for estimating demand on the county's water supply system (see Section 5.1.5), because some allowance for losses must be made for well-based systems. Water loss was estimated separately for the county system.

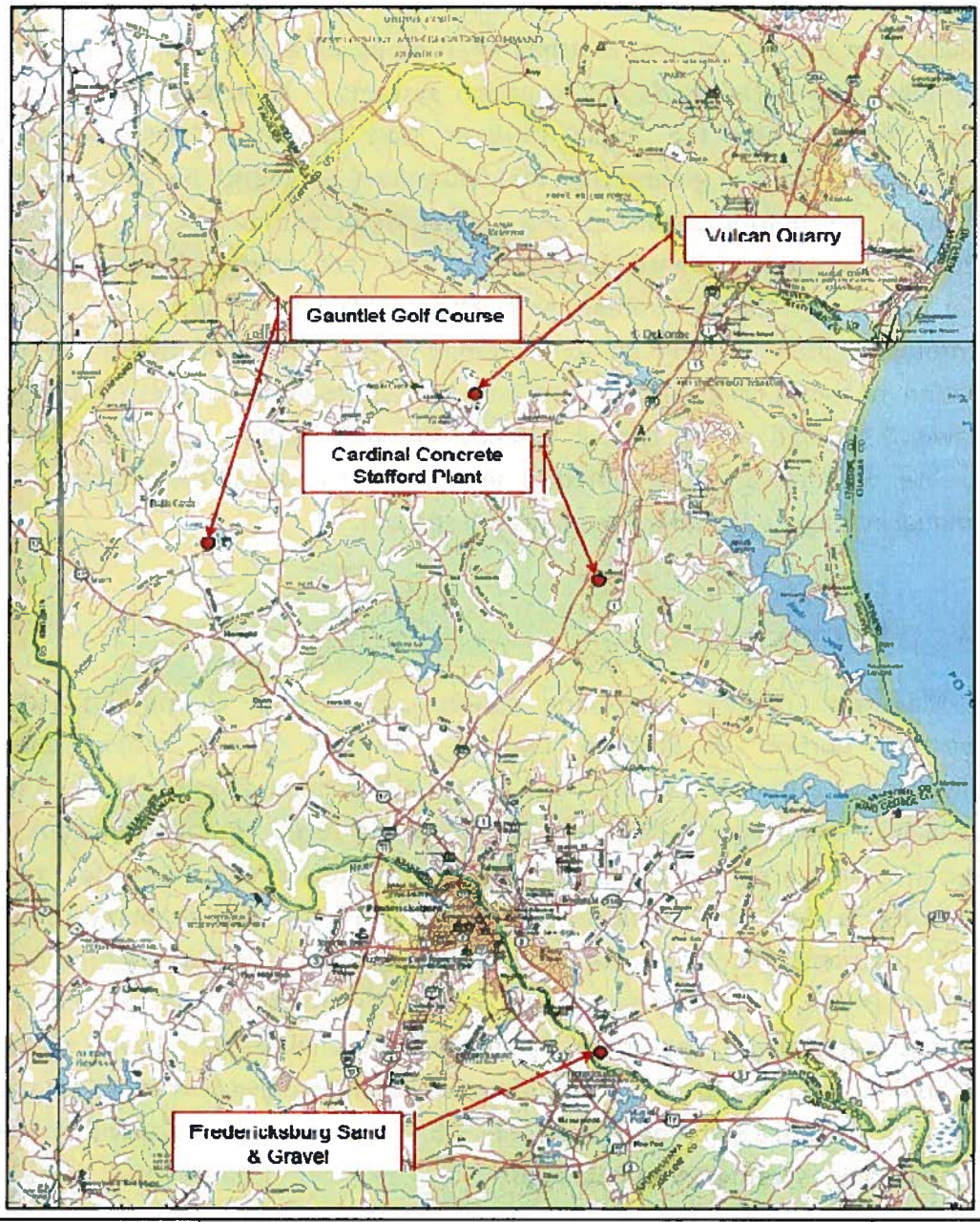
Inquiry with various state and agricultural professional organizations resulted in an estimate of 20 agricultural wells with an average production of 40,000 gpd. No records of production are required for agricultural wells, and they are seasonal in nature. Based on the current estimate, 800,000 gpd are used for agriculture, for approximately six months of the year. Additional groundwater use may occur in the future if multiple golf course developments such as the proposed Augustine one are implemented. The total agricultural and commercial (golf course) demand could be as high as 1.6 mgd. On the high end, it is possible that production from the aquifers underlying Stafford County could range between 3 and 4 mgd in the near future if the proposed golf courses are developed. (Draper Aden, GW Management Plan, 2004).

Currently (2005), as discussed in Section 2.1.3 and Section 2.4, there are an estimated 29,952 people in approximately 9,984 households using 2.1 mgd of groundwater, principally from individual self-supplied residential wells. However, this population and the estimated 2.1 mgd effectively includes that total of approximately 0.014 mgd of groundwater use that is reported to VDH by the four privately operated Community water systems detailed in Appendix C. For 2005, an additional 0.040 mgd of groundwater is used by 12 non-community water systems that are regulated by VDH. As a result, a minimum of 2.14 mgd of groundwater withdrawals by self-supplied users of less than 300,000 gallons per month is estimated.

As of 2005, 3 of the golf courses that had been proposed are developed and operating, using groundwater withdrawals for irrigation systems – Augustine, Cannon Ridge at Celebrate Virginia, and the Aquia Harbour Golf Course. These self-supported commercial water users of greater than 300,000 gallons per month have not reported the water source descriptors, capacities and annual water withdrawals to VDEQ to date. Their 2005 water use is estimated to be the same as that reported for year 2006 for the Gauntlet (0.043 mgd annual average, an average of 0.077 mgd during the period from April through September, and up to 0.11 mgd during the peak month), until better information becomes available. Three golf courses together are estimated to have withdrawn 0.13 mgd as an annual average for year 2005. For 2005, agricultural groundwater withdrawals are assumed to be steady at the previously estimated 0.4 mgd as an annual average (0.8 mgd for the 6-month season).

#### 3.2.4.2 Vulcan Quarry

Vulcan Materials Company owns and operates the Vulcan Quarry, located in the northwestern portion of Stafford County. During normal mining operations, groundwater flows from the walls of the quarry and collects at the bottom in a "sump area" which is approximately 200 feet below ground level. Pumps are then used to dewater the sump area and pump the water to the top of the quarry for treatment. Treated water is then released into Aquia Creek as a permitted discharge through the Virginia Department of Environmental Quality (DEQ) and the Virginia Marine Resources Commission (VMRC). Twenty years ago, when DEQ required that all mines report groundwater withdrawals, the Vulcan Quarry average annual groundwater withdrawals ranged from 0.083 to 0.270 mgd. The reported groundwater withdrawals for the years 1996 through 2005 are summarized in Table 3-5. The average annual withdrawal from the pit pump ranges from 0.29 to 0.88 mgd.




MALCOLM PIRNIE

**Other Surface Water and Groundwater Users Location Map**

**FIGURE 3-1**

## Table 3-5
## Vulcan Quarry
## Groundwater Withdrawals
## (Pit Pump Discharge)

| Month | Average Daily Withdrawal (mgd) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1996 | 1997 | 1998 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
| January | 0.41 | 0.29 | 0.39 | 0.21 | 0.25 | 0.26 | 0.26 | 0.23 | 0.28 |
| February | 0.25 | 0.46 | 0.69 | 0.35 | 0.19 | 0.20 | 0.39 | 0.58 | 0.20 |
| March | 0.23 | 0.47 | 0.47 | 0.37 | 0.44 | 0.25 | 0.61 | 0.25 | 0.43 |
| April | 0.30 | 0.51 | 0.36 | 0.45 | 0.30 | 0.29 | 0.60 | 0.33 | 0.37 |
| May | 0.41 | 0.24 | 0.43 | 0.22 | 0.31 | 0.24 | 0.65 | 0.39 | 0.37 |
| June | 0.31 | 0.23 | 0.38 | 0.32 | 0.53 | 0.47 | 0.54 | 0.55 | 0.48 |
| July | 0.54 | 0.45 | 0.17 | 0.51 | 0.47 | 0.26 | 0.71 | 0.25 | 0.21 |
| August | 0.53 | 0.22 | 0.15 | 0.35 | 0.35 | 0.33 | 0.74 | 0.44 | 0.25 |
| September | 0.35 | 0.17 | 0.11 | 0.64 | 0.32 | 0.22 | 0.81 | 0.44 | 0.26 |
| October | 0.38 | 0.27 | 0.11 | 0.20 | 0.26 | 0.31 | 0.41 | 2.32 | 0.56 |
| November | 0.36 | 0.47 | 0.10 | 0.16 | 0.23 | 0.40 | 0.61 | 2.40 | 0.20 |
| December | 0.51 | 0.22 | 0.15 | 0.17 | 0.16 | 0.30 | 0.59 | 2.40 | 0.34 |
| **Average** | **0.38** | **0.33** | **0.29** | **0.33** | **0.32** | **0.30** | **0.58** | **0.88** | **0.33** |

Source: 1996 – 2005 DEQ raw water withdrawal data

Note: No data were reported to DEQ for 1999 withdrawals

### 3.2.4.3 Cardinal Concrete

Cardinal Concrete Company owns and operates the Cardinal Concrete Plant in Stafford, Virginia (see Figure 3-1). During normal plant operations, groundwater is pumped from an onsite well (Well #1) to be used as process water at the facility. The withdrawals made from Well #1, as reported to DEQ, are presented in Table 3-6. The average annual groundwater withdrawal ranges from 0.007 to 0.014 mgd.

**Table 3-6**
**Cardinal Concrete Groundwater Withdrawals (Well #1)**

| Month | Average Daily Withdrawal (mgd) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
| January | 0.006 | 0.006 | 0.006 | 0.007 | 0.008 | 0.005 | 0.009 | 0.005 | 0.007 | 0.007 |
| February | 0.007 | 0.005 | 0.008 | 0.010 | 0.011 | 0.004 | 0.006 | 0.006 | 0.009 | 0.008 |
| March | 0.007 | 0.006 | 0.015 | 0.009 | 0.010 | 0.007 | 0.010 | 0.012 | 0.013 | 0.010 |
| April | 0.007 | 0.009 | 0.016 | 0.011 | 0.011 | 0.007 | 0.014 | 0.013 | 0.011 | 0.014 |
| May | 0.007 | 0.010 | 0.012 | 0.009 | 0.019 | 0.006 | 0.009 | 0.011 | 0.013 | 0.012 |
| June | 0.007 | 0.009 | 0.014 | 0.012 | 0.015 | 0.010 | 0.010 | 0.012 | 0.015 | 0.015 |
| July | 0.007 | 0.009 | 0.017 | 0.012 | 0.014 | 0.009 | 0.013 | 0.012 | 0.012 | 0.013 |
| August | 0.007 | 0.010 | 0.015 | 0.012 | 0.016 | 0.010 | 0.010 | 0.009 | 0.017 | 0.015 |
| September | 0.007 | 0.010 | 0.015 | 0.013 | 0.014 | 0.007 | 0.011 | 0.014 | 0.013 | 0.013 |
| October | 0.009 | 0.009 | 0.015 | 0.016 | 0.021 | 0.007 | 0.009 | 0.014 | 0.014 | 0.010 |
| November | 0.008 | 0.006 | 0.013 | 0.014 | 0.015 | 0.007 | 0.007 | 0.011 | 0.011 | 0.011 |
| December | 0.005 | 0.007 | 0.012 | 0.011 | 0.014 | 0.007 | 0.007 | 0.010 | 0.009 | 0.008 |
| **Average** | **0.007** | **0.008** | **0.013** | **0.011** | **0.014** | **0.007** | **0.010** | **0.011** | **0.012** | **0.011** |

Source: 1996 – 2005 DEQ raw water withdrawal data

## 3.3 Treated Water Demands

Historical demand data for the Stafford County public water supply system were obtained from the county's Department of Utilities. Total system sales (metered demand) for the period 1982 through 2005 are presented in Table 3-8. These data indicate a 7.4% average annual compound growth rate for metered demand for the period 1982 – 2005.

**Table 3-7**
**RELATIONSHIP OF DEMOGRAPHICS TO DEMAND**
**BASED ON MUNICIPAL DATA**

| | |
|---|---|
| Total Population: 2002 | 102,700 |
| Projected Population (5% annually): 2012 | 167,287 |
| Municipal Water Users (Residential):<br>25,951 residential accounts x 3.0 people per account | 77,853 |
| Groundwater Users in 2002: 102,700 – 77,853 | 24,847 |
| Residential Groundwater Demand (2002): 24,847 x 70 gpd | 1.74 mgd |
| Estimated Agricultural Demand (6 months) – Static 20 wells at 40,000 gpd | 0.80 mgd |
| Projected Demand – Residential (5% annually) 2007 | 2.22 mgd |
| Projected Demand – Residential (5% annually) 2012 | 2.83 mgd |

Source: *Stafford County Groundwater Management Plan,* Draper Aden, October 2004

The residential groundwater use and demand projections were also calculated using an alternate method. This method was based on population and population served projections (see Table 5-4), and assumed that all population that was not served by the county system relied on groundwater wells for their potable water needs. Assuming a per capita use rate of 68 gpd, the 2000 residential groundwater use would have been on the order of 1.6 mgd, which is consistent with the estimate provided in the *Stafford County Groundwater Management Plan.*

**TABLE 3-8**
**TOTAL SYSTEM SALES (METERED DEMAND)**
**1982 – 2005**

| Year | System Sales (mgd) |
|---|---|
| 1982 | 1.49 |
| 1983 | 1.55 |
| 1984 | 1.68 |
| 1985 | 1.92 |
| 1986 | 2.13 |
| 1987 | 2.27 |
| 1988 | 2.61 |
| 1989 | 2.90 |
| 1990 | 3.20 |
| 1991 | 3.60 |
| 1992 | 3.54 |
| 1993 | 3.95 |
| 1994 | 4.19 |
| 1995 | 4.44 |
| 1996 | 4.41 |
| 1997 | 4.86 |
| 1998 | 5.20 |
| 1999 | 5.83 |
| 2000 | 5.65 |
| 2001 | 6.40 |
| 2002 | 6.84 |
| 2003 | 6.63 |
| 2004 | 6.93 |
| 2005 | 7.78 |

Source: Stafford County Department of Utilities Treated Water Sales Records, 1982-2005
For 2005 disaggregated use by category, residential, CIL, heavy industrial, military use, production water use, unaccounted for water loss and sales to other CWS are summarized in Appendix C, Forms 3-F, Page 17.

**Table 3-9**
**2005 Estimated Self-Supplied Groundwater Demand**
**All Sectors**

| Year | Population Self-Supplied | Residential Wells | Potable Residential Water Use Self-Supplied (mgd) | Potable VDH Non-Community "Business" Water Use (mgd) | Heavy Industrial/ Mining (mgd) | Golf Course Irrigation (mgd) | Agricul-ture (mgd) | Total (mgd) |
|---|---|---|---|---|---|---|---|---|
| Estimated Current | | | | | | | | |
| 6-Month Seasonal Peak Average | | | 2.22 ** | 0.08 | 0.56 | 0.231 * | 0.8 | 3.89 |
| Annual Average 2005 tion 2.1.3) (Section 3.2.4) | 29,952 | 9,984 | 2.10 | 0.04 | 0.34 | 0.13 * | 0.40 | 3.01 |

*Estimated to be same as Gauntlet Golf Course for each of 3 golf courses -annual average = 3 X 0.043 mgd and 6-month peak season average = 3 X 0.077 mgd

** For seasonal peak, added 4 gpd per person for outdoor water use to the 70 gpd annual average use. "Residential Water Use Self-Supplied" effectively included 0.014 mgd used by the four privately operated Community Water Systems regulated by VDH.

# Chapter 4 EXISTING RESOURCE INFORMATION

## 4.1 Geologic Conditions

Stafford County is divided into two major geologic zones: the Piedmont Plateau, generally west of I-95, and the Coastal Plain, east of I-95, which resulted from erosion of the Piedmont Plateau. The general environmental characteristics of Stafford County are reflected by the different geological characteristics within these two areas.

The Piedmont geology is underlain by hard igneous and metamorphic crystalline rock, which constitutes the hard basement strata underlying the surface soils in the agriculturally oriented lands of the county's western half. This geology also produces steep topography from the characteristic erosion patterns indicative of these rock formations. These geologic structures yield only small aquifers with inconsistent fractures in the bedrock. The water-bearing fractures occur most commonly in the upper 150 feet and few exist below 350 feet. Therefore, wells are an unreliable source of large supplies of drinking water west of I-95. These formations provide good foundation material for buildings.

The eastern part of the county was formed by ancient erosional deposits from upland streams and tidal inundation. The sedimentary beds of the Coastal Plain fall within two groups, the Potomac Group of the Cretaceous and the Tertiary Group.

The Potomac Group is a result of stream, river and fluvial erosion and deposition of sediments from the hinterlands. The Tertiary Group, marine formations found with few exceptions south of Aquia Creek, are a result of alternating encroachment and retreat of the ancient sea. The beds have been laid down in wide, wedge-like layers of marine sands, silts and clays on top of fluvial deposits which all lie upon a crystalline basement strata sloping to the east and extending out as the continental shelf.

The Potomac Group is associated with the watersheds of Widewater, Aquia Creek, Accokeek Creek and Potomac Creek and the Claiborne Run and Little Falls Run areas of the Rappahannock River basin.

These fluvial deposits consist of layers of sandstone, cobbles, gravel and sands. Within the Patuxent Formations of these unconsolidated layers, water is recharged into coastal plain aquifers. This area, which lies mostly west within the Coastal Plain zone, is the link between surface water and groundwater and may provide large groundwater supplies to local wells. Along the lower reaches of these watersheds, more fine-grained deposits, generally clays, are found which may impose severe limitations on development.

The Tertiary Marine deposits are generally found south of Aquia Creek and have a range of formations from green sands to silt and clay. Because of the clay content in these formations, this area imposes severe limitations to urban uses.

The county's only major north-south roads (I-95 and Jefferson Davis Highway) were constructed over the prime aquifer recharge area. As a result, large amounts of land within the recharge area are currently developed, and the remainder is under considerable development pressure, making it difficult to protect the aquifer and its water quality. Furthermore, excessive impervious surfaces of roads and parking lots, and the influence of septic fields over these areas, present a threat to future groundwater yields and quantities.

Throughout this eastern geographic area, the water table is generally high, which presents problems for building foundations, basements and septic systems. The marine soils deposits, which generally lie east of the fluvial geology, consist of soils which are slippage prone, swelling clays. Land slippage is more likely to occur on steep slopes; however, swelling clays can displace foundations on flat terrain.

## 4.2 Hydrologic Conditions

### 4.2.1 Groundwater Hydrology

The hydrogeologic setting is a function of the underlying geologic features. Stafford County is characterized as having three distinct geological units, trending from west to east: the Piedmont Crystalline Bedrock System, the Fall Zone (or Coastal Plain Aquifer recharge zone) and the Coastal Plain System. In general, these systems are geologically unique from one another and have very distinct characteristics. The Piedmont system is dependent on fractures for groundwater protection, yield, and recharge. The Coastal Plain system is described as an

eastwardly thickening wedge of sediments that is dependent on precipitation recharge and porosity of sands and gravels for storage. The Fall Zone is an area where a thin veneer of Coastal Plain sediments overlies a highly faulted crystalline bedrock, and is generally the area of outcrop (and resulting recharge) of the Coastal Plain aquifers.

The following sections briefly describe the units. Figure 4-1 presents the bedrock geology of the county (Stafford County Groundwater Management Plan, Draper Aden, October 2004).

#### 4.2.1.1 Piedmont Bedrock Aquifer

The Piedmont, generally to the west of I-95, is an area of crystalline bedrock containing numerous fracture zones from ancient faulting. Groundwater in the Piedmont area tends to be plentiful where wells intersect the fracture zones. However, wells that are developed outside of the fracture zones are likely to experience low yields, especially during dry and excessively dry periods. The depth of wells is a less important determinant of well yield and stability than proximity to a fracture zone, although bored wells in the soil horizon are impractical and vulnerable to deep well pumping in this region.

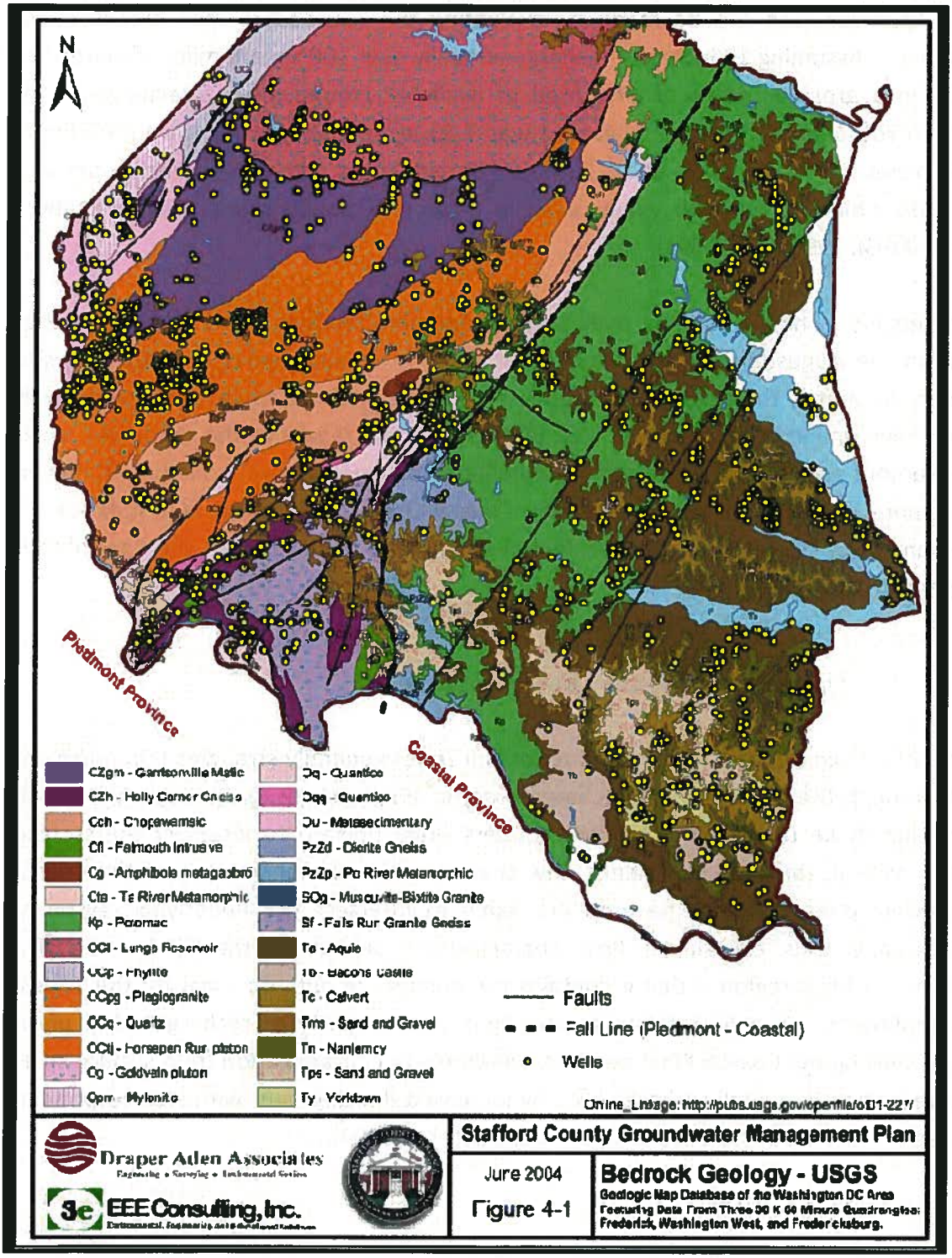
In general, the crystalline bedrock geology of Stafford County is a highly faulted assemblage of metamorphic gneisses, phyllites and amphibolites intersected by igneous intrusions and plutons. Geologic ages range from pre-Cambrian to late Silurian. In general, groundwater flow is a function of fracture density. Fracture density is generally a function of geologic structure. Very little study has been conducted on the crystalline bedrock aquifer of Stafford County. Two recent studies (EGGI, Augustine Golf Club, 1996; ENSAT, Celebrate Virginia!, 2002) provide some limited insight to the characteristics of the aquifer. Bedrock wells at the Augustine site were capable of sustained production in excess of 300 gpm. The Augustine site is located in the central portion of the county, west of Interstate 95. There was indication, however, that pumping at such rates did impact surrounding wells. Off-site wells completed in the soils (saprolite) above the bedrock ("dug" or bored wells) were impacted to dryness. Typical residential wells average a yield of approximately 18 gpm (see graph on Figure 4-2). Estimates of potential recharge in the Piedmont have not been developed on a regional basis. A very

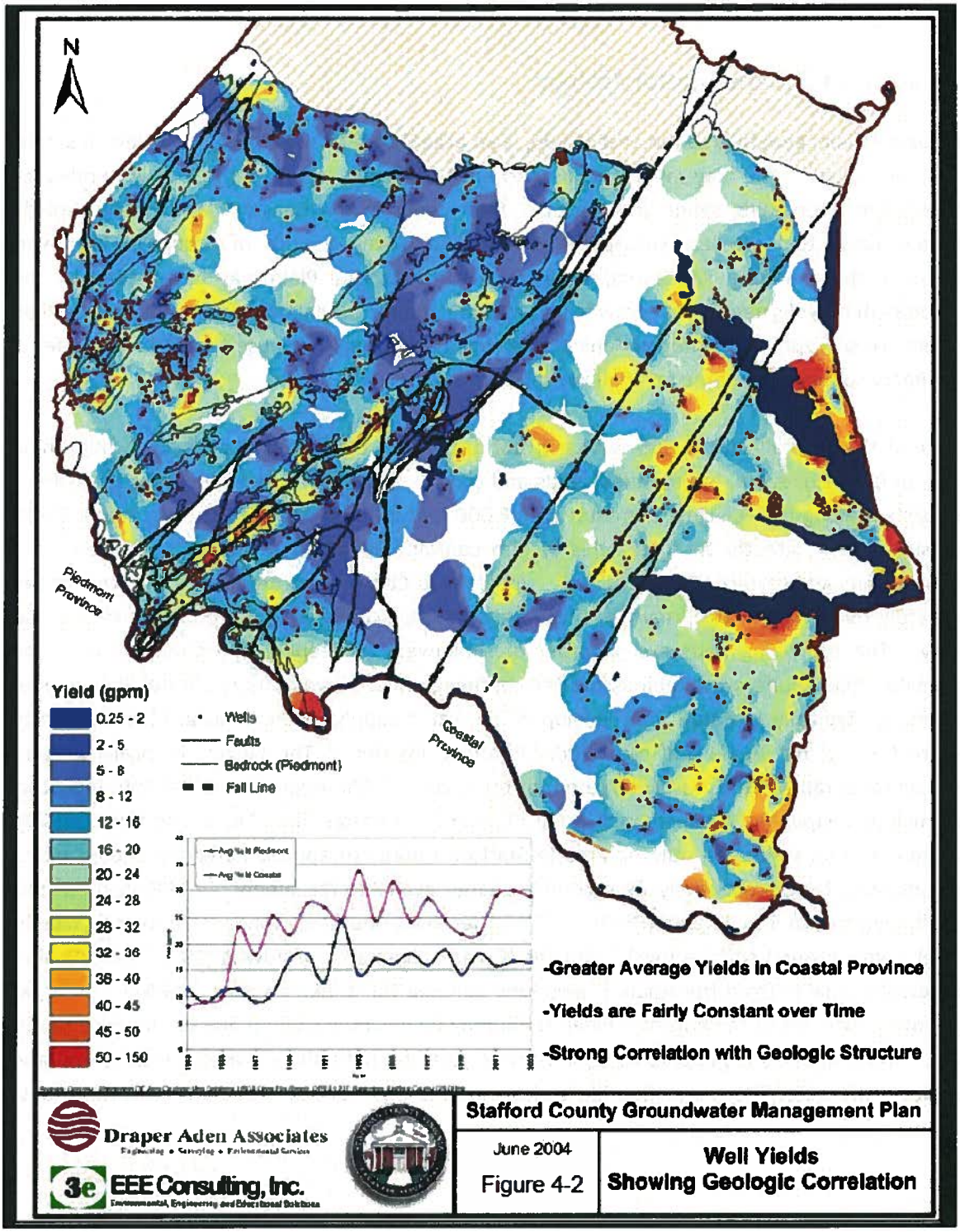
rough approximation can be made by evaluating the 150 square mile extent of the Piedmont. Assuming 10 inches of recharge annually over 100 square miles of watershed results in a gross estimate of 47.6 mgd of available groundwater. Recharge in the northern recharge of the sites evaluated was 7.35 inches per year with a maximum of 11.68 inches per year (Nelms, et al., 1997). For estimation purposes, 10 inches per year was used which agrees with values used in previous groundwater studies in Stafford County (EGGI, 1996; GKY, 1994).

Water quality is highly variable over small geographic areas in the Piedmont aquifer. Wells on the Augustine site exhibited variable water quality across the 200 acre site. Wells to the east of the site had elevated sulfate concentrations; while, to the west, wells did not have similar geochemistry. One interesting trend regarding the residential use of the Piedmont aquifer is that the year of installation of the wells in the Piedmont appears to be more recent than for those in the Coastal Plain. This trend may indicate the development of the Piedmont for residential use is more recent than in the Coastal Plain (Draper Aden, October 2004).

#### 4.2.1.2 The Coastal Plain Aquifer Recharge Zone

The Coastal Plain Aquifer Recharge Zone (or Fall Zone) generally straddles I-95 north and south through the county. The recharge area, in simple terms, is the zone where the layers that make up the Coastal Plain aquifers slope upward to intersect the surface. Shallow wells in this area experience flow characteristics similar to those in the Coastal Plain, while deep wells in the area are liable to intersect the underlying crystalline bedrock, and thus experience flow characteristics similar to the Piedmont. The significance of this region is that it contains the majority of outcrop areas for the Coastal Plain sediments. The outcrop areas are where the majority of recharge takes place, thereby making the Coastal Plain aquifers vulnerable to contamination from surface spills, and a reduction in overall recharge area by increased development with a corresponding increase in impervious surfaces (Draper Aden, October 2004).


N
Piedmont Province
Coastal Province
CZgm - Garrisonville Mafic
CZh - Holly Corner Gneiss
Cch - Chopawamsic
Cfl - Falmouth Intrusive
Cg - Amphibole metagabbro
Cta - Ta River Metamorphic
Kp - Potomac
OCl - Lunga Reservoir
OCp - Rhyolite
OCpg - Plagiogranite
OCq - Quartz
OCtl - Horsepen Run pluton
Cg - Goldvein pluton
Opm - Mylonite
Oq - Quantico
Oqq - Quantico
Ou - Metasedimentary
PzZd - Diorite Gneiss
PzZp - Po River Metamorphic
SOg - Muscovite-Biotite Granite
Sf - Falls Run Granite Gneiss
Te - Aquia
Tb - Bacons Castle
Tc - Calvert
Tms - Sand and Gravel
Tn - Nanjemoy
Tps - Sand and Gravel
Ty - Yorktown
Faults
Fall Line (Piedmont - Coastal)
Wells
Online_Linkage: http://pubs.usgs.gov/openfile/of01-227/
Draper Aden Associates
EEE Consulting, Inc.
Stafford County Groundwater Management Plan
June 2004
Figure 4-1
Bedrock Geology - USGS
Geologic Map Database of the Washington DC Area
Featuring Data From Three 30 X 60 Minute Quadrangles:
Fredericksburg, Washington West, and Fredericksburg.


N
Piedmont Province
Coastal Province
Yield (gpm)
0.25 - 2
2 - 5
5 - 8
8 - 12
12 - 16
16 - 20
20 - 24
24 - 28
28 - 32
32 - 36
38 - 40
40 - 45
45 - 50
50 - 150
Wells
Faults
Bedrock (Piedmont)
Fall Line
-Greater Average Yields in Coastal Province
-Yields are Fairly Constant over Time
-Strong Correlation with Geologic Structure
Draper Aden Associates
3e EEE Consulting, Inc.
Stafford County Groundwater Management Plan
June 2004
Figure 4-2
Well Yields
Showing Geologic Correlation

### 4.2.1.3 Coastal Plain Aquifer System

The Coastal Plain, generally to the east of I-95, is an area that features alternating layers of sands, gravels and clays. The clay layers act as barriers to impede the movement of groundwater between the intervening sands and gravels. Deep wells in the Coastal Plain usually provide generous flows that are less susceptible to variance during periods of drought. However, because of the confining clay layers, deep wells in the Coastal Plain may be affected by the development of wells nearby that draw from the same aquifer. Shallow wells in the Coastal Plain aquifers are susceptible to interruptions during times of drought, because the surface aquifer is the primary source of recharge for shallow wells.

In general, the Coastal Plain aquifer system in Stafford County consists of an eastwardly thickening wedge of unconsolidated, interbedded sands and clays. These deposits range in thickness from non-existent along the Fall Line to greater than 6,000 feet in thickness beneath the Eastern Shore Peninsula. At its greater thickness, this system contains up to eight underlying sequences of confining units and corresponding aquifers. As Stafford County is located far to the west of the eastwardly thickening wedge, many of these units have pinched out and are not present in the county. The remaining units are, in order of shallowest to deepest, the Calvert, Aquia and Middle Potomac Aquifers and their associated confining units. Two primary Coastal Plain aquifer systems are typically targeted and developed for water supply in the Coastal Plain system in Stafford County: the Aquia and the Middle Potomac Aquifers. The Calvert is locally present based on topography, but is rarely targeted for production. The Aquia is used for light industrial and small municipal and domestic supply throughout the Coastal Plain (Meng and Harsh, 1988). The Aquia has an estimated outcrop area in Stafford County of approximately 28 square miles, which equates to approximately 27 mgd of recharge available for supply. Yields in the Aquia typically range from 5 to 20 gpm (F&ME. 1987). Depths to the Aquia range from near surface to 60 feet below ground surface (bgs). Studies (Focazio, Speiran and Rowan, 1993) indicate that groundwater quality from the Aquia is generally suitable for drinking water supplies. In areas adjacent to estuaries of the Potomac River, there may be elevated sodium due to influence of salt water. In other specific geographic regions, there may be naturally elevated levels of iron and fluoride. Salt water, iron, and fluoride concentrations may require treatment before potable use.

The Middle Potomac Aquifer serves as the principal source of large production groundwater wells in the Virginia Coastal Plain system (Harsh and Lazniak, 1990). The Middle Potomac outcrops in the central portion of Stafford County over an area of approximately 36 square miles (O'Brien & Gere, 1991). Approximately 15 inches of precipitation per year infiltrate to the subsurface and replenish the aquifer (Harsh and Lazniak, 1990). This results in approximately 25 mgd available for supply. Of that, approximately 50% is lost to base flow discharge to surface water and increased impervious surface due to development. This results in a production capacity of 12.5 mgd. As of 1991, only 250,000 gpd were being produced from the Middle Potomac in Stafford County (O'Brien & Gere, 1991). Recent data indicate current production is approximately 500,000 gpd. Individual well production yields have been measured at rates up to 750 gpm (approximately 1 mgd). Typical yields range from 10 to 300 gpm, or 15,000 to 430,000 gpd (F&ME, 1987). Depths to the Middle Potomac range from 60 to over 400 feet in Stafford County. The Middle Potomac aquifer is confined by a clay layer ranging from 20 to 45 feet in thickness. This layer restricts vertical groundwater flow between the Aquia and Middle Potomac aquifers. Long-term pump tests in the Middle Potomac have shown little impact to shallow residential wells in the Aquia (O'Brien & Ger, 1991).

Groundwater quality data indicate that the Middle Potomac can exhibit elevated levels of turbidity, iron and pH (basic/somewhat corrosive). Elevated concentrations of these parameters may require treatment before potable use.

### 4.2.2 Surface Hydrology

#### 4.2.2.1 Watersheds

There are two major watersheds within the county, the Potomac and the Rappahannock Rivers. The Aquia, Accokeek, Chopawamsic, Widewater and Potomac Creeks and their tributaries all drain into the Potomac River. The Rappahannock basin, which also has several small watersheds, has nine major sub-basins (Horsepen Run, Alcotti Run, Falls Run, Richland Run, Claiborne Run, England Run, Rocky Pen Run, Little Falls Run and White Oak Run) which drain into the Rappahannock River. Figure 4-3 depicts the boundaries of the main Hydrologic Units (HU) within the county and lists the total area (acres) and percent of the total land area that is covered by each HU.

Approximately 5,394 acres of the county are covered by water. The west side of the Potomac River generally forms the eastern boundary of the county, and the south side of the Rappahannock River forms the southern boundary. In general, the Potomac River sub-watershed runs in a west to east direction across the county, with the Rappahannock River sub-watersheds running more northwest to southeast across the county.

#### 4.2.2.2 Water Supply Reservoirs

Abel Lake, located on Potomac Creek approximately 10 miles from its confluence with the Potomac River, serves as a primary source of drinking water for the southern portion of Stafford County. At the normal pool elevation of 139 ft. msl, Abel Lake impounds approximately 1.3 billion gallons with a surface area of 185 acres. The raw water safe yield of Abel Lake is 6.1 mgd at the normal pool elevation. Able Lake is approximately 2.5 miles long at normal pool and has a mean dept of 21 feet. While the Gauntlet Golf Course withdrawals from Curtis Lake were not considered in the safe yield analysis for Abel Lake (see Section 3.2.3.3), the average annual withdrawal of 0.025 mgd represents only between 0.1 and 0.2 percent of the average flow into Abel Lake.

Smith Lake, located on Aquia Creek approximately 9 miles from its confluence with the Potomac River, serves as the second primary source of drinking water for Stafford County. At normal pool elevation of 90 ft. msl, total storage is approximately 2.11 billion gallons. The raw water safe yield of Smith Lake is 7.7 mgd at normal pool elevation. There are two main "arms" of Smith Lake, supplied by Aquia Creek and by Beaverdam Run, with a reach of 2.7 miles at normal pool and a mean depth of 41 feet. As discussed in Section 3.2.3.2, the Vulcan Quarry withdraws process water from Aquia Creek; however, this withdrawal was not factored into the safe yield analysis for Smith Lake. However, since the analysis conservatively assumed that the Lunga Reservoir watershed would not contribute flows into Smith Lake (see Section 2.2), the combined effects of Lunga Reservoir and the Vulcan Quarry withdrawals should not reduce the estimated safe yield of Smith Lake.

In 2005, the average annual raw water withdrawal for the Smith Lake and Abel Lake Water Treatment Facilities combined was 10.16 mgd.

A third water supply reservoir is currently being designed in south Stafford. The Rocky Pen Run Reservoir, located between Route 17 (Warrenton Road) and the Rappahannock River west of Interstate I-95, is planned to open by 2012. The reservoir surface area will cover 503 acres and hold 5.29 billion gallons of water. The reservoir has a drainage area of 5.18 square miles and will also draw water from the Rappahannock River.

## 4.3 Meteorological Conditions

The Stafford County climate is temperate, or more specifically, sub-humid and is marked by extremes of precipitation and temperature. The average growing season is about 169 days and has ranged from 117 to about 198 days. The average annual temperature in Stafford County is 35° Fahrenheit (F) in January and 77° F in July. The highest maximum average annual temperature is 68.6° F and the lowest minimum average annual temperature is 44.0° F as recorded at the Fredericksburg National Park (Southeast Regional Climate Center, period 1/1/1930 to 3/31/1997, Station #443192).

The average annual precipitation for Stafford County is 41.12 inches as recorded at the Fredericksburg National Park, and 38.57 inches as recorded at the Quantico station in the northeastern part of the county (Southeast Regional Climate Center, period 8/1/1948 to 3/31/1976, Station #446979). The average annual snowfall for Stafford county ranges from 14.6 inches in Fredericksburg National Park to 16.1 inches at the Quantico station. The wettest month of the year is August in Quantico, with an average rainfall of 4.55 inches; and July at Fredericksburg National Park, with an average rainfall of 4.49 inches. The driest month of the year is October in Quantico, with an average rainfall of 2.57 inches; and February at Fredericksburg National Park, with an average rainfall of 2.65 inches.

## 4.4 Environmental Conditions

Environmental resources and impact, i.e., open water and vegetated wetlands, stream length and fisheries habitat, uplands and land use characterization as they relate to assessment of specific sites with potential for water supply/storage projects are also discussed in Section 8.2.4.

### 4.4.1 Wetlands

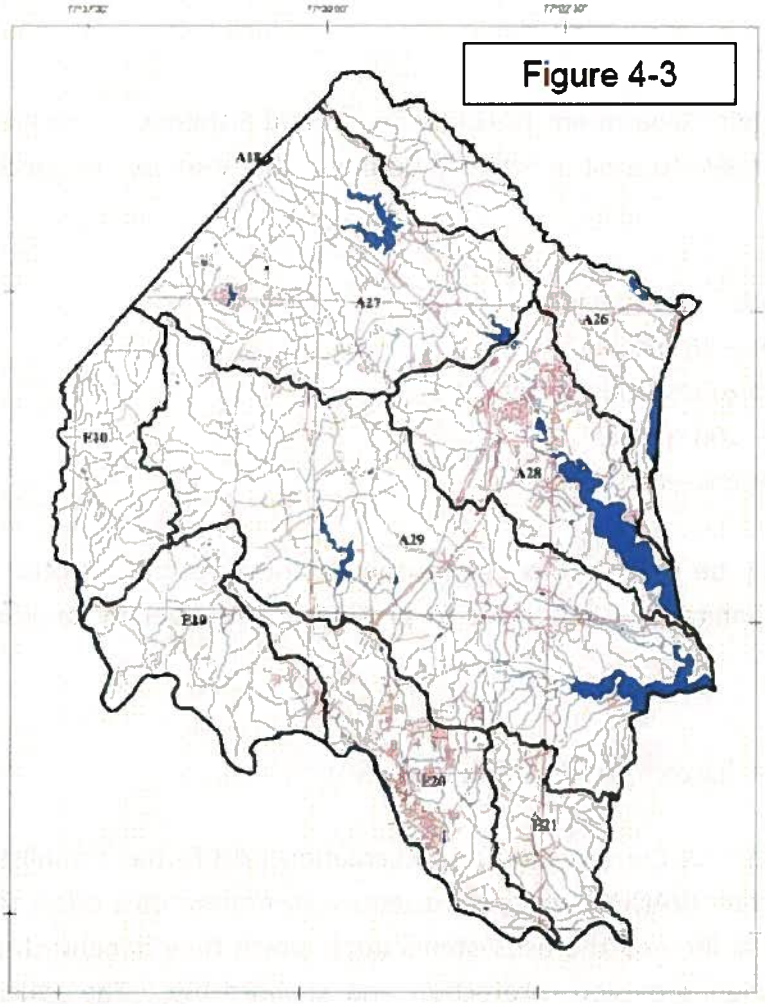
It is estimated that there are approximately 4,500 acres of tidal and non-tidal wetlands within Stafford County. According to the Stafford County Tidal Marsh Inventory prepared by the Virginia Institute of Marine Sciences, there are approximately 1,337 acres of tidal marsh in Stafford County. The Potomac and Accokeek Creeks account for 705 acres of tidal marsh, Aquia Creek for 420 acres and other tributaries of the Potomac River for the remaining 212 acres.

### 4.4.2 Forestland

Based on the 1985 report entitled "The Forest Resource of Stafford County", Stafford County had an inventory of 130,200 acres of forested land. It is estimated that the amount of forested land is currently 100,000 acres. The majority of the forested land is held by private landowners with varying parcel sizes. Approximately 21,876 acres of timberland is located within the Quantico Marine Corps Base (QMCB) boundaries.

As a natural resource, forests are an indispensable asset to the county and its residents. Stafford's forests consist of deciduous hard woods, mixed soft woods and a vast number of pipe forests. Forests produce clean air and water by filtering out pollution. Tree root systems prevent soil erosion. The forest canopy and leaf layer protect against runoff. Forested watersheds protect water quality and provide areas for the recharge of groundwater supplies. Trees provide safe nesting places and are a valuable food source for a variety of animal species. Forest areas provide excellent habitats for a number of wildlife species.

Figure 4-3




**HYDROLOGIC UNITS**
**STAFFORD COUNTY (179) – 179,954 ACRES**
HYDROLOGIC UNIT BOUNDARY
ROADS / QUADRANGLE EDGES
WATER FEATURES

4 0 4 MILES

EQUATY LOCATION

| HYDROLOGIC UNIT | HYDROLOGIC UNIT NAME | USGS HUC | AREA (ACRES) | PERCENTAGE OF JURISDICTION |
|---|---|---|---|---|
| A11 | LOWER CEDAR RUN / TOWN RUN | 02070010 | 21.4 | 0.01 |
| A26 | POTOMAC RIVER / QUANTICO CREEK / CHOPAWAMSIC CREEK | 02070011 | 18,401.9 | 10.28 |
| A27 | UPPER AQUIA CREEK / BEAVERDAM RUN | 02070011 | 32,524.1 | 18.17 |
| A28 | LOWER AQUIA CREEK | 02070011 | 20,948.0 | 11.73 |
| A29 | POTOMAC RIVER / POTOMAC CREEK | 02070011 | 54,521.1 | 30.47 |
| P30 | RAPPAHANNOCK RIVER / DEEP RUN / ROCK RUN | 02080103 | 12,797.2 | 7.13 |
| P19 | RAPPAHANNOCK RIVER / MOTTS RUN | 02080104 | 14,454.0 | 8.30 |
| P26 | RAPPAHANNOCK RIVER / MASSAPONAX CREEK | 02080104 | 16,303.0 | 9.11 |
| P21 | RAPPAHANNOCK RIVER / MILL CREEK / GOLDENVALE CREEK | 02080104 | 8,813.5 | 4.81 |

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VIRGINIA DEPARTMENT OF CONSERVATION AND RECREATION
DIVISION OF SOIL AND WATER CONSERVATION
RICHMOND, VIRGINIA

PREPARED FOR
USDA NATURAL RESOURCES CONSERVATION SERVICE
VIRGINIA DEPARTMENT OF CONSERVATION AND RECREATION
VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

### 4.4.3 Wildlife

According to the Virginia Department of Game and Inland Fisheries, there are approximately 242 wildlife species known to exist in Stafford County. The numbers of species are listed by habitat as follows:

Wetlands – 101 species
Beaches – 26 species
Riparian zones – 90 species
Water – 108 species
Urban areas – 80 species

Note that species may be cited in more than one habitat location. Protecting habitat and reducing impacts to habitat are important to protecting the diversity of wildlife within the county.

### 4.4.4 Endangered, Threatened or Sensitive Species

The Virginia Department of Conservation and Recreation (VDCR) has established the Virginia Natural Heritage Program (VANHP) which represents a comprehensive effort to save Virginia's native plant and animal life and the ecosystems upon which they depend through inventory, conservation information provision, protection and stewardship. The VANHP has defined Natural Heritage Resources, or "NHRs", as rare plant and animal species, rare and exemplary natural communities and significant geologic features. Table 4-1a lists the NHRs for Stafford County, including their global, state and federal status with regard to their protection priorities. Table 4-1b lists the definitions of all codes found in Table 4-1a.

### 4.4.5 Soil Types, Land Use, and Resource Protection Areas

Stafford County's soils, in general, have limitations for either land development or prime agricultural uses. An extraordinary amount of land has environmental characteristics which pose development hazards. The SCS soil survey indicates that only 4.5% of the county's soils have slight limitations for development. Approximately 95 out of every 100 acres have some soil and geophysical characteristics which limit or constrict urban development potential.

A large part of the county has soils which have severe limitations for the development of buildings, roads, and septic tanks. In many areas, the soil deficiencies are coupled with steep slopes or floodplains.

Within the Piedmont region of the county, west of I-95, many areas have soils suitable for foundations and basements. In the western part of the region, agricultural land competes with large lot housing development, because the soils are also good for septic systems. Current land use in Stafford County is illustrated on Figure 4-4. Closer to I-95, the soils are less suitable for septic systems; however, they can support building foundations. Figure 4-4 also illustrates the Resource Protection Areas within the county, which include streams, rivers and a buffer area along them.

Around Abel Lake, the soils are not as good for septic systems. This area is characterized by "fingers" of different soils, where a narrow finger of soil which can support septic fields is followed by another strip of soils which is poor for septic fields. While the soils in the Piedmont Region are more suitable for septic system location than in other areas of the county, the geology in this area indicates that well reliability may be hard to achieve because of small inconsistent fractures in the bedrock.

Within the Potomac Region and the Coastal Plain areas, severe soil erosion over the years has left long, steep ridges which fall off into streambeds. These areas have clay soils which are subject to sliding and slip swelling. The soil composition, coupled with the steep topography, provides poor foundations for buildings, roads and utilities. On the other hand, this is an area of the county where the geology indicates that more reliable wells can be established.

### 4.4.6 Floodplain

The floodplain is an area subject to periodic inundation by water. The county regulates development activity in the flood way, flood fringe and the one hundred year flood plain in order to minimize flooding hazards. Floodplain areas are important in protecting life and property as well as wildlife habitats, water quality and preventing severe erosion.

Flood prone areas of the county have been documented by the Federal Emergency Management Agency (FEMA) on the National Flood Insurance Maps in a program which is administered by the United States Department of Housing and Urban Development. Stafford entered the National Flood Insurance Program on November 19, 1980. Based on FEMA's maps, areas subject to severe flooding are along the Rappahannock River and some of its tributaries east of I-95, along Potomac Creek and Accokeek Creek, below the reservoir at Aquia Creek, along Austin Run running east of I-95 into Aquia Creek, and at Brent Marsh along the Potomac River east of Arkendale.

MALCOLM PIRNIE
EXISTING RESOURCE INFORMATION 4

**TABLE 4-1A**
**LIST OF NATURAL HERITAGE RESOURCES**
**FOR STAFFORD COUNTY**

| Scientific Name | Common Name | State Rank | Federal Status | State Legal Status | Last Year Observed |
|---|---|---|---|---|---|
| **Birds** | | | | | |
| *Haliaeetusleucocephalus* | Bald Eagle | S2, S3B, S3N | LT | LT | 2002 |
| **Bivalvia (Mussels)** | | | | | |
| *Alasmidonta heterodon* | Dwarf Wedgemussel | S1 | LE | LE | 2003 |
| *Alliptio lanceolata* | Yellow Lance | S2S3 | SOC | SC | 1926 |
| **Coleoptera (Beetles)** | | | | | |
| *Lordithon niger* | Black Lordithon Rove Beetle | SH | | | ND |
| **Communities** | | | | | |
| Natural Community | Basic Mesic Forest | SNR | | | 1999 |
| Natural Community | Coastal Plan Dry Calcareous Forest/Woodland | SNR | | | 2002 |
| Natural Community | Eastern Hemlock – Hardwood Forest | SNR | | | 1998 |
| Natural Community | Mesic Mixed Hardwood Forest | SNR | | | 2002 |
| Natural Community | Oak – Hickory Woodland/Savanna | S1 | | | 1999 |
| Natural Community | Oak/Heath Forest | SNR | | | 1999 |
| Natural Community | Piedmont/Coastal Plain Oak – Beech/Heath Forest | SNR | | | 2002 |
| Natural Community | Piedmont Prairie | SNR | | | 1999 |
| Natural Community | Tidal Freshwater Marsh | SNR | | | 2002 |
| Natural Community | Tidal Hardwood Swamp | SNR | | | 2002 |
| **Other** | | | | | |
| Great Blue Heron Rookery | | S2 | | | 1998 |
| **Vascular Plants** | | | | | |
| *Aeschynomene virginica* | Sensitive Joint-vetch | S2 | LT | LT | 1997 |
| *Bacopa rotundifolia* | Round-leaved Water-hyssop | S1 | | | 1987 |
| *Cabomba caroliniana* | Carolina Fanwort | S1 | | | 1991 |
| *Eriocaulon parkeri* | Parker's Pipewort | S2 | | | 1996 |
| *Isotria medeoloides* | Small Whorled Pogonia | S2 | LT | LE | 2005 |
| *Lathyrus palustris* | Vetchling | S1 | | | 1975 |
| *Lythrum alatum* | Winged-loosestrife | S2 | | | 1939 |
| *Ptilimnium nodosum* | Harperella | S1 | LE | LE | 2005 |
| *Schoenoplectus fluviatilis* | River Bulrush | S2 | | | 1999 |
| *Vitis rupestris* | Sand Grape | S1? | | | 1976 |

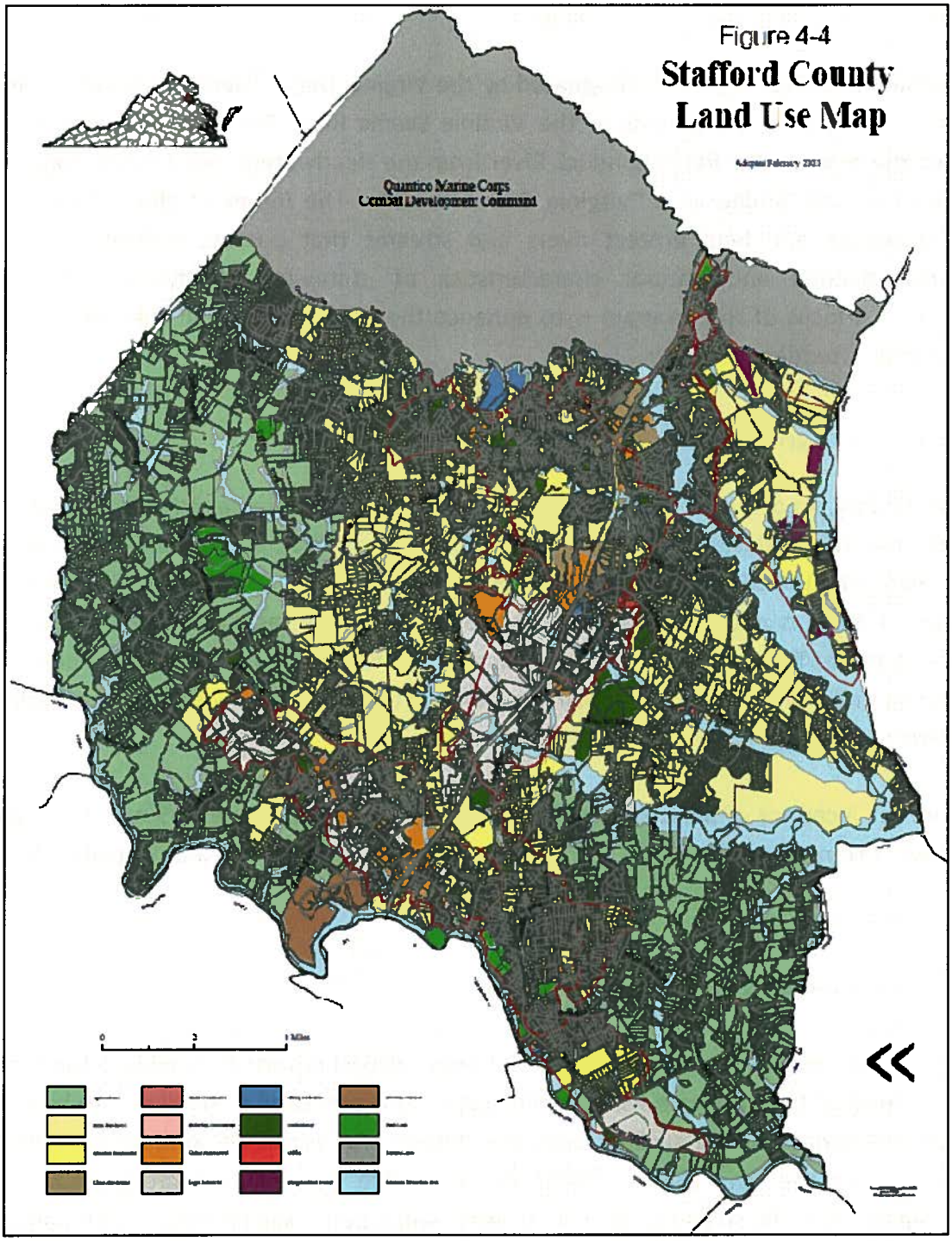
Source: Virginia Department of Conservation and Recreation, Virginia Natural Heritage Program, Natural Heritage Resources Website query for Stafford County, June 2006

**TABLE 4-1B**
**NATURAL HERITAGE RESOURCE**
**RANKING CODE DEFINITIONS**

| | |
|---|---|
| **State Rank** | |
| S1 | Critically imperiled in the state because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from the state. Typically 5 or fewer populations or occurrences; or very few remaining individuals (<1000) |
| S2 | Imperiled in the state because of rarity or because of some factor(s) making it very vulnerable to extirpation from the state. Typically 6 to 20 populations or occurrences or few remaining individuals (1,000 to 3,000) |
| S3 | Vulnerable in the state either because rare and uncommon, or found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extirpation. Typically 21 to 100 populations or occurrences (1,000 to 3,000) |
| S#B | Breeding status of an animal within the state |
| S#N | Non-breeding status of animal within the state. Usually applied to winter resident species |
| SNR | Unranked; state rank not yet assessed |
| S#? | Inexact or uncertain numeric rank |
| **Federal Status** | |
| LT | Listed Threatened |
| LE | Listed Endangered |
| SOC | Species of Concern species that merit special concern (not a regulatory category) |
| **State Legal Status** | |
| LT | Listed Threatened |
| LE | Listed Endangered |
| SC | Special Concern animals that merit special concern according to VDGIF (not a regulatory category) |

Source: Virginia Department of Conservation and Recreation, Virginia Natural Heritage Program

Figure 4-4
**Stafford County Land Use Map**



### 4.4.7 Recreationally Significant Rivers

The Rappahannock River has been designated by the Virginia Department of Conservation and Recreation's (DCR) as a component of the Virginia Scenic River System. The Program has designated the reach of the Rappahannock River from the Headwaters near Chester Gap to the Ferry Farm/Mayfield Bridge as a "Virginia Scenic River". The intent of this program is to identify, designate and help protect rivers and streams that possess outstanding scenic, recreational, historic and natural characteristics of statewide significance for future generations. A focus of the program is to enhance the conservation and wise use of scenic rivers and their attendant corridors.

### 4.4.8 Impaired Streams

In Stafford County, a portion of the Rappahannock River is listed as impaired water by the DEQ. In addition, two tributaries to the Rappahannock River, Alcotti Run and Deep Run are listed as impaired waters by the DEQ due to elevated fecal coliform levels. The planned intake on the Rappahannock River is not located within an impaired segment, as illustrated on Figure 4-5. Within the Potomac River Basin in Stafford County, Potomac Run, Potomac Creek, Aquia Creek and Accokeek Creek are all listed as impaired waters by the DEQ due to elevated fecal coliform and Escherichia coli (E. coli), as illustrated on Figure 4-6.

In addition, the locations of point source discharges are shown on figures 4-5 and 4-6. These figures were taken from the DEQ's 2006 Water Quality Assessment and Impaired Waters Report.

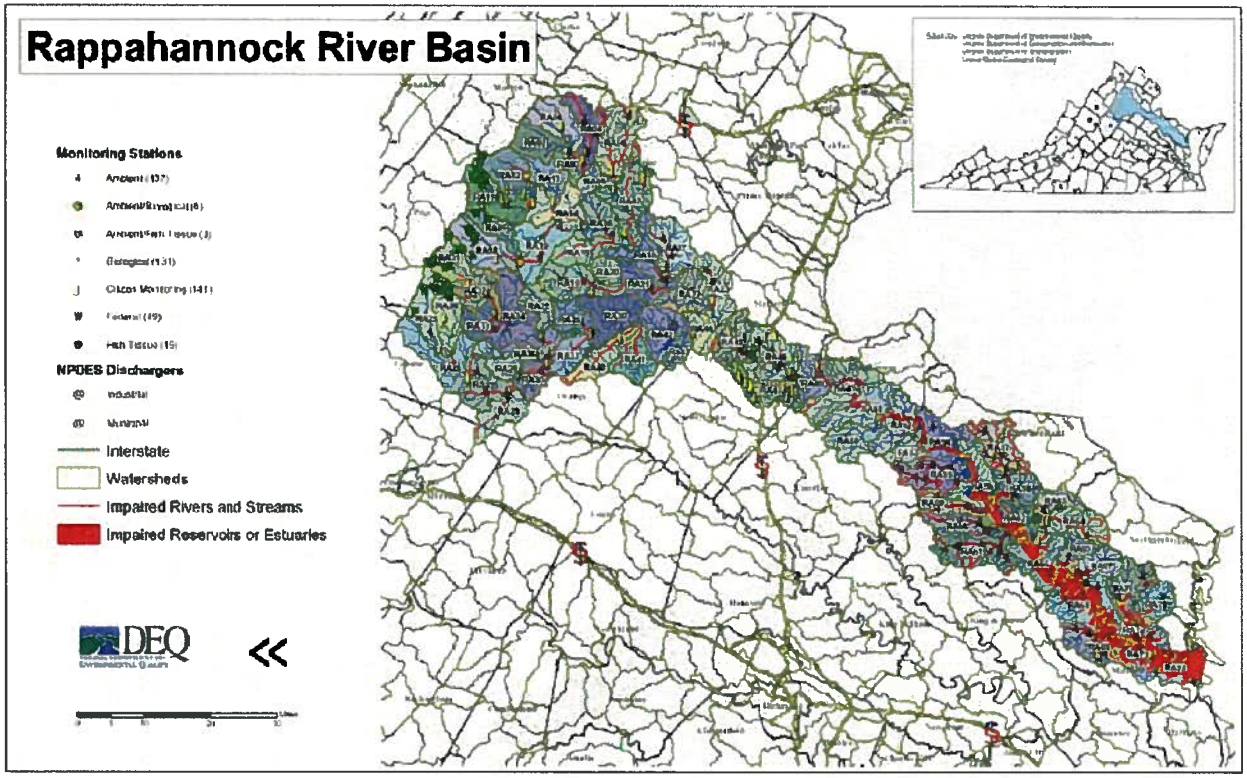
### 4.4.9 Anadromous Fish

The Virginia Department of Game and Inland Fisheries (VDGIF) reports that prior to the Embrey Dam beach, most of the upstream fish sampling collections consisted of small mouth bass, rock bass, redbreast sunfish, white suckers, redhorse suckers, American eel and various cyprinids (minnows). Since the dam breach, VDGIF District Office has also collected hickory shad, blueback herring, alewife, striped bass, yellow perch, white perch and channel catfish during

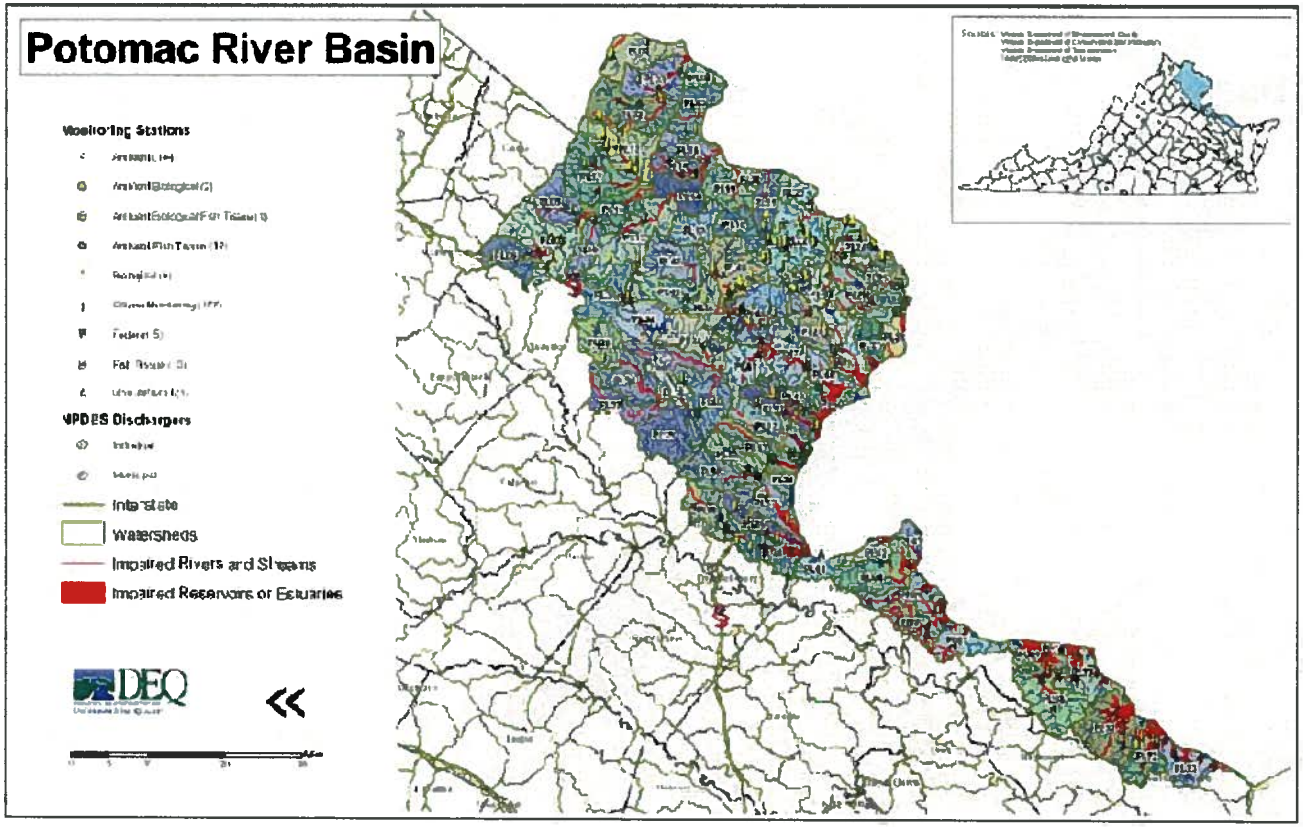
fall sampling. Fish Pass Coordinator's crew sampling has included collecting hickory shad, blueback herring and 12" – 18" striped bass at the Mott's Run area. Spring sampling by the Fish Pass Coordinator's crew has also collected American shad in 2004 (one gravid female from one mile upstream of Mott's Run landing, i.e., not far from the permitted Rocky Pen Run intake site). In April 2007, the collection included four American shad near the Mott's Run landing.

American Shad Restoration Program

With the breaching of Embrey Dam near Fredericksburg in February 2004 and subsequent removal of the entire structure in March 2005, anadromous fish can now migrate upstream to and beyond the planned Rappahannock River intake location. Above Fredericksburg in the Rappahannock River there is a 45 mile stretch of confirmed historical American shad spawning and nursery area. From 2003 – 2006, a total of 14.2 million shad fry (approximately 10 mm. in length) have been stocked in the Rappahannock watershed upstream of Fredericksburg (i.e., upstream of the permitted Rocky Pen Run facilities). Based on experience, the 4-5 year maturation period for stocked fry, and recent sampling results noted above, by about 2009 VDGIF expects to begin seeing mature hatchery-origin American shad from this stocking program returning to the Rappahannock in some numbers.




| MALCOLM PIRNIE | Rappahannock River Basin<br>2006 DEQ Map of 303(d) Impaired Waters | FIGURE 4-5 |
|---|---|---|




MALCOLM PIRNIE

Potomac River Basin
2006 DEQ Map of 303(d) Impaired Waters

FIGURE 4-6

# Chapter 5 PROJECTED WATER DEMAND

## 5.1 Population and Demand Projections

The most recent projections of Stafford County population were completed by Malcolm Pirnie as part of the *Stafford County Needs Assessment* (MPI, 2001) and are presented in this section. Prior to this study, the most recent projections of Stafford County population and water demand were presented in the report **Comprehensive Water Supply Study** (O'Brien & Gere, 1991). Demand projections presented in that report were primarily based on historical water demand in the county. Five demand projection methodologies were used and resulted in Year 2030 projections ranging from 22.9 mgd to 28.6 mgd. A build-out demand for the entire county of 31.85 mgd was also estimated.

Because the projections presented in the 1991 report were based primarily on historical use patterns, they included an implicit assumption that future growth in water demands will be the same as that experienced in the past. Future use rates may be more or less than those experienced in the past, depending on the effectiveness of existing and future water conservation efforts in the county, possible changes in the type and style of development, and the cost of water in relation to other living expenses.

Different methodologies than those employed in the **Comprehensive Water Supply Study** (O'Brien & Gere, 1991) have been used to project Stafford County water demands in the future. This section describes the methodologies used to project demands, identifies existing and anticipated conservation activities in the county, and presents demand projections with and without additional conservation through the year 2050.

### 5.1.1 Methodologies

Future water demands were projected using a multi-variable approach that separates the total water demand into different user groups. This approach segregates heavy industrial, commercial, and military water demands from residential demands. The existing Zoning Map for Stafford County is presented as Figure 5-1. The following demand categories have been identified for the Stafford County system:

- Residential: Water demand of the general population living in the areas served

- Commercial, Institutional and Light Industrial: Water demand created by employment at the workplace. This category also includes light industrial establishments whose water use is similar to commercial demands, with little to no process water usage.

- Heavy Industrial: Water demand of large industrial process facilities. The demands for employee sanitary uses and process water are included.

- Water Loss: The difference between the quantity of water pumped to distribution and all metered water usage. Some water loss included unmetered, but essential, uses such as those which occur from fire hydrants for fire fighting and water main flushing.

An additional potential use of water in Stafford County is for agricultural irrigation. The Stafford County Department of Utilities does not currently supply water for agricultural irrigation. It is also assumed that agricultural crop irrigation demands will not be met by the County's water system in the future (though reuse of effluent from the county's wastewater treatment facilities should be considered in the future). This analysis projects only potable, treated water demands on the county water supply system to Year 2050.

### 5.1.2 Conservation

Water conservation is the conscious effort by a utility, business, or individual to safe water. Every gallon of water not used is one less to be stored, purified and distributed. It also may represent one less gallon that must be heated for washing or bathing, thus saving energy costs, or one less gallon of water that must pass through some form of wastewater treatment before it is returned to the environment. Normal conservation practices can provide long-term benefits by permanently reducing water demands during normal operating conditions.

Water use restrictions are also considered a form of conservation because they result in demand reductions. However, they differ from normal conservation measures in that they are reserved as contingency measures for emergency situations. Use restrictions are intended to produce short-term water demand reductions during water supply emergencies. According to the Commonwealth of Virginia Guidance for Conducting a Comprehensive Public Drinking

Water Supply Needs Assessment (Virginia, May 2000), future need is the difference between projected future water demand and current water capacity. The Commonwealth's definition of future need excludes potential effects from use restrictions. Nevertheless, use restrictions in Stafford County are discussed in Section 7.0. Stafford County currently encourages normal water conservation practices in its service area. Specific measures employed by the county include public education programs and water supply system improvements (e.g., leak detection and repair). In addition, rate structures and billing incentives are used to encourage water conservation. For example, the County's current water rate structure includes progressively higher monthly service charges as customer use increases. In addition, there are significant cost surcharges for water use during water emergency conditions. (See Appendix B for current water rate structure and emergency water surcharge rates.)

Non-residential customers are billed using a flat rate structure. For many industries, the cost of water is a major operating expense. Therefore, there is a financial incentive for industries locating in the county to conserve water. Industries typically include water conservation activities in their daily operations to reduce costs.

### 5.1.3 Population Projections

A critical predictor of future water demands is population growth. The U.S. Census of Population is prepared by the U.S. Department of Commerce, Bureau of the Census, and provides estimates of total population by jurisdiction. The population levels of Stafford County in 1970, 1980, 1990 and 2000, based on the Census, were 24,587; 40,470; 61,236; and 92,446 persons, respectively. The 2000 Census data show that a 5.1 percent increase in the county population occurred since 1990, and places Stafford County as the fifth fasting growing county or city in Virginia for the period on a percentage basis. Based on the 2004 final and 2005 Provisional Population Estimates, Stafford County has experienced a 26.9% increase in population to 117,300 persons between April 1, 2000 and July 1, 2005. This population increase results in an average increase of 4,743 people per year. Figure 5-2 illustrates the 2000 Census population distribution for Stafford County.

Population projections for Stafford County are available through the Virginia Employment Commission (VEC). The VEC is vested with the authority to prepare official short- and long-term population projections for use by state agencies and the General Assembly.

Long-range Stafford County population projections to Year 2050 were developed by the VEC in 1999 and were obtained from the VEC in October 2000. These state population forecasts were adopted for this study and are presented in Table 5-1 along with other previous VEC and Virginia Department of Planning and Budget (VDPB) projections for Stafford County.

TABLE 5-1
STATE POPULATION PROJECTIONS FOR STAFFORD COUNTY

| Projection | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|---|
| VDPB 1983 | 70,000 | 81,200 | 91,400 | 101,600 | | |
| VDPB 1986 | 70,400 | 84,100 | 97,800 | 111,500 | | |
| VEC 1990 | 83,600 | 105,400 | 127,200 | 149,000 | | |
| VEC 1993 | 83,809 | 94,718 | 105,627 | 116,536 | | |
| VEC 1997 | 93,800 | 121,000 | | | | |
| VEC 1999 | 98,002 | 123,998 | 149,994 | 175,990 | 201,986 | 227,982 |

Source: *Stafford County Needs Assessment*, Malcolm Pirnie, April 2001

The state has typically underestimated near-term growth in Stafford County. As a result, the state's population projections have generally increased for the county. For example, based on the 2005 county population of 117,300, the county has already exceeded the 2030 population projected by the state in 1983, 1986 and 1993. Given the past history of under-prediction of Stafford County growth, it is possible that the latest VEC population projections (1999) may also turn out to be low with respect to actual population growth.

Based on the most recent VEC population projections, a county growth rate of 2,600 persons per year is projected to occur between 2000 and 2050. As shown in Table 5-2, this growth rate is reflective of observed county growth in recent decades, and is well below the level of growth observed during the 1990s.

An additional means of evaluating the projected 2000 – 2050 population growth is to consider whether other Virginia communities have experienced similar or greater growth within 50 years. As shown in Table 5-3 and Figure 5-3, five Virginia communities have grown more than the specific population range projected for Stafford County (i.e., 92,446 to 227,982 over 50 years) in less than 50 years and, in several cases, in much less than 50 years. A sixth Virginia community (Chesapeake) is also on track to experience this growth. These data also show that seven Virginia communities have experienced long-term (30 to 50-year) average annual

population growth exceeding the average annual growth of 2,711 persons per year projected for Stafford County over 50 years. It is clear from these data that the VEC projections adopted for this study are plausible based on historical growth in the county as well as observed growth in other high growth areas of the Commonwealth.

The county population projections through 2050 which have been adopted by the Stafford County Department of Utilities for purposed of long-term water supply planning are presented in Table 5-3 and Figure 5-4. It is prudent to plan for the projected Year 2050 population level based on factors such as the rapid growth that has occurred in the county, current county land use development plans, and planned transportation improvements such as a new airport in Stafford County and a beltway around Fredericksburg which would pass through Stafford County. In addition, the Virginia Department of Environmental Quality (DEQ), the principal water resource management agency of the Commonwealth, utilizes a 50-year water supply planning horizon policy. Figure 5-5 illustrates the projected population growth change in Stafford County from the year 2000 to 2030 by Traffic Analysis Zone (TAZ) Districts.

In early 2006, Malcolm Pirnie performed a historical population analysis for Stafford County using the 2004 Final and 2005 Provisional Population Estimates as provided by the University of Virginia, Demographics and Workforce Unit, Weldon Cooper Center for Public Service. These data provided updated population estimates for the years 2001 through 2005, which show a 26.9% increase to a population of 117,300 residents between April 1, 2000 and July 1, 2005. This population increase results in an average increase of 4,743 people per year. The revised Stafford County Historical Population Growth from 1960 to 2005 is illustrated in Figure 5-6. These recent population projections show that the County has grown more rapidly in the last five years than was projected in the *Stafford County Needs Assessment* (MPI, 2001) and illustrate that the County is experiencing rapid population growth, which further supports the need for a new water supply.

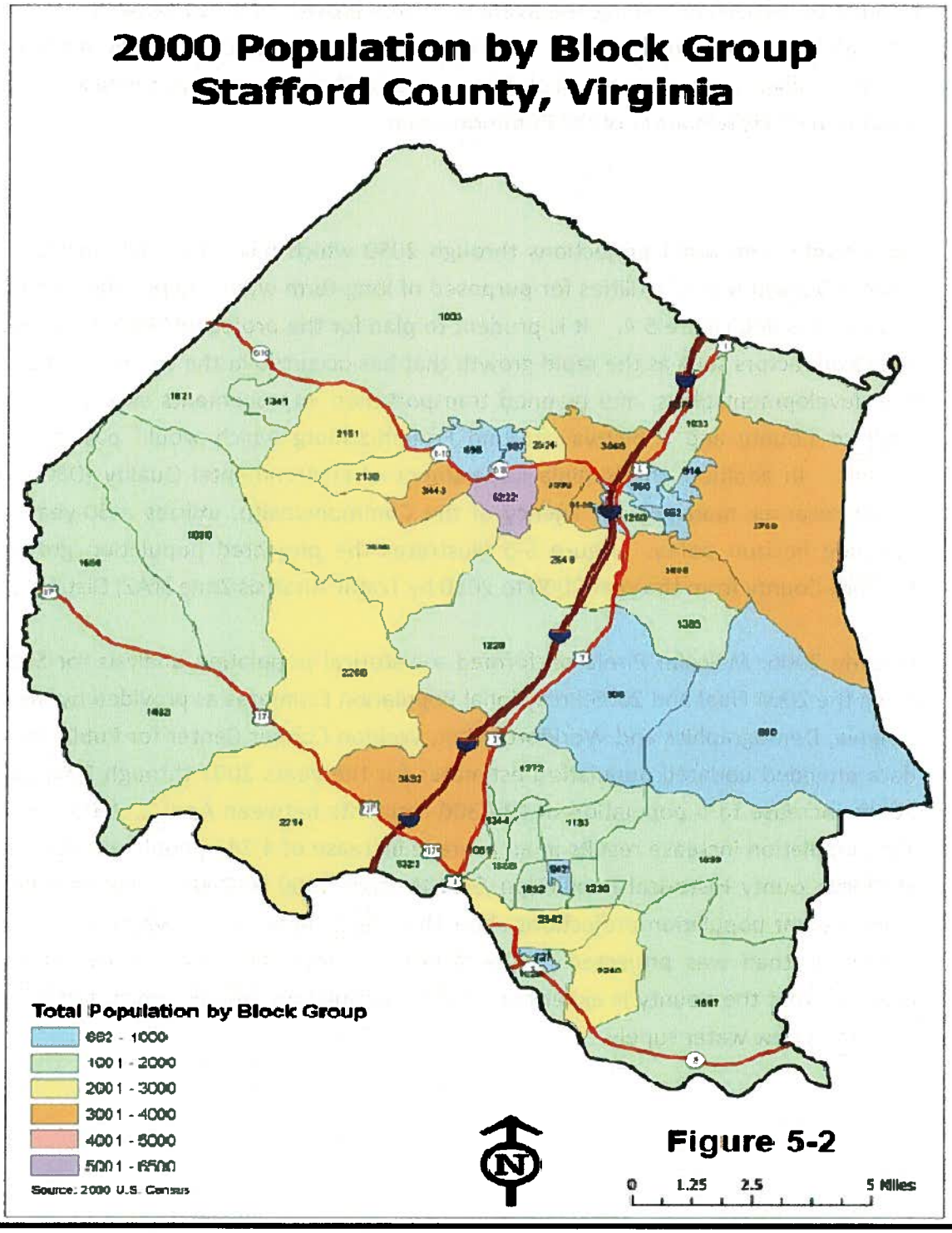
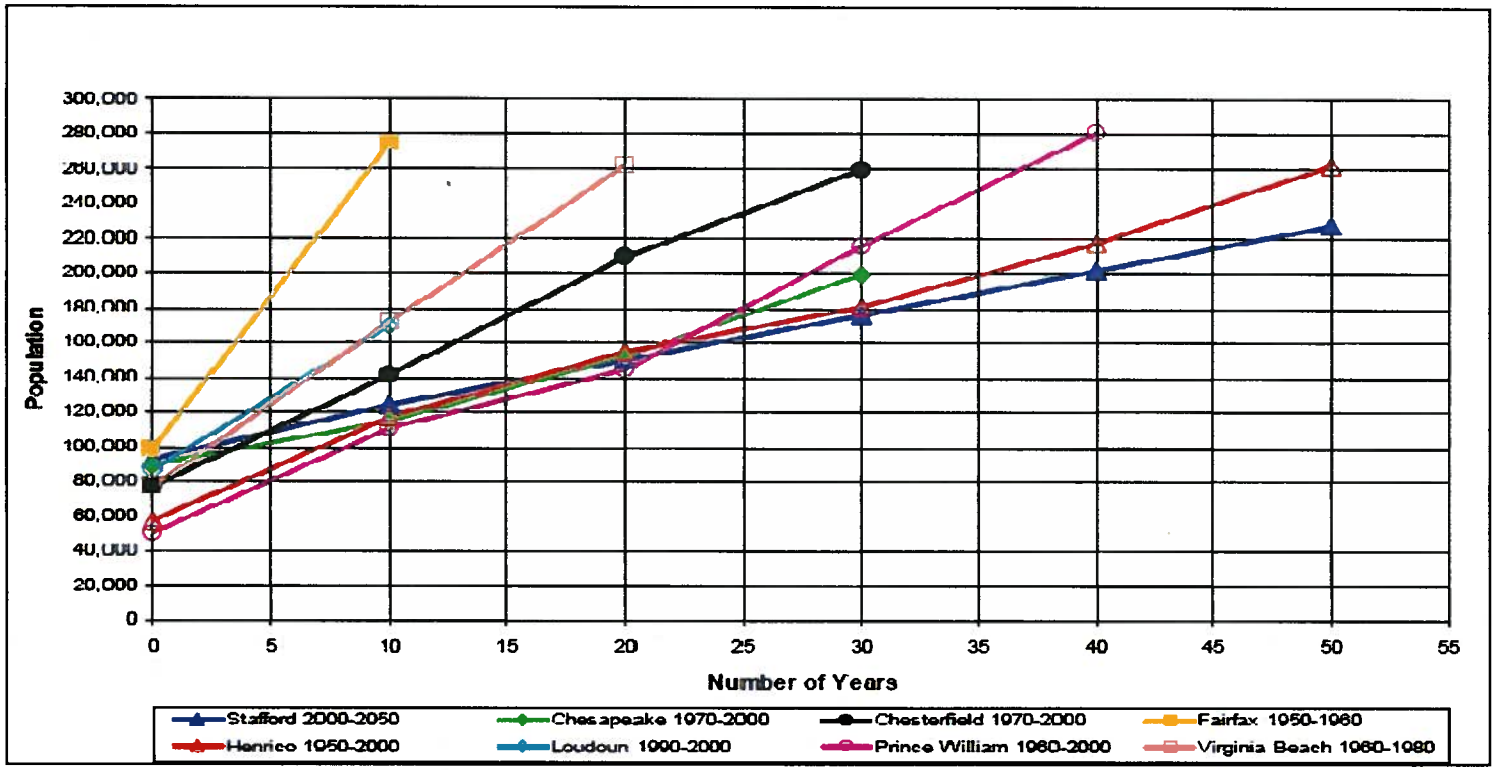

2000 Population by Block Group
Stafford County, Virginia
Total Population by Block Group
662 - 1000
1001 - 2000
2001 - 3000
3001 - 4000
4001 - 5000
5001 - 6500
Source: 2000 U.S. Census
N
0 1.25 2.5 5 Miles

Figure 5-2




MALCOLM PIRNIE

Population Trends in Selected Virginia Communities

FIGURE 5-3

**TABLE 5-2**
**HISTORICAL RATES OF STAFFORD COUNTY POPULATION GROWTH**

| Years | Number of Years | County Population Growth | Rate of Growth (persons/year) |
|---|---|---|---|
| 1970-2000 | 30 | 67,859 | 2,262 |
| 1980-2000 | 20 | 51,976 | 2,599 |
| 1990-2000 | 10 | 31,210 | 3,121 |

Source: *Stafford County Needs Assessment*, Malcolm Pirnie, April 2001

**TABLE 5-3**
**HISTORICAL POPULATION TRENDS IN SELECTED VIRGINIA COMMUNITIES**

| | 1950 | 1960 | 1970 | 1980 | 1990 | 2000 | Average Annual Population Growth (1950-2000) | |
|---|---|---|---|---|---|---|---|---|
| City of Chesapeake | | | 89,580 | 114,486 | 151,982 | 199,184 | 3,653 | * |
| Chesterfield County | 40,400 | 71,197 | 77,045 | 141,372 | 209,564 | 259,903 | 4,390 | |
| Fairfax County | 98,557 | 275,002 | 454,275 | 596,901 | 818,358 | 969,749 | 17,424 | |
| Henrico County | 57,340 | 117,339 | 154,463 | 180,735 | 217,849 | 262,300 | 4,099 | |
| Loudoun County | 21,147 | 24,549 | 37,150 | 57,427 | 86,129 | 169,599 | 2,969 | |
| Prince William County | 22,612 | 50,164 | 111,102 | 144,703 | 215,677 | 280,813 | 5,164 | |
| City of Virginia Beach | 42,277 | 77,127 | 172,106 | 262,199 | 393,089 | 425,257 | 7,660 | |
| | | | | | 2000 | 2050 | (2000-2050) | |
| Stafford County Projected Population Growth | | | | | 92,446 | 227,982 | 2,711 | |

* Average annual population growth for Chesapeake based on 1970-2000.

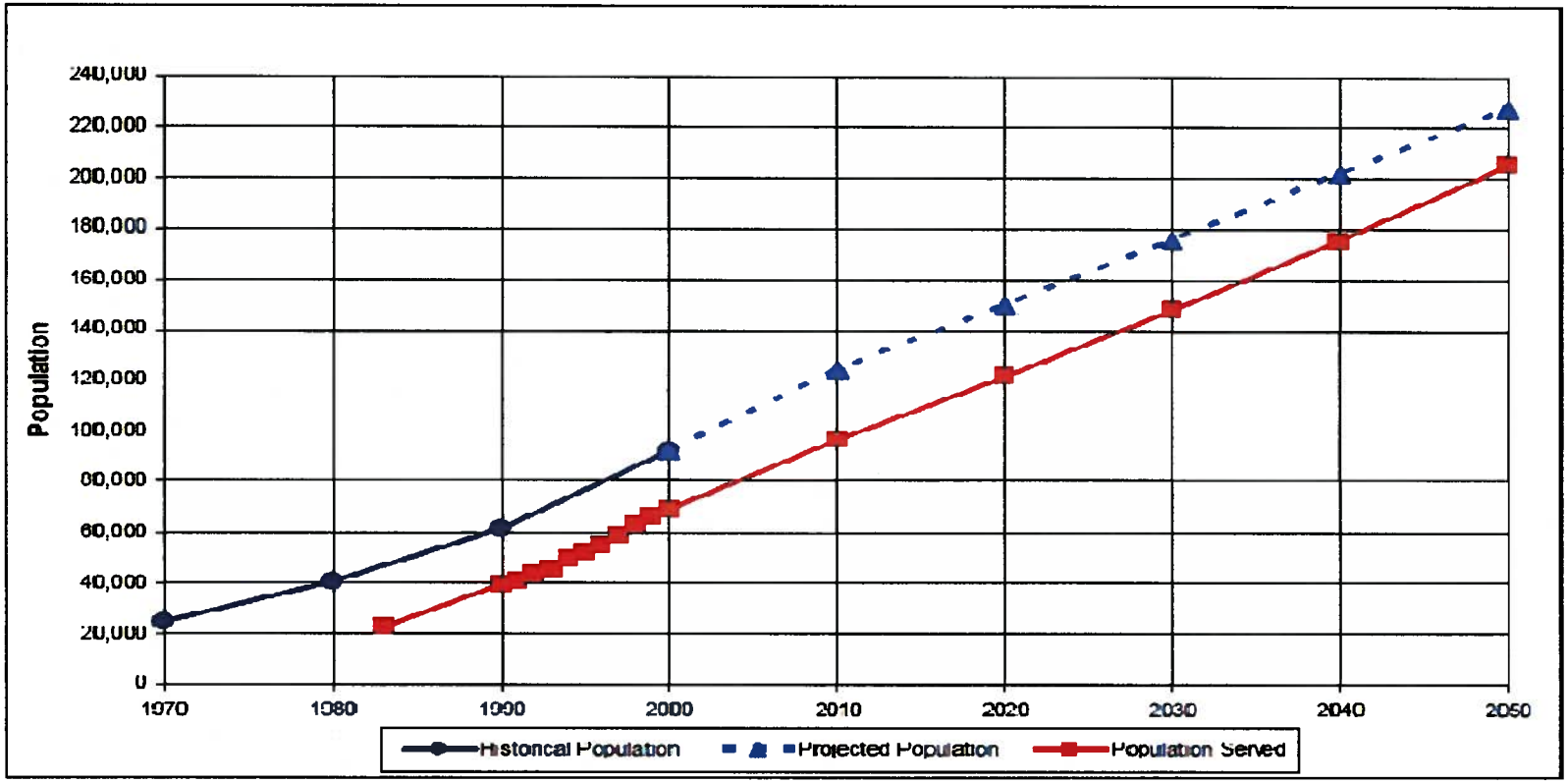
Data Sources: University of Virginia - Weldon Cooper Center for Public Service "Virginia Statistical Abstract 1996-97 Edition" (1996); U.S. Census Bureau 2000 Census population figures (released April 2, 2001); and Virginia Employment Commission "Long Range Population Projections" (provided to Malcolm Pirnie by VEC on October 23, 2000).

TABLE 5-4
ADOPTED PROJECTIONS OF POPULATION AND POPULATION SERVED FOR STAFFORD COUNTY

| Year | Population | Percent of Population Served | Population Served |
|---|---|---|---|
| 2000 | 92,446 | 75 | 69,335 |
| 2010 | 123,998 | 78 | 96,718 |
| 2020 | 149,994 | 81 | 121,495 |
| 2030 | 175,990 | 84 | 147,832 |
| 2040 | 201,986 | 87 | 175,728 |
| 2050 | 227,982 | 90 | 205,184 |

Source: *Stafford County Needs Assessment*, Malcolm Pirnie, April 2001

7




MALCOLM PIRNIE | Historical and Projected Stafford County Populations | FIGURE 5-4

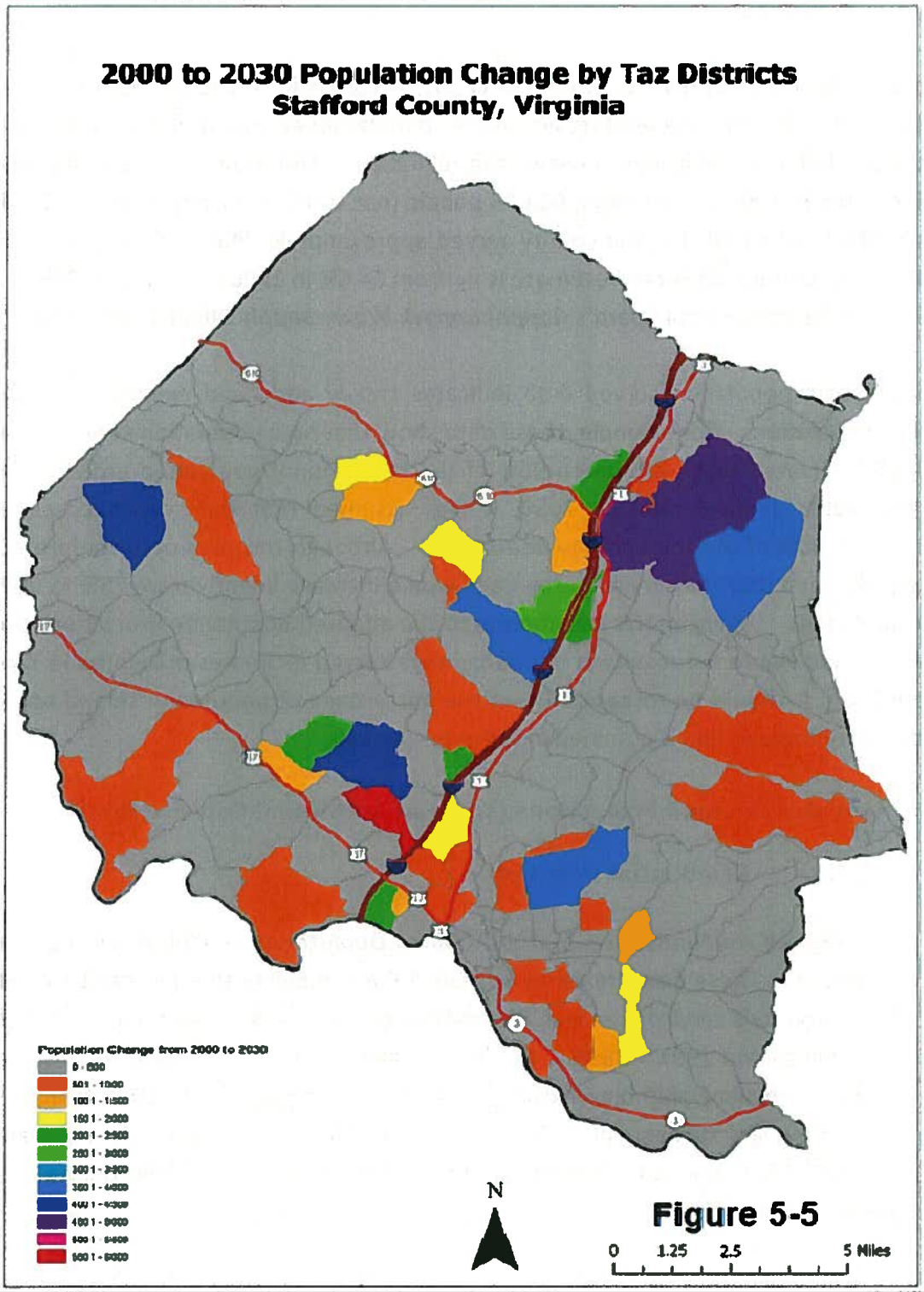

2000 to 2030 Population Change by Taz Districts
Stafford County, Virginia
Population Change from 2000 to 2030
N
0 1.25 2.5 5 Miles

Figure 5-5

### 5.1.4 Population Served

Not all of the total population within the county is currently served by the public water supply system. To estimate the existing and future population served, Stafford County Department of Utilities billing records were reviewed in July 2000. These data are listed in Table 5-5 and indicate that in 1999 an estimated 66,673 people (not connections) were served by the county. It is further estimated that the county served approximately 74.6% of the total population in 1999. This population served estimate is up from 64.6% in 1990 and 50% in 1983 as estimated in the State Water Control Board's ***Rappahannock Water Supply Plan*** (SWCB, 1988).

The historical population served data indicates steady and rapid expansion of the county's service population. For example, these data show that new population served between 1990 and 1999 equated to an estimated 96% of the total county population growth. In order to project water demand through 2050, it was assumed that the service population would increase to 90% of the total county population. Although this may occur before 2050, it was simply assumed that the service percentage would increase linearly from 75% to 90% between 2000 and 2050. Applying this assumption to the adopted population projections presented in Table 5-4 and Figure 5-4 results in the percentage served estimates presented in Table 5-4 and Figure 5-4. It should be recognized that the percentage of population served has historically grown more rapidly than is assumed in these projections.

### 5.1.5 Water Demand Projections (Without Additional Conservation)

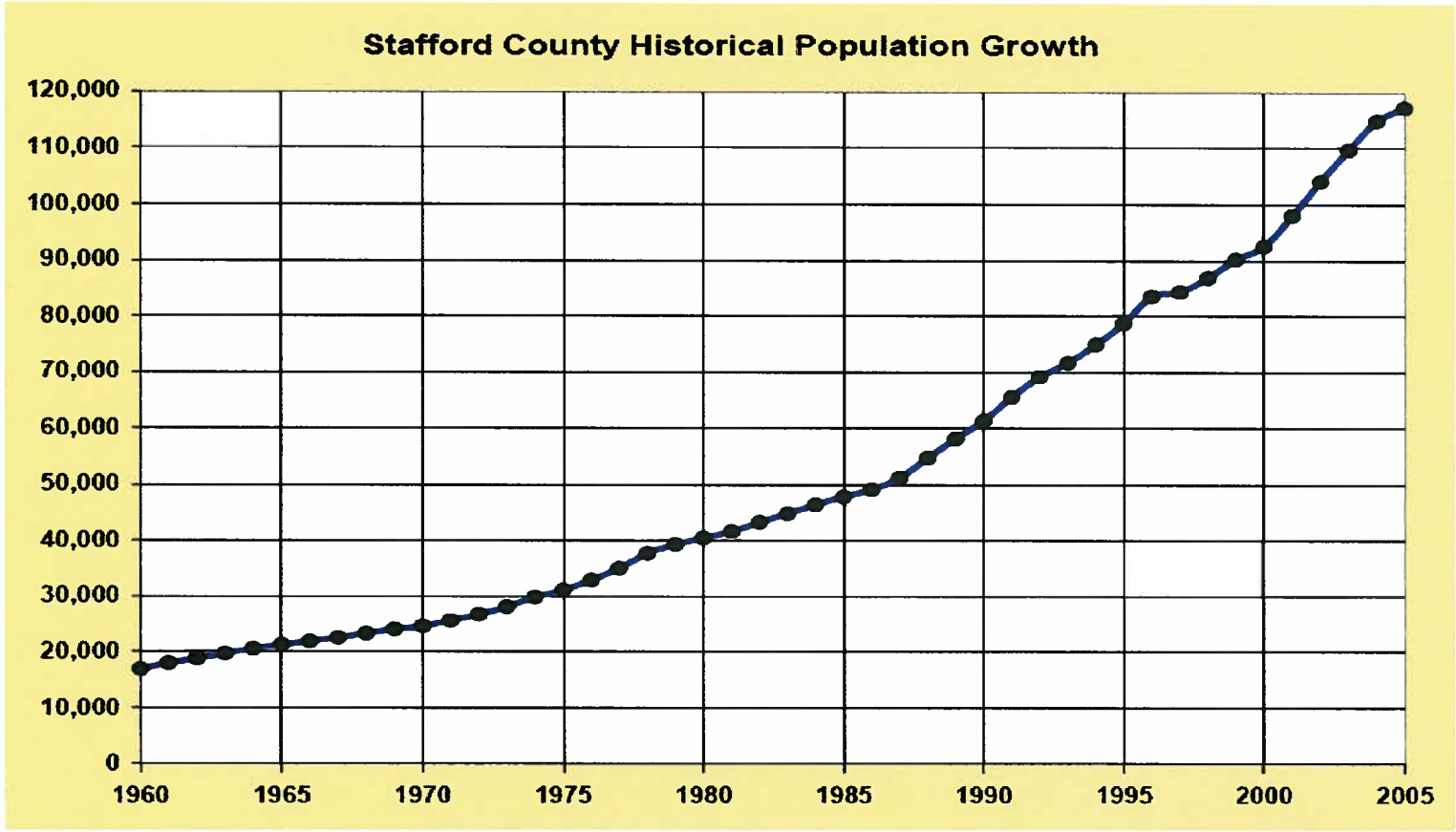
#### 5.1.5.1 Residential Demand

To estimate residential use, Stafford County Department of Utilities billing records were reviewed. These data are listed in Table 5-6 and indicate that per capital residential use in the county's service area was 69.6 gallons per day (gpd) in 1999 and averaged 68.7 gpd over the period 1991 – 1999. In 1994, uniform national standards for the manufacture of water-efficient plumbing fixtures took effect pursuant to the 1992 Energy Policy Act. Over the years subsequent to 1994 (1995 – 1999), per capita residential water use has averaged 68.0 gpd and appears to be slightly lower than levels before the national standards took effect.

Multiplying the 1995 – 1999 average per capita use of 68 gpd by the population served in each year (Table 5-4) results in projected residential demands (see Table 5-7). Projected Year 2050 residential water demand is 14.0 mgd.

The adopted 68 gpd per capita (gpcpd) residential use rate is low compared to the most recent USGS records for water use in the region. According to USGS data from 1995, average residential use was 86 gpcpd in Virginia and 97 gpcpd in the Southeastern United States as a whole. The adopted 68 gpd use rate is also low when considering that indoor per capita use alone averaged more than this (69.2 gpd) in the 12 study sites evaluated in the American Water Works Association (AWWA) Research Foundation's "Residential End Uses of Water" study (AWWARF, December 1999).

Monthly records of Stafford County residential water sales were reviewed in order to estimate the breakdown between indoor and outdoor residential use. Residential monthly demand ratios were computed for each of the last 10 years and are shown in Figure 5-7. Based on these ratios, the lowest months of residential use are December through May. For purposes of this analysis, it was assumed that outdoor residential use is negligible during these months. The difference between average residential demand in these six low-use months versus each full year was used to estimate average outdoor use. For the period 1991 – 1999, the estimated average annual per capita outdoor residential use ranged between 3.6 and 10.7 gpd with an average of 7.4 gpd and a median value of 8.6 gpd. Based on these figures, average per capita indoor residential use is estimated to comprise about 60 gpd of the adopted 68 gpd overall residential use rate. This level of estimated indoor use is far less than the average indoor use rate of 69.3 gpd determined through the recent AWWARF study. Despite the current low rate of residential water use in Stafford County, some future reduction in use is still possible.




MALCOLM PIRNIE | Stafford County Historical Population Growth | FIGURE 5-6

**TABLE 5-5**
**ESTIMATED POPULATION SERVED BY STAFFORD COUNTY**

| Year | Persons Served | County Population | % Served |
|---|---|---|---|
| 1990 | 39,585 | 61,236 | 64.6 |
| 1991 | 41,445 | | |
| 1992 | 43,401 | | |
| 1993 | 45,459 | | |
| 1994 | 49,460 | | |
| 1995 | 52,433 | | |
| 1996 | 55,184 | | |
| 1997 | 58,754 | | |
| 1998 | 63,334 | | |
| 1999 | 66,673 | 89,325 * | 74.6 |

Source: *Stafford County Needs Assessment*, Malcolm Pirnie, April 2001

**TABLE 5-6**
**RESIDENTIAL USE IN STAFFORD COUNTY UTILITIES SERVICE AREA**

| Year | Residential Sales (mgd) | Persons Served | Per Capita Use (gpd) |
|---|---|---|---|
| 1991 | 2.94 | 41,445 | 70.8 |
| 1992 | 2.93 | 43,401 | 67.5 |
| 1993 | 3.26 | 45,459 | 71.7 |
| 1994 | 3.39 | 49,460 | 68.6 |
| 1995 | 3.64 | 52,433 | 69.5 |
| 1996 | 3.61 | 55,184 | 65.5 |
| 1997 | 4.00 | 58,754 | 68.1 |
| 1998 | 4.26 | 63,334 | 67.2 |
| 1999 | 4.64 | 66,673 | 69.6 |
| | | Average 1991-1999 | 68.7 |
| | | Average 1995-1999 | 68.0 |

Source: *Stafford County Needs Assessment*, Malcolm Pirnie, April 2001

Multiplying the 1995-1999 average per capita use of 68 gpd by the population served in each year (Table 5-5) results in projected residential demands (see Table 5-7). Projected Year 2050 residential demand is 14.0 mgd.

**TABLE 5-7**
**STAFFORD COUNTY**
**RESIDENTIAL DEMAND PROJECTIONS**

| Year | Population Served | Per Capita Residential Use (gpd) | Demand (mgd) |
|---|---|---|---|
| 2000 | 69,335 | 68 | 4.7 |
| 2010 | 96,718 | 68 | 6.6 |
| 2020 | 121,495 | 68 | 8.3 |
| 2030 | 147,832 | 68 | 10.1 |
| 2040 | 175,728 | 68 | 11.9 |
| 2050 | 205,184 | 68 | 14.0 |

Source: *Stafford County Needs Assessment*, Malcolm Pirnie, April 2001

### 5.1.5.2 Commercial Demand

The Commercial, Institutional and Light Industrial (Commercial) user category includes all water use in places of business, schools, hospitals, restaurants, stores, warehouses, non-water intensive industries and all other uses that are not specifically included in the Residential, Heavy Industrial, Military or Water Loss categories.

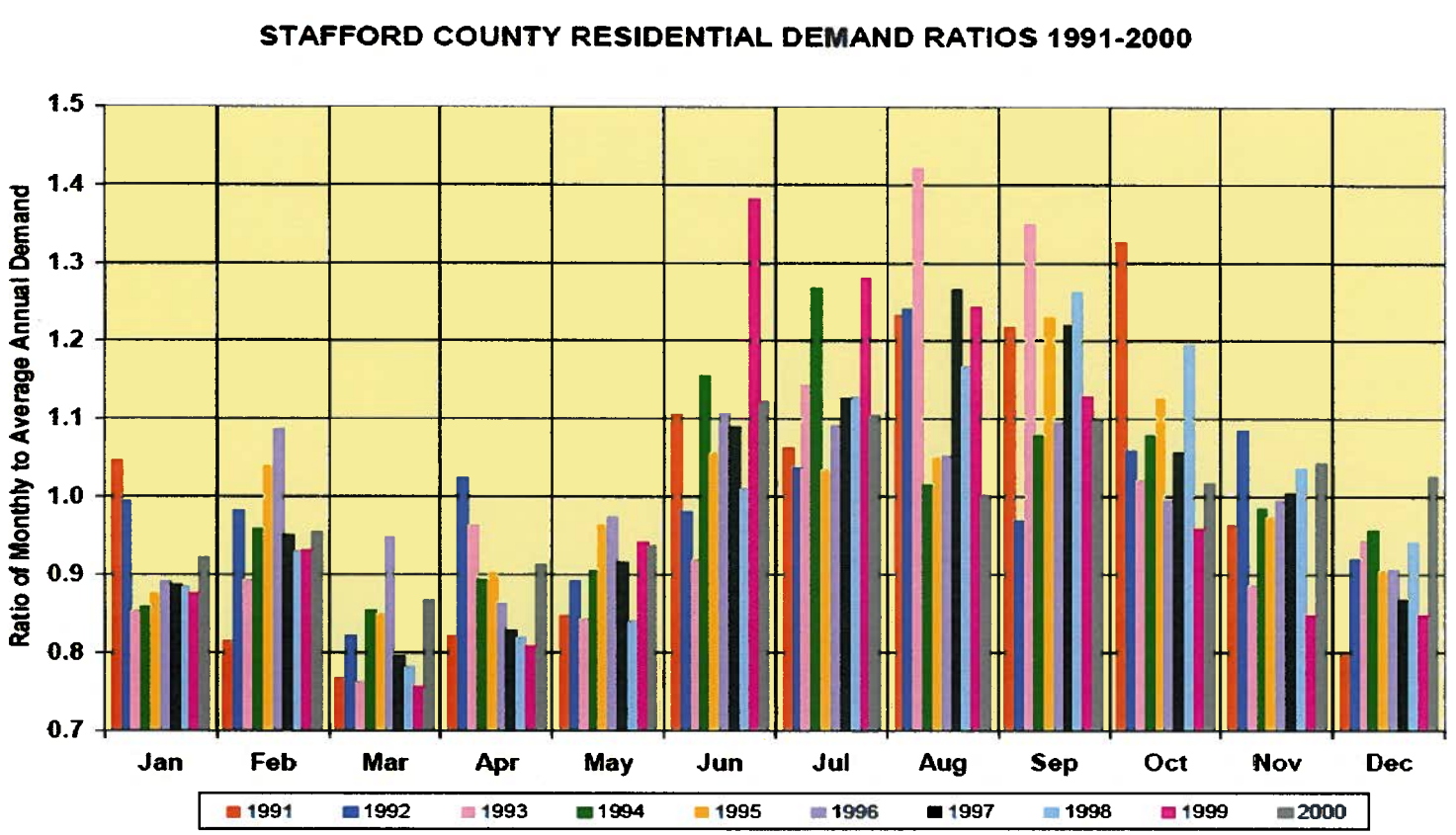
Commercial water demands are sometimes estimated based on a per employee use rate (obtained from Base Year metered usage) multiplied by employment projections in a given year. Commercial water demands may also be presented in terms of a use rate per land use acre. Detailed information on existing and future land uses in the county is available from county planners. As discussed below, both methods were considered for use in developing commercial demand projections. The adopted commercial projections were made based on a per employee use rate.

Commercial demands are sometimes projected based on a use rate per acre multiplied by estimates of future developed commercial acreage. Commercial demand factors per acre for Stafford County are documented in the Comprehensive Water Supply Study (O'Brien & Gere, 1991), which refers to the County of Stafford, Virginia Water and Sewer Master Plan (CDM, 1990 and Final Update June 25, 1993). Commercial per acre water usage rates for Stafford County were estimated in these studies as 1,000 gpd for commercial and institutional land uses; 1,500 gpd for light industrial use; and 2,000 gpd for office use. To identify an appropriate use rate for projecting long-term demands, data from existing and designated land uses were obtained from the Stafford County Land Use Plan approved in 1996 by the Stafford County Planning Commission. The total commercial, light industrial and institutional land in use in 1995 was estimated to be 2,365 acres. At build-out of the existing Land Use Plan, a total of 14,751 acres of land within the entire county is designated for commercial, light industrial and institutional uses. The breakdown of 1995 and future commercial land use types is presented in Table 5-8.

One possible scenario is that commercial build-out could occur by the end of the planning period, in which case 14,751 acres of commercial lands would be developed by Year 2050. To further develop this scenario, it was assumed that the weighted average Commercial Category per acre use rate would be about 1,300 gpd by the end of the planning horizon.

Under these assumptions, commercial, institutional and light industrial water demands would increase to 19.2 mgd in Year 2050 under the build-out commercial land use development assumptions. This very high resulting demand level is largely due to the assumption that commercial build-out would occur by 2050. This land use based forecasting method requires more realistic estimates than are currently available of how rapidly land designated for commercial uses would be developed. Therefore, this method was not used to develop the adopted commercial demand projections.

The selected method for projecting commercial demand is based on the estimated number of future employees in the county and a per employee use rate. To evaluate Stafford County employment trends, quarterly non-agricultural employment data were obtained from the VEC for the period 1990 – 1999. Average annual employment figures were developed from these data and are listed in Table 5-9 along with historical commercial use data. Although 1999 employment represents only 25% of the estimated 1999 population of 89,325, these data show that county employment has doubled (99% increase) in only nine years, as compared to an estimated 46% population increase over the same period.




MALCOLM PIRNIE | Stafford County Monthly Residential Demand Ratios | FIGURE 5-7

TABLE 5-8
STAFFORD COUNTY 1995 AND BUILDOUT COMMERCIAL LAND USE AREAS

| Commercial Category | 1995 Acreage | Buildout Acreage |
|---|---|---|
| Commercial | 1,431 | 4,834 |
| Institutional | 292 | 1,680 |
| Light Industrial | 642 | 8,237 |
| Total | 2,365 | 14,751 |

Source: *Stafford County Land Use Plan*, approved in 1996

TABLE 5-9
COMMERCIAL USE IN STAFFORD COUNTY
UTILITIES SERVICE AREA

| Year | Commercial Sales (mgd) | County Employment | Per Employee Use (gpd) |
|---|---|---|---|
| 1990 | | 11,117 | |
| 1991 | 0.63 | 11,038 | 57.0 |
| 1992 | 0.59 | 11,510 | 51.0 |
| 1993 | 0.67 | 12,887 | 51.7 |
| 1994 | 0.71 | 14,045 | 50.6 |
| 1995 | 0.76 | 15,858 | 48.1 |
| 1996 | 0.77 | 16,852 | 45.7 |
| 1997 | 0.80 | 18,038 | 44.2 |
| 1998 | 0.82 | 20,202 | 40.6 |
| 1999 | 0.96 | 22,124 | 43.3 |
| | | Average 1991-1999 | 48.0 |
| | | Average 1995-1999 | 44.4 |

Source: *Stafford County Needs Assessment*, Malcolm Pirnie, April 2001

Actual employment levels in other nearby areas were assessed in order to project future employment levels in Stafford County. Using the quarterly non-agricultural employment data obtained from the VEC and provisional July 1, 1999 population estimates obtained from the University of Virginia – Weldon Cooper Center for Public Service, average 1999 employment levels and percentages were calculated for the jurisdictions and regional Planning District Commissions (PDCs) listed in Table 5-10. These data show that total employment in Virginia represents about 48% of the State population, whereas the employment percentage in the nearby Northern Virginia and Richmond Regional PDCs represents between 54 and 57% of population.

TABLE 5-10
1999 EMPLOYMENT LEVELS IN AREAS OF VIRGINIA

| Jurisdiction or PDC | Average 1999 Employment | Estimated 1999 Population | Employment as % of Population |
|---|---|---|---|
| City of Chesapeake | 78,481 | 197,000 | 39.8 |
| Chesterfield County | 104,194 | 252,200 | 41.3 |
| Fairfax County | 500,098 | 942,200 | 53.1 |
| Henrico County | 160,397 | 249,200 | 64.4 |
| Loudoun County | 75,582 | 155,900 | 48.5 |
| Prince William County | 73,298 | 267,800 | 27.4 |
| City of Virginia Beach | 158,594 | 421,000 | 37.7 |
| | | | |
| Richmond Regional PDC | 480,073 | 837,200 | 57.3 |
| Northern Virginia PDC | 941,565 | 1,739,000 | 54.1 |
| Hampton Roads PDC | 668,782 | 1,503,200 | 44.5 |
| Total of 3 PDCs | 2,090,420 | 4,079,400 | 51.2 |
| | | | |
| State of Virginia | 3,289,475 | 6,872,900 | 47.9 |

Source: *Stafford County Needs Assessment*, Malcolm Pirnie, April 2001

For this study, it is projected that Stafford County employment, exclusive of military staff and civilians employed at Quantico Marine Corps Base (QMCB), will grow to about 50% of the county's population by Year 2050 as additional commercial and industrial development occurs in the county. This projection is based, in part, on the current trend of county employment increasing over twice as rapidly as population on a percentage basis. In addition, the county expects to take on the commercial and industrial employment characteristics of large Virginia metropolitan areas, and Virginia as a whole, as growth continues over the next 50 years. It is expected that heavy industrial employment will represent on the order of 5% of total population, thereby reducing Year 2050 commercial employment to about 45% of total population. The commercial employment percentage is projected to grow in linear fashion from approximately 25% in 2000 to 45% in 2050 as indicated in Table 5-11. The resulting commercial employment projections in Table 5-11 are less than Stafford County employment projections of 40,862 (Year 2010) and 65,814 (Year 2025) being used in a current transportation model and transportation impact fee study. The majority of the difference is likely due to the QMCB and heavy industrial employment which is not included in the commercial employment projections found in Table 5-11.

TABLE 5-11
STAFFORD COUNTY
COMMERCIAL DEMAND PROJECTIONS

| Year | Total Population | Percent of Population in Commercial Employment | Commercial Employment | Commercial Use Rate (gpd/employee) | Demand (mgd) |
|---|---|---|---|---|---|
| 2000 | 92,446 | 25 | 23,112 | 45 | 1.0 |
| 2010 | 123,998 | 29 | 35,959 | 48 | 1.7 |
| 2020 | 149,994 | 33 | 49,498 | 51 | 2.5 |
| 2030 | 175,990 | 37 | 65,116 | 54 | 3.5 |
| 2040 | 201,986 | 41 | 82,814 | 57 | 4.7 |
| 2050 | 227,982 | 45 | 102,592 | 60 | 6.2 |

Source: *Stafford County Needs Assessment*, Malcolm Pirnie, April 2001

To estimate commercial use, Stafford County Department of Utilities billing records were reviewed. These data are listed in Table 5-9 and indicate that per employee commercial use in the county's service area was 43.3 gpd in 1999 and averaged 48.0 gpd over the period 1991 – 1999. In the years subsequent to Energy Policy Act regulations taking effect in 1994, per employee commercial use has declined to an average of 44.4 gpd. However, these use figures are based on the simplifying assumption that all employees are served by Stafford County. In reality, some county employees are not located within the county's service area and, consequently, actual per employee use within the service area is probably somewhat higher. In addition, the largest private sector employer in the county is GEICO Insurance which employs about 3,900 persons at its regional headquarters. Department of Utilities staff believes that the very low per employee use in GEICO's office environment is causing a substantial downward skew in the current per employee use of the county's commercial sector.

Detailed water use studies were recently conducted for the Lower Virginia Peninsula as reported in HDR Engineering's Water Needs Assessment 2000 – 2050 (HDR, November 2000). The HDR study estimated current commercial per employee use to be 51.3 gpd on the Lower Peninsula. Other communities in the Mid-Atlantic region have significantly higher commercial per employee use. For example, recent studies have indicated per employee use of 77 gpd for the Orange Water and Sewer Authority which serves the area around Chapel Hill, North Carolina. The Town of Cary, North Carolina is, like Stafford County, undergoing rapid population growth (estimated 1999 Cary population of

92,972) and is reporting per employee commercial use of 76 gpd. Another major North Carolina water utility, the Fayetteville Public Works Commission, is reporting current per employee commercial use of 73 gpd in its service area.

It is believed that a commercial use rate in the range bracketed by these Virginia and North Carolina communities will develop over time in Stafford County as it takes on a more urban character with a greater mix of institutional and light industrial facilities in the commercial sector. Based on this expectation, and the under prediction of commercial use due to employment outside the county service area, the per employee use rate is projected to increase in linear fashion from 45 to 60 gpd over the planning horizon as indicated in Table 5-11.

Based on the projected employment and per employee use rates listed in Table 5-11, demands in the commercial sector would reach 6.2 mgd in Year 2050. The commercial demand projections listed in Table 5-11 were adopted for this study. It is believed that there is more certainty with regard to future employment levels and per employee use than with the rate of future land development and per acre use assumptions associated with the land use based forecasting method. Some future reduction in commercial use is possible.

#### 5.1.5.3 Heavy Industrial Demand

The Heavy Industrial category includes industrial, manufacturing and food processing industries with high average daily water use. Current (1999) industrial water use is very low in the Stafford County Department of Utilities service area (i.e., less than 0.1 mgd). Consequently, projecting industrial water demands requires an assessment of the opportunity and economic incentives for attracting new industry to the area. As discussed below, a land use based method as well as a method based on observed use in other communities was considered for use in developing industrial demand projections. The adopted heavy industrial projections were made based on observed industrial use in other communities.

Future heavy industrial demands are sometimes projected based on a use rate per acre multiplied by estimates of future developed heavy industrial acreage in a given year. An industrial demand factor of 4,500 gallons/day/acre is documented in the Comprehensive Water Supply Study (O'Brien & Gere, 1991), which refers to the County of Stafford, Virginia Water and Sewer Master Plan (CDM, 1990 and Final Update June 25, 1993).

The factor is based on design criteria provided by Stafford County Department of Utilities (CDM, 1990 and Final Update June 25, 1993). The heavy industrial per acre use rate of 4,500 gpd was used to estimate future heavy industrial demands for this projection method.

To estimate future heavy industrial land use acreage, data concerning existing and designated land uses were obtained from the Stafford County Land Use Plan approved in 1996. Heavy industrial land in use in 1995 was estimated to total 30 acres. At build-out of the existing Land Use Plan, a total of 527 acres of land within the county is designated for heavy industrial usage. One possible scenario is that industrial build-out could occur by the end of the planning period, in which case 527 acres of heavy industrial lands would be developed by Year 2050. Under these assumptions, heavy industrial demand would increase to 2.4 mgd by 2050. A major drawback with this land use based projection is that there is an extremely high degree of uncertainty associated with the per acre use rate. Therefore, this method was not used to develop the adopted heavy industrial demand projections.

The selected method for projecting heavy industrial demand is based on comparisons made to actual industrial use in other nearby areas. Water utilities staff from several large Virginia communities in Northern Virginia, the greater Richmond area and Hampton Roads were contacted in August 2000 to obtain current industrial water consumption data. Unfortunately, some utilities do not separately track industrial customer use. However, from the Richmond metropolitan area, Chesterfield and Henrico counties were able to provide water use records indicating that average industrial use in 1999 was 2.9 mgd in Chesterfield and 3.8 mgd in Henrico. For Henrico County, industrial use has averaged 3.9 mgd over 10 years (FY 1990 – 1999) and annual use over that period has been as high as 4.8 mgd. As indicated in Table 5-3, current population levels in Chesterfield and Henrico counties are both within 15% of Stafford County's projected 2050 population. For the Hampton Roads area, the USACE's January 1997 Final EIS included 1990 metered heavy industrial use rates for communities on the Lower Virginia Peninsula. In 1990, heavy industrial use was 5.2 mgd in James City County, 2.7 mgd in Newport News and 2.2 mgd in York County. Both James City and York counties have substantially fewer residents than currently live in Stafford County.

Even if very little industrial use currently exists in an area, industrial demands can grow quickly when a water-intensive industry locates in an area. For example, Motorola recently announced plans to locate a semiconductor plant in Goochland County's West Creek Industrial Park. This single industrial facility would ultimately use about 9 mgd of potable water. White Oak Semiconductor in Henrico County will use 4 to 5 mgd. Dominion Semiconductor in Manassas, Virginia will ultimately use about

8 mgd. It is quite possible that this type of high water use industry will also be attracted to Stafford County.

Based on actual industrial use in other comparable Virginia counties, an allowance of 4.0 mgd was selected as a reasonable planning assumption to accommodate future major in the county. It is projected that heavy industrial demand will steadily increase to this Year 2050 level. The heavy industrial demand projections listed in Table 5-12 were adopted for this study. It is believed to be more reasonable to rely on actual use in other communities rather than accepting the major uncertainties regarding per acre use and future land development rates associated with the land use based forecasting method.

**Table 5-12**
**Stafford County**
**Industrial Demand Projections**

| Year | Demand (mgd) |
|---|---|
| 2000 | 0 |
| 2010 | 0.8 |
| 2020 | 1.6 |
| 2030 | 2.4 |
| 2040 | 3.2 |
| 2050 | 4.0 |

Source: *Stafford County Needs Assessment,* Malcolm Pirnie, April 2001

### 5.1.5.4 Military Demand

Stafford County has recently coordinated with the Quantico Marine Corps Base (QMCB) to provide treated potable water to the base in the future. Current discussions between the county and QMCB have indicated that the QMCB is interested in buying up to 1.5 mgd of treated potable water from Stafford County.

The county's current (1998) contract with QMCB provides for supply of up to 0.75 mgd. At present (2005), QMCB purchases an average of 0.3 mgd from Stafford County. However, a 1.5 mgd allowance for treated water sales to QMCB has been included in the adopted demand projections beginning in 2020 and is held constant during the remainder

of the planning horizon. Given the likelihood that future military consolidation activities would cause further expansion of facilities and personnel at QMCB, it is possible that QMCB could require additional water beyond 1.5 mgd in the future. According to the *Marine Corps Times,* "Marine Corps Base Quantico could possibly have the third largest gain of personnel in the state if the Secretary of Defense's Base Realignment and Closure (BRAC) recommendations are approved by Congress." If the recently released BRAC recommendations are approved, it could result in an influx of more than 3,000 personnel to the base. However, it is not possible to quantify additional sales at this time.

### 5.1.5.5 Water Losses

Water Losses are the difference between a water utility's finished water production and all metered water usage. A distinction can be made between authorized water loss uses and other water losses. Authorized uses are specific unmetered uses of water that a water utility recognizes to be beneficial and/or necessary. The following uses may be considered authorized water losses by a water utility:

- Unmetered use from fire hydrants (e.g., fire fighting and training, street washing, construction, water main flushing, sewer main cleaning and storm drain flushing).
- Unmetered connections (e.g., public buildings, schools, cemeteries or parks). Stafford County currently has very few unmetered connections.
- Treatment facility process water

Other water losses comprise all other uses, losses and measuring errors. Examples include the following:

- Distribution system leakage
- Service line leakage
- Unauthorized use (e.g., theft, deliberate bypass of meters and illegal tapping)
- Inaccurate meters
- Inadequate system controls (e.g., malfunctioning valves)
- Incorrect meter reading and billing

Water loss estimates for water supply systems vary greatly depending on the types and degrees of authorized water losses and unauthorized water losses. To estimate the percentage of water loss for the Stafford County system, Department of Utilities records of finished water production (i.e., raw water withdrawals less process use) and total system sales (i.e., metered demand) were reviewed in July 2000. These data are listed in Table 5-13 and indicate that water loss has averaged 20% of finished water production over the period 1991 – 1999 and has ranged between 17.1 and 22.6% on an annual basis. More recently (post 2005), more emphasis has been placed on quantifying water use for flushing water mains and other scheduled uses of water resulting in a reduction of annual water loss percentages to the 10 to 15% level. Efforts continue to reduce water loss to below 10%.

The Stafford County water loss estimate reflects a combination of unauthorized water use losses and other water losses. The system is flushed using fire hydrants once a year and was estimated to account for approximately 21 million gallons of water losses per year. Due to development patterns within the county, there are many dead end water mains in the water transmission piping which require frequent flushing. The county is currently in the process of completing loops and eliminating as many of these dead end lines as possible. These system improvements should greatly reduce the need for frequent flushing, thereby reducing authorized water losses.

From a purely economic perspective, considering the cost of producing the water that is lost, it is in the county's best interest to reduce its water losses as much as possible. The county is currently placing emphasis on developing and implementing an aggressive program to reduce its water loss percentage. It is expected that reductions will be achieved through leak detection and repair programs, eliminating dead end within the system to minimize the need for flushing and revising its flushing program to more efficiently serve the system.

For purposes of this study, the percentage of water losses in Stafford County's system is projected to decrease from 20% to 15% by 2020 and is held constant during the remainder of the planning horizon. A survey of U.S. water utilities was recently sponsored by the AWWA and completed in January 2001. As part of this survey, water loss percentages were compiled for utilities within the U.S. Environmental Protection Agency's (USEPA) Region 3 (includes Virginia). The survey results show that average

**Table 5-13**
**Water Losses in Stafford County Water System**

| Year | Finished Water Production (mgd) | Total System Sales (mgd) | Water Losses (mgd) | Water Losses (% of Finished Water Production) |
|---|---|---|---|---|
| 1991 | 4.41 | 3.60 | 0.81 | 18.4 |
| 1992 | 4.27 | 3.54 | 0.73 | 17.1 |
| 1993 | 4.79 | 3.95 | 0.84 | 17.6 |
| 1994 | 5.37 | 4.19 | 1.18 | 22.0 |
| 1995 | 5.56 | 4.44 | 1.12 | 20.2 |
| 1996 | 5.63 | 4.41 | 1.22 | 21.7 |
| 1997 | 6.13 | 4.86 | 1.27 | 20.7 |
| 1998 | 6.71 | 5.20 | 1.52 | 22.6 |
| 1999 | 7.33 | 5.83 | 1.50 | 20.4 |
| | | Average 1991-1999 | | 20.1 |

Source: *Stafford County Needs Assessment,* Malcolm Pirnie, April 2001

water loss is 18.9% at 25 smaller utilities serving populations of less than 10,000. For 19 medium-sized utilities serving populations between 10,000 and 100,000, average water loss is 14.7%. For 11 large utilities serving over 100,000 people, average water loss is 17.5%. The county's projected long-term water loss level of 15% is comparable to the

lowest average level among the three water system size categories recently surveyed in USEPA Region 3. With an efficient program in place to reduce the water loss percentage, the county's aggressive goal can be met.

The projected 15% water loss for Stafford County will be divided between authorized uses and other water losses. The percentage of unmetered, but essential water use (i.e., authorized water losses), is estimated by Stafford County to be 1 to 2% of total finished water production. For example, unmetered use from fire hydrants occurs for fire-fighting and main flushing. Unmetered, but legitimate, connections may also exist within the county. By 2020, it is estimated that the percentage of other water losses will decline to 13 to 14% of the county's total finished water production. These losses may occur due to factors such as distribution system leakage, service line leakage, and other losses in the distribution system.

## 5.2 Summary of Adopted Stafford County Projections

### 5.2.1 Population Projections

Total population in Stafford County is projected to increase over the planning horizon from 92,446 persons in 2000 to 227,982 persons in 2050. Water demand projections for the county's public water system depend not only on the region's total population, but also on the population served by these systems (see Table 5-4). The population served by Stafford County is projected to increase from approximately 75% of the total population in 2000 to 90% of the total population in 2050.

### 5.2.2 Water Demand Projections (Without Additional Conservation)

Total potable demand (without additional conservation) on Stafford County's system is projected to increase significantly over the planning period to a Year 2050 value of 30.1 mgd. Projected demands for each usage sector are presented in Table 5-14 for the adopted forecast methods.

### 5.2.3 Water Demand Projections (With Additional Conservation)

The Energy Policy Act of 1992 established uniform national water efficiency standards for the manufacture of four types of plumbing fixtures: toilets, kitchen and lavatory faucets, showerheads and urinals. In January 2000, the AWWA commissioned a study to estimate the long-term impact of the national water efficiency standards on water consumption from public water systems. The completed AWWA study is entitled Impact of the National Plumbing Standards on Water Infrastructure Investments (Maddaus et al., January 2001). Results from a survey of 16 utilities serving nearly 11 million people across the United States indicate that, by 2020, water consumption will be reduced by between 3.3 and 9.1% depending on the system. On average, water savings of 3.4% are projected by 2010 and 5.7% by 2020 at these utilities.

The AWWA study also included a survey of many additional water systems in the United States which allowed the utility data to be categorized by USEPA region and service area population. For USEPA Region 3, which includes Virginia, the average projected water savings is 6.7% at smaller utilities serving populations of less than 10,000. For medium-sized utilities serving populations between 10,000 and 100,000, the average projected savings is 11.4%. For large utilities serving over 100,000 people, the average projected savings is 9.9% by 2020. On a national basis, the overall average projected water savings were 5% by 2010 and 8% by 2020.

For this assessment of Stafford County's future demands, it is projected that future water savings (not including water loss reductions) will eventually approach 8%. This projection matches the national 8% savings projection. The future water savings, as a percentage of total potable water demand on the County's system, are projected to increase in a linear fashion to 8% by 2030 and remain constant during the remainder of the planning horizon. These water savings would be accomplished through installation of water efficient plumbing fixtures in new construction as well as from retrofitting older construction. Active conservation programs such as public education programs, rate structures and other billing incentives should also contribute to future savings. Still other potential water savings will likely come as a result of the U.S. Department of Energy's recently issued clothes washer conservation standards (Federal Register, January 12, 2001).

TABLE 5-14

SUMMARY OF PROJECTED STAFFORD COUNTY POTABLE WATER DEMAND

| Year | Total County Population | Residential | | | Commercial/Institutional/ Light Industry | | | Heavy Industry | Military | | UAW | | Total Demand (mgd) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Population Served | Per Capita Use (gpd) | Demand (mgd) | Commercial Employment | Per Employee Use (gpd) | Demand (mgd) | Demand (mgd) | Water Sales (mgd) | Sub-total Demand (mgd) | % of Total Demand | Demand (mgd) | Without Additional Conservation | Future Water Savings (%) | With Additional Conservation |
| 2000 | 92,446 | 69,335 | 68 | 4.7 | 23,112 | 45 | 1.0 | 0.0 | 0.75 | 6.5 | 20 | 1.6 | 8.1 | 0 | 8.1 |
| 2010 | 123,998 | 96,718 | 68 | 6.6 | 35,959 | 48 | 1.7 | 0.8 | 1.25 | 10.4 | 17.5 | 2.2 | 12.5 | 2.7 | 12.2 |
| 2020 | 149,994 | 121,495 | 68 | 8.3 | 49,498 | 51 | 2.5 | 1.6 | 1.5 | 13.9 | 15 | 2.5 | 16.3 | 5.3 | 15.5 |
| 2030 | 175,990 | 147,832 | 68 | 10.1 | 65,116 | 54 | 3.5 | 2.4 | 1.5 | 17.5 | 15 | 3.1 | 20.6 | 8 | 18.9 |
| 2040 | 201,986 | 175,728 | 68 | 11.9 | 82,814 | 57 | 4.7 | 3.2 | 1.5 | 21.4 | 15 | 3.8 | 25.1 | 8 | 23.1 |
| 2050 | 227,982 | 205,184 | 68 | 14.0 | 102,592 | 60 | 6.2 | 4.0 | 1.5 | 25.6 | 15 | 4.5 | 30.1 | 8 | 27.7 |

Source: *Stafford County Needs Assessment*, Malcolm Pirnie, April 2001

Stafford County considers the 8% water savings projection to be an aggressive target, even though somewhat higher percentage reductions were projected for medium and larger systems in USEPA Region 3 in the recent AWWA study. There are several reasons why higher water savings reductions may be unlikely in Stafford County. For example, as discussed in Section 5.1.5, the current rate of per capita indoor residential use is low in the county. Furthermore, outdoor residential use is only estimated to comprise about 12% of current total residential water use, thus further limiting potential water savings. Nevertheless, some future reduction in use will still occur, since replacement savings will occur from retrofitting older homes with ultra-low flow plumbing fixtures. However, these potential savings will be somewhat reduced, since a substantial portion of the county's residents live in housing constructed subsequent to the uniform national water efficiency standards taking effect. In fact, Stafford County Department of Code Administration records show that building permits have been issued for new construction of 9,803 residential dwellings between 1994 and 2000.

In the commercial sector, some future demand reduction is also possible through replacement savings from retrofitting older businesses with ultra-low flow plumbing fixtures. However, it is anticipated that these savings will be very small, since the pre-1994 employment level was only between 11 and 13% (in the early 1990s) of projected 2050 commercial employment. Overall, more future water savings may come in the residential sector than in the commercial sector, since much of the county's commercial development is very new and the associated per employee use is currently low.

Finally, it should also be recognized that the county's 8% water savings projection is in addition to an aggressive goal of reducing current water losses from 20% to 15% or less. The county's resultant 2050 water demand projection is 27.7 mgd when these future water savings are included (see Table 5-14). In addition to 27.7 mgd, it is estimated that the residents outside the limits of the county system will experience a future decreased groundwater demand to approximately 1.64 mgd by the year 2050, including:

- an estimated decrease to 1.6 mgd for residential potable groundwater used by 2050 for the 10% of county residents outside the limits of the county water system (approximately 22,798 persons), plus

- an estimated steady minimum of 0.04 mgd of "business" potable water groundwater demand by 2050 for privately-operated non-community water systems serving the public at businesses, schools, churches and recreational facilities that are outside the limits of the county water system

In addition to this residential demand, it is estimated that there may be a seasonal agricultural groundwater demand ranging from 0.8 to 2.0 mgd, depending on the future development of proposed golf courses within the county. These groundwater demand estimates are based on the county's projected population and the percent of population that will be served by the county's public water system.

## 5.3 Projected Demands Outside the County Water Supply System

### 5.3.1 Projected Demands for Self-Supplied Surface Water Withdrawals

Vulcan Quarry withdrawals from Aquia Creek have been relatively steady for 9 of the past 10 years (1996 – 2005) at 0.275 mgd as a long-term annual average (see Table 3-6). In 2005, the Vulcan Quarry operators expressed their intentions to continue operations of this quarry for at least the near-term future. This heavy industrial/mining surface water demand is projected to continue at similar rates throughout the planning period.

Gauntlet Golf Course withdrawals from Curtis Lake (Long Branch Creek) are projected to continue at similar rates to those reported for 2005 (0.043 mgd annual average, 0.077 mgd during April – September season and approaching 0.11 mgd during the 3 peak months) throughout the planning period.

As of 2005, one vegetable farmer was identified as making surface water withdrawals (see Appendix C). This use is projected to continue at the same rates throughout the planning period.

Also, in the Lower Potomac River watershed, Aquia Harbor Golf Course is estimated to use 0.043 mgd annual average or 0.077 mgd during April – September season throughout the planning period.

In the Rappahannock River watershed Cannon Ridge Golf Course at Celebrate! Virginia withdraws water from an impounded tributary of the Rappahannock River and is estimated to use 0.0.092 mgd annual average or 0.161 mgd during the April - September peak season in 2008. (This is being used as a proxy for 2005). This water use is projected to continue at similar withdrawal rates throughout the planning period.

### 5.3.2 Projected Demand for Groundwater Withdrawals

**Residential**

As shown in Table 5-15, the information in Table 5-4 can be used to back-calculate the self-supplied residential population (i.e., those not served) and to project groundwater demand. However, year 2005 data suggests that these projections are currently under-estimating existing self-supplied residential groundwater use by 0.34 mgd (19%). Two factors contribute to this:

- overall residential population growth in the period 2000 – 2005 has been more rapid than the adopted projections
- the "percent of population served" has lagged behind the projection

In short, for 2005, not only are there more new county residents, but more of them are residing outside the limits of the county water system than had been projected in Table 5-15. This has helped to keep the county system water demands within the projected range despite faster population growth, but has resulted in an apparent significant increase in residential self-supplied groundwater users. This short-term trend is more nearly in line with the projections in Table 5-3.

For planning purposes, the assumed pattern for self-supported population and residential groundwater demand – of an initial increase through 2025, followed by a decrease later in the planning period – is expected to re-emerge and to prevail over longer time periods. This should result from the planned system expansion and increase in the "percent of population served" through the planning period. Therefore, specific projections by decade have not been

included in this Water Supply Plan, because it is being drafted during a transitional period. Adjusted projections, by decade, will be more responsibly made in a later iteration of the Water Supply Plan, after 2010, as CIP system expansion projects are completed, groundwater management policies are implemented, a revised Comprehensive Plan is implemented and longer-term trends may be more clearly established.

Instead, ranges of water use as benchmarks for a meaningful sequence of time periods are projected in Table 5-16. The "near future" increase period will culminate sometime between year 2012 and year 2025 (Table 5-15). For this increase period, for the residential groundwater demand projection:

- The upper end of the projected range (2.83 mgd annual average) is taken from Table 3-7. It is based on faster population growth overall and assumes that growth occurs at equal rates inside and outside the limits of the county system-served area, i.e., the percentage of the county population that is served by the county system is fairly steady in the early years of the period.

- By contrast, the lower end of the projected groundwater demand range (2.38 mgd annual average) is also presented for the 2012 – 2025 time period in Table 5-16. This lower end of the range takes the year 2005 existing residential groundwater demand as a baseline, and increase thereafter by the same increments of additional water demand per year that were observed in Table 5-15.

**Total**

As discussed partially in Section 2.1.3, in Section 2-4 and in Section 5.2.3, and as summarized in Table 5-16; currently, and in the near future, annual average groundwater withdrawals totaling on the order of 3.01 mgd (in year 2005) to 4.25 mgd (by sometime in the period 2012 – 2025) are projected as needed to supply or operate five sectors of self-supplied water users in the outlying areas of the county that are not served through expansion of the county's water system during that period. They include:

- Privately-operated community water supply systems serving the public (projections are included within residential self-supplied, due to method used)

- Individual residential users and non-community water supply systems ("residential and business" with water use initially increasing and then decreasing)
- Golf course irrigators with usage increasing as new courses are added
- Heavy industrial/mining users including Vulcan Materials and Cardinal Concrete, with water use remaining steady
- Agricultural users

Annual average total groundwater demand includes an existing 2.14 mgd (Section 2.4), increasing to 2.87 mgd (Table 3-5, Table 5-4, Table 5-15 and Table 5-16) groundwater demand for potable uses (i.e., residential and business) during this "near future" period (years 2005 – 2025). Thereafter, by 2050, this potable water demand from groundwater sources outside the limits of the county system is projected to gradually decrease to 1.64 mgd. At the same time, demand for other sectors of groundwater uses is expected to remain steady at a 1.38 mgd annual average. The resulting total annual average groundwater demand by 2050 is projected to have decreased back to rates on the order of 3.02 mgd.

Groundwater demands for the 6-month peak season (April – September) for the 5 sectors of water users combined are estimated at 3.89 mgd in year 2005, increasing to 5.23 mgd in years 2012 – 2025, and then decreasing back to 3.84 mgd by year 2050.

**TABLE 5-15**
**BASED ON TABLE 5-4 AND TABLE 5-5**
**RESULTANT PROJECTIONS OF SELF-SUPPLIED RESIDENTIAL GROUNDWATER DEMAND**

| Year | Total County Pop. | % of Pop. Served | Population Served | Pop. Self-Supplied | Res. Use Self-Supplied (mgd) | Residential Wells | Per cap. Res. use self--supplied (gpd) | Served Residential Accounts |
|---|---|---|---|---|---|---|---|---|
| **History** | | | | | | | | |
| 1983 (SWCB 1988) | 45,650 | 50% | 22,780 | 22,780 | 1.61 | 6,207 | 70.8 | 6,207 |
| 1990 (Table 5-5) | 61,236 | 64.6% | 39,558 | 21,678 | 1.53 | 6,774 | 70.8 | 12,362 |
| 1999 (Table 5-5) | 89,325 | 74.6% | 66,673 | 22,652 | 1.59 | 7,551 | 70 | 21,507 |
| **Estimated Current** | | | | | | | | |
| 2005 (Section 2.1.3) | 117,300 | 74.46% | 87,346 | 29,952 | 2.10 | 9,984 | 70 | 29,116 |
| **Projections** | | | | | | | | |
| 2000 (MPI, 2001) | 92,446 | 75% | 69,335 | 23,112 | 1.57 | 7,704 | 68 | |
| 2005from Table 5-14 and MPI 2001 | 108,222 | 76.72% | 83,026 | 25,196 | 1.76 | 8,399 | 70 | 27,675 |
| 2010 (MPI 2001) | 123,998 | 78% | 96,718 | 27,280 | 1.91 | 9,093 | 70 | |
| 2020 (MPI 2001) | 149,994 | 81% | 121,495 | 28,499 | 1.99 | 9,500 | 70 | |
| 2025 from Table 5-14 and MPI 2001 | 162,947 | 82.5% | 134,431 | 28,516 | 2.00 | 9,505 | 70 | |
| 2030 (MPI 2001) | 175,900 | 84% | 147,756 | 28,144 | 1.97 | 9,381 | 70 | |
| 2040 (MPI 2001) | 201,986 | 87% | 175,728 | 26,258 | 1.84 | 8,753 | 70 | |
| 2050 (MPI 2001) | 227,982 | 90% | 205,184 | 22,798 | 1.60 | 7,599 | 70 | |

TABLE 5-16
PROJECTIONS OF SELF-SUPPLIED GROUNDWATER DEMAND
ALL SECTORS

| Year Estimate | Population Self-Supplied | Residential Wells | Potable Res. Use Self-Supplied (mgd) | Potable VDH Non-Comm. "Bus." Use (mgd) | Heavy Ind. Mining (mgd) | Golf Course Irrigation (mgd) | Agriculture (mgd) | Total (mgd) |
|---|---|---|---|---|---|---|---|---|
| Est. Current | | | | | | | | |
| 6-mo. Seasonal Peak 2005 | | | 2.22 ** | 0.08 | 0.56 | 0.231 * | 0.8 | 3.89 |
| Annual Avg. 2005 (Sections 2 & 3) | 29,952 | 9,984 | 2.10 | 0.04 | 0.34 | 0.13 * | 0.40 | 3.01 |
| Projections | | | | | | | | |
| 2007 (DAA, 2004) | 29,952+ | 9,984+ | 2.22 | 0.04 | 0.38 | 0.20 | 0.40 | |
| 6-mo. Seasonal Peak 2012 thru 2025 | | | 2.99 to 2.52 | 0.08 | 0.56 | 0.80 | 0.8 | 5.23 to 4.76 |
| Annual Avg. 2012 thru 2025 | 29,952+ | 9,984+ | 2.83 | 0.04 | 0.38 | 0.6 | 0.4 | 4.25 to 3.80 |
| 2030 | 28,144+ | 9,381+ | 1.97+ | 0.04 | 0.38 | 0.60 | 0.4 | |
| 2040 | 26,258+ | 8,753+ | 1.84+ | 0.04 | 0.38 | 0.6 | 0.4 | |
| 6-mo. Seasonal Peak 2050 | | | 1.69 | 0.8 | 0.56 | 0.8 | 0.8 | 3.84 |
| Annual Avg. 2050 | 22,798 | 7,599 | 1.60 | 0.04 | 0.38 | 0.60 | 0.4 | 3.02 |

* One known active 2005: Augustine GC (estimated annual average 0.13 mgd or peak 6-month seasonal average 0.231 mgd - based on Cannon Ridge GC and near-by Somerset GC in Orange County.)

** Added 4 gpd per person for outdoor water use to 70 gpd annual average use

# Chapter 6 WATER DEMAND MANAGEMENT

Water Demand Management practices are followed at all times, regardless of the state of the county's water supply system. Practices such as requiring low-flow plumbing fixtures, requesting water conservation by the system users, and routine leak detection and repair are followed in an effort to conserve water for future use. Normal conservation practices can provide long-term benefits by permanently reducing water demands during normal operating conditions.

## 6.1 Adopted Building Code

Stafford County has adopted the Virginia Uniform Statewide Building Code, as provided in Chapter 6, Title 36 (§ 36-97 et seq.) of the Code of Virginia. The Code was adopted and enforcement began in 1986. Since 1994, the adopted building code has required that all new construction within the county utilize water efficient plumbing fixtures, including toilets, kitchen and lavatory faucets, showerheads and urinals. In addition, older construction is required to be retrofitted with water efficient plumbing fixtures.

## 6.2 Public Information Program

The Stafford County Department of Utilities issues an annual Water Quality Report to residents of Stafford County. These reports provide information regarding the water supply system, water quality testing results, upcoming projects, water conservation tips, and other issues directly related to the system.

According to the County's Resolution to Establish a Policy Relating to Use of Public Water During Emergencies, the County Administrator, with the approval of the Chairman of the Board of Supervisors for Stafford County, is authorized to declare water emergencies in the county. Such water emergencies may affect the use of water in any area of the county, and serve to control and restrict the use of water during an emergency caused by a water shortage or other cause. The public shall be notified of a water emergency by the publication of an emergency proclamation once per day for two consecutive days in a newspaper that is circulated throughout the county, or by distribution of printed circulars in the county. Upon declaration of a water emergency, the public is required to comply with use restrictions as discussed in Section 7.0.

## 6.3 Water Main Leak Detection and Replacement

The Department of Utilities FY2006 through 2011 Capital Improvements Plan (CIP) has allocated funds for each year of the CIP to replace substandard and corroded water mains throughout the county as part of the Water Rehabilitation Program. Several of the older subdivisions in the county were constructed with waterlines of insufficient size and material. These galvanized and cast iron pipes are the main cause of frequent water main breaks. Other problems in these areas include inadequate and faulty shut-off valves, insufficient fire protection and poor water quality. As part of the CIP, these substandard and corroded water mains will be replaced with larger pipe made of modern materials. This proactive plan will serve to prevent leaks from occurring in the first place by replacing older pipes before they become a problem.

## 6.4 Annual Water Audit Program

On an annual basis, the county compares its finished water production and total system sales to determine the volume of water losses in the distribution system. The average annual water losses as a percent of finished water production was 20.1% for the years 1991 through 1999 (see Table 5 -13). The following uses may be considered authorized water losses by a water utility:

- Unmetered use from fire hydrants (e.g., fire fighting and training, street washing, construction, water main flushing, sewer cleaning and storm drain flushing)
- Unmetered connections (e.g., public buildings, schools, cemeteries or parks). Stafford County has very few unmetered connections.
- Treatment facility process water

Other water losses include all other uses, losses and measuring errors. Examples include the following:

- Distribution system leakage
- Service line leakage

- Unauthorized use (e.g., theft, deliberate bypass of meters, and illegal tapping)
- Inaccurate meters
- Inadequate system controls (e.g., malfunctioning valves)
- Incorrect meter reading and billing

Stafford County projects water losses within the system to decrease from 20% to 15% by the year 2012. For planning purposes only, the county projects that water losses will remain at 15% during the remainder of the planning horizon. This goal of 15% is comparable to the lowest average level of water losses among the three water system size categories recently surveyed in USEPA region 3. Efforts are underway to verify whether water losses are attributable to metering or billing inaccuracies or are the result of actual leaks within the water distribution system. The formal goal is to reduce water losses to the 8 to 10% range by 2012. Continued annual comparisons between treated water production and total systems sales will allow the county to track its progress in meeting its water loss reduction goal.

# Chapter 7 DROUGHT RESPONSE AND CONTINGENCY PLAN

A Drought Response and Contingency Plan is required to set use restrictions on both the water system users and the operation of the water supply source in the event of a drought or other water shortage emergency. Stafford County utilizes an ordinance which outlines specific water supply conditions during which use restrictions are implemented. Upon completion of the Rocky Pen Run Reservoir and Rappahannock River Pumping Project, the county will be required to follow specific permitted operating conditions in the event of a water emergency or drought. These two components of the county's Drought Response and Contingency Plan are discussed in this section.

## 7.1 Existing Use Restrictions

The Stafford County Board of Supervisors has adopted a policy relating to the use of water during emergencies (see county ordinance included in Appendix B). The policy defines three water shortage stages during which specific restrictions would apply:

- Stage I: Occurs when moderate, but limited, supplies of water are available. During this stage, voluntary use restrictions are employed by the county.
- Stage II: When water supplies become further stressed and very limited supplies of water are available, Stage II restrictions are implemented. At this level, mandatory use restrictions or absolute curtailment of less essential uses of water are implemented.
- Stage III: Occurs when critically limited supplies of water are available. Water use would be restricted to purposes which are absolutely essential to life, health, and safety.

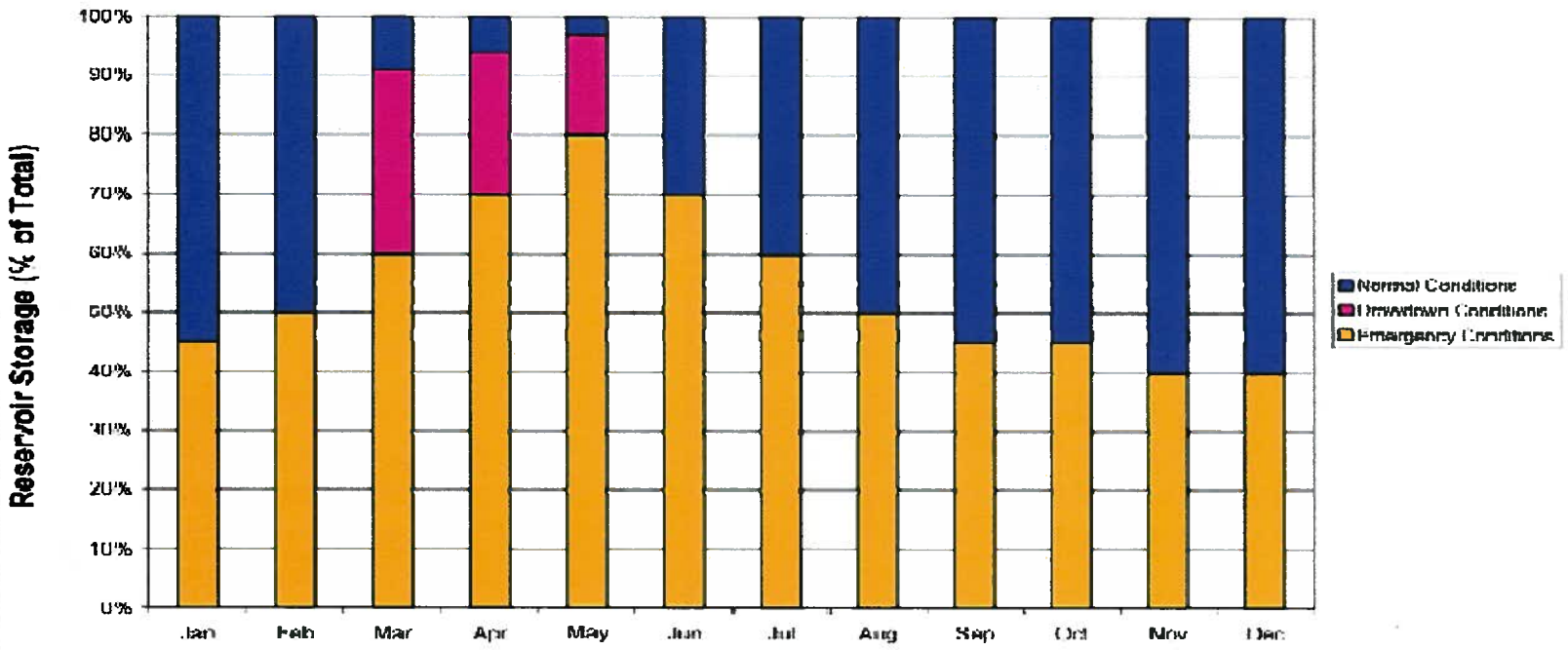
The conditions set forth in this ordinance serve to conserve water during periods of drought and give the county a method of determining the level of cooperation that is required of the users.

In addition, the county has updated its water rate structure to include substantial cost surcharges for residential and non-residential users during emergency water conditions. During a Class A water emergency, the county charges a 15% surcharge on all residential and non-residential users independent of the quantity of water that is purchased. During a Class B water emergency, the county charges residential users increasingly higher surcharges, ranging from 25% to 100%, as use increases. Under the same conditions, non-residential customers are charged a 50% surcharge. The emergency water rates for the county are included in Appendix A.

## 7.2 Permit Conditions

Stafford County will be required to follow specific operating conditions that are set forth in its VWP Permit (No. 99-2064) for the Rocky Pen Run Reservoir. These permit conditions place restrictions on withdrawals from the Rappahannock River that are dependent on reservoir levels (as a percentage of total volume) and stream flows within the Rappahannock River. River withdrawals will be restricted to periods when natural stream flow levels exceed the Rappahannock River flow levels illustrated in Figure 2-6. When the reservoir level drops below the normal pool, and as permitted by the allowable pumping rates, water will be withdrawn from the Rappahannock River and pumped to the reservoir.

Normal drawdown and emergency storage conditions as a function of the Rocky Pen Run Reservoir storage level are illustrated in Figure 7-1. In order for the county to take advantage of the most permissive Rappahannock River pumping rules during emergency conditions, mandatory conservation and use restrictions must be implemented. To maximize available supplies under a severe drought condition, the county, therefore, has a strong incentive to implement mandatory use restrictions. For example, if the total reservoir storage in August of any given year is at or below 50%, emergency conditions are in effect (see Figure 7-1). As shown on the Rappahannock River Allowable Pumping Rules graph (see Figure 2-6), withdrawals from the Rappahannock River during emergency conditions in August can occur when river flows exceed the top of the red area for that month (258 mgd).




MALCOLM PIRNIE

Rocky Pen Run Reservoir
Storage Conditions for Determining Applicable
Rappahannock River Pumping Rules

FIGURE 7-1

# Chapter 8 STATEMENT OF NEEDS AND ALTERNATIVES

## 8.1 Comparison of Supply and Demand

Based on the potable demand projections presented in Section 5.2 and the existing 13.0 mgd treated water safe yield of the existing Stafford County system, the county is projected to experience a water supply deficit sometime between the years 2010 and 2015 (see Figure 8-1). Based on this analysis, new water supplies capable of providing at least 14.7 mgd of additional treated water safe yield are needed to meet the county's projected Year 2050 demand of 27.7 mgd (with additional conservation). Accounting for estimated raw water transmission and treatment losses of 6%, at least 15.6 mgd of additional raw water safe yield is needed to meet projected Year 2050 demand.

As discussed partially in Section 2.1.3, in Section 2.4, in Section 3.2.4, in Section 5.2.3 and in Section 5.3.2 and as summarized in Table 5-16, currently and in the near future annual average groundwater withdrawal demand totaling on the order of 3.01 mgd (in year 2005) increasing to 4.25 mgd (by sometime in the period 2011 – 2025) is projected as needed to supply or operate five sectors of self-supplied water users in the outlying areas of the county that are not served through expansion of the county's water system during that period. Increases are projected primarily in residential and golf course irrigation withdrawals. This includes 2.14 mgd (in year 2005) increasing to 2.87 mgd (by sometime in the period 2012 – 2025) groundwater demand for potable uses (i.e., residential and business) during this "near future" period (years 2005 – 2025). Thereafter, by 2050, this potable water demand from groundwater sources outside the limits of the county water system is projected to gradually decrease to 1.64 mgd, while demand for other sectors of groundwater uses remains steady at 1.38 mgd annual average. The resulting total annual average groundwater demand by 2050 is projected to have decreased back to rates on the order of 3.02 mgd.

Based on the estimated recharge, the total available groundwater in the county was roughly estimated to be 47.6 mgd from the Piedmont Aquifer and 27 mgd and 12.5 mgd in the Aquia and Middle Potomac Aquifers of the Coastal Plain, respectively (see Sections 4.2.1.1 and 4.2.1.3). These estimates do not represent the available yield of groundwater wells in the

county; however, presuming some dispersion throughout the county of development that will rely on groundwater, the supply should be adequate to satisfy projected future groundwater demands.

The raw water deficit projection of 15.6 mgd may underestimate additional water supply needs if any of the following conditions occur:

- Water savings (exclusive of water loss reduction) fall short of 8% target
- Water losses are not reduced to 15% or less
- Quantico Marine Corps Base requires more county water than currently planned
- Highly water-intensive industry locates in Stafford County
- County population continues to grow more rapidly than currently projected by VEC
- Service area expands to encompass more than 90% of future population
- Drought more severe than mid-1960s drought occurs. Safe yield analysis has shown that the early 1930s drought would result in lower safe yield from all reservoirs in the county

All of these potential conditions are considered plausible. County growth more rapid than projected may be especially plausible. Further evidence that the county's current rapid development trends and population growth will continue can be seen in the many significant proposed transportation, utility and commercial/residential development projects in Stafford County and the greater Fredericksburg area. Some examples of significant undeveloped proposed projects include:

- Embrey Mill: 2,400 dwelling units; 750,000 square feet of retail/office space, middle school
- Celebrate Virginia: 3+ million square feet of office space, up to 10% retail, 3 golf courses
- Stafford Marketplace: 80+ acres retail, 300+ apartments
- Stafford Regional Airport: 5,000-foot runway. Opened December 2001
- Augustine Central: 700+ dwelling units

## 8.2 Evaluation of Alternatives

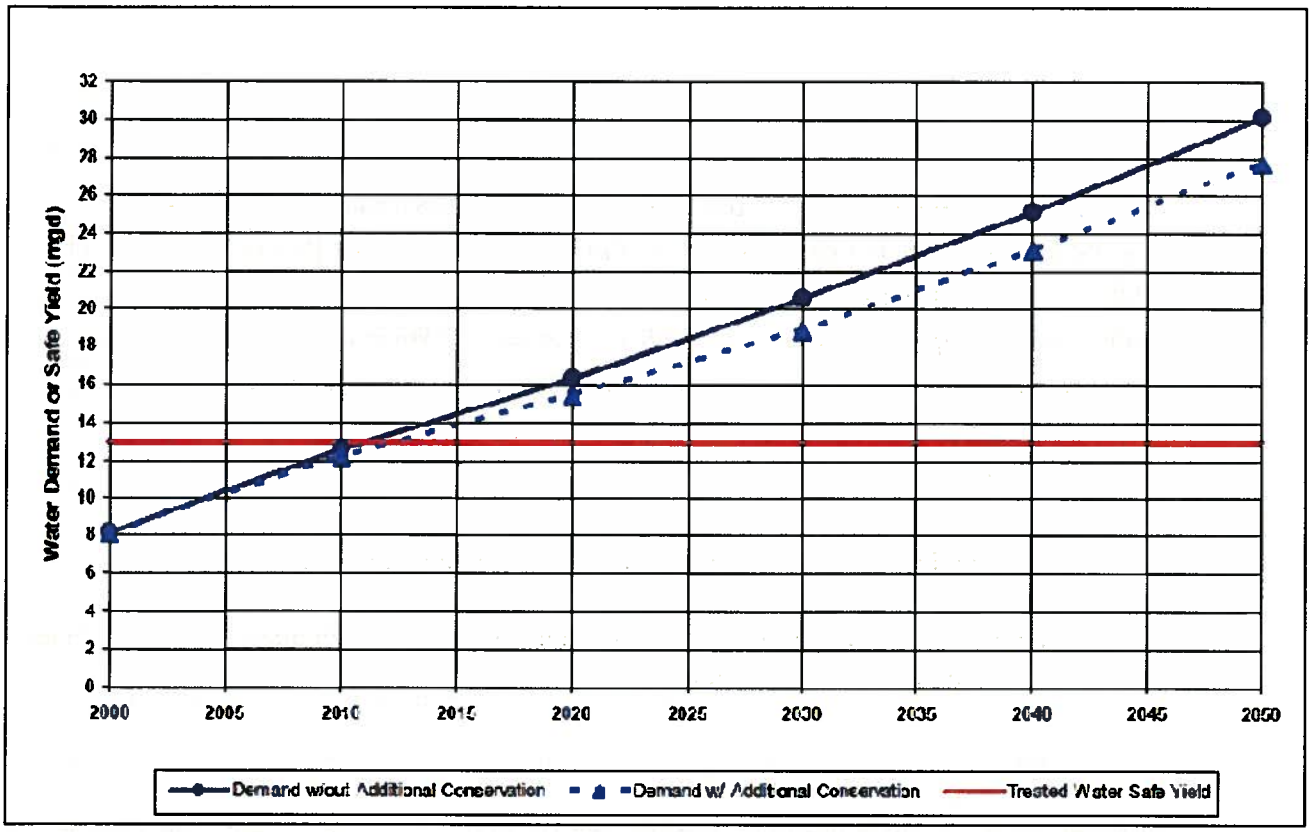
### 8.2.1 Evaluation Methodology

#### 8.2.1.1 Overview

This section describes the methods used to evaluate alternatives in the Environmental Impact Report (EIR) for the Rocky Pen Run Reservoir Project (Malcolm Pirnie, October 1999). Each water supply development alternative has the potential to provide some public water supply benefit for Stafford County. Therefore, each alternative was evaluated with respect to the following feasibility or practicability criteria:

- **Yield**
- **Availability** in light of institutional or regulatory constraints
- **Reliability** in light of risks and/or constraints associated with quantity of supply, water quality or technology
- **Cost**

Alternatives were deemed impracticable, and screened out, if they failed any one or more of these criteria. Remaining practicable alternatives were then carried forward for comparison of their potential environmental impacts. The impact comparison provides an objective method of determining the least damaging, practicable alternative.




MALCOLM PIRNIE | Projected Demand vs. Existing Safe Yield | FIGURE 8-1

### 8.2.1.2 Criteria

Four practicability criteria were used to evaluate alternatives. These criteria are yield, availability, reliability and cost. **Yield** considered the potential water supply benefits of each alternative. **Availability** considered the legal, regulatory, and institutional obstacles that a particular alternative faced. **Reliability** considered the unavoidable failure potential, public health concerns, effectiveness of available treatment technologies, and stage of technological development associated with each alternative. **Cost** considered the current capital and operating costs of an alternative relative to other alternatives, and the affordability of required customer water rate increases. Each of these criteria is discussed in more detail in the following sections.

### 8.2.1.3 Yield

The safe yield of a water supply source must be evaluated to determine its potential water supply benefit. When applied to surface water sources, safe yield is the quantity of water which may be withdrawn during some critical dry period without depleting the source. Safe yield values are not absolute values calculated on the basis of exact data. Rather, safe yield values are linked to levels of risk associated with the probability of occurrence of a selected critical drought over an extended future period. Consequently, safe yield values are based on management decisions as to the reliability, resilience and vulnerability of systems during critical dry periods and the level of risk considered acceptable.

The yield capacities of groundwater sources are a function of well pump capacity, head and hydrologic properties of the aquifer(s). Standard methods are not available for analyzing the yield of groundwater sources. Consequently, defining groundwater safe yield can be very involved. Factors often considered in evaluating groundwater yield include the relationship of groundwater discharge to recharge, consolidation of the aquifer(s) and penetration of saline water or other forms of pollution.

#### 8.2.1.4 Availability

Legal, regulatory and institutional issues can severely delay (i.e., to a point where demand exceeds supply) or even prevent a water development project from being implemented. Necessary land and water rights must be acquired; and, in some cases, defended in litigation; permits from Federal, state and local agencies obtained; and approvals from other localities obtained in the case of a project located outside the boundaries of the project's owner. An alternative may be considered unavailable if legal, regulatory or institutional obstacles are insurmountable. For example, the U.S. Army Corps of Engineers (USCOE), U.S. Environmental Protection Agency (USEPA), Virginia Department of Environmental Quality (DEQ), Virginia Department of Health (VDH), or another state, federal or local agency may determine that an alternative is not able to be permitted. Determinations of unavailability are based on the likelihood of severe delays, uncertainties associated with potential permit denials, or other insurmountable legal or institutional constraints.

#### 8.2.1.5 Reliability

Alternatives may be deemed technically infeasible if they are judged vulnerable to mechanical or electrical failures, pipe failures, downtime or other system disruption that cannot be eliminated or adequately reduced through redundancy in the design. Storage, or the capacity to deliver partial flows during disruptions, could improve reliability. Serious public health concerns (i.e., documented water quality problems) associated with use of certain water supply sources, as expressed by VDH staff or other qualified experts, may also render an alternative infeasible with respect to reliability. In addition, the effectiveness of USEPA-determined Best Available Technology in the treatment of water may be evaluated in determining whether an alternative is considered reliable. Reliability also considers whether water supply technologies are still in an experimental stage and whether major areas of technical uncertainty exist.

#### 8.2.1.6 Cost

Alternatives may be economically infeasible if they are too costly to implement. For example, an alternative that involves costly raw water treatment may impose an unacceptable financial burden on the system's customers (USEPA, 1990). In addition, water purveyors have a responsibility to provide a reasonable cost water supply to their customers, if such a supply is available.

For the EIR, major capital and operating costs developed for Stafford County's **Comprehensive Water Supply Study** (O'Brien & Gere, 1991) were used for comparison of alternatives. Major costs identified are those associated with construction, land acquisition, engineering and legal fees, and power consumption.

#### 8.2.1.7 Environmental Impact

Environmental suitability can be defined as the extent to which environmental harm can be avoided. Since environmental values are protected by a variety of regulatory and institutional constraints, suitability can be defined as the extent to which a project avoids constraints that could prevent implementation or satisfactory operation. Impacts may occur to features such as wetlands, groundwater aquifers, cultural resources, land use, wildlife, threatened and endangered species, and other environmental attributes.

### 8.2.2 Description of Alternatives

In recognition of both the evolving Stafford County water supply needs identified in Section 5.0, and the regulatory requirements outlined in Section 8.2.1, water resource development alternatives have been identified and are presented as follows:

1. Expansion of existing Abel Lake
2. Development of Potomac River and Rappahannock River tributaries for surface water reservoirs
3. Development of off-stream pumped storage reservoirs adjacent to the Rappahannock River

4. Development of Vulcan Quarry offline storage reservoir adjacent to Aquia Creek

5. Desalination of Potomac River water

6. Groundwater development

The "No Action" alternative is also carried forward pursuant to the Council on Environmental Quality's National Environmental Policy Act regulations. The physical characteristics of the alternatives are described in conceptual detail in the following subsections.

#### 8.2.2.1 Expansion of Abel Lake

As discussed in Section 2.3, Abel Lake is a 185-acre reservoir in central Stafford County on Potomac Creek, approximately 10 miles from its confluence with the Potomac River. An earthen dam 960 feet long and 94 feet high at its maximum section impounds on-stream surface water from a 30.5 square-mile contributing drainage area. A normal pool elevation of 139 feet msl provides a total storage capacity of 1.303 BG, and a usable storage capacity of 0.977 BG, or 75 percent of total storage. The current safe yield of Abel Lake is approximately 6.1 mgd. A water treatment plant is located adjacent to the reservoir. Raising the Abel Lake Dam an additional 11 feet would create an approximate 1.6 mgd and 0.8 BG increase in safe yield and usable storage, respectively. An additional dike would be required to protect the Abel Lake Water Treatment Plant (O'Brien & Gere, 1991). The plant was placed on-line in 1982 with a permitted capacity of 2.0 mgd. It has since been expanded to a capacity of 6.0 mgd.

#### 8.2.2.2 Run-Of-River Reservoirs in Potomac/Rappahannock Tributaries

Additional potential on-stream reservoir locations within Stafford County have been identified by O'Brien & Gere in the **Comprehensive Water Supply Study** (1991). Reservoir recharge at the five sites described below would be controlled by natural runoff from their respective contributing drainage areas. O'Brien & Gere (1991) used a regression analysis between storage and safe yield at Smith Lake and Abel Lake to determine the safe yield for the Run-of-River Reservoirs.

#### 8.2.2.2(a) Austin Run

Austin Run is a tributary of Aquia Creek and is located approximately 1.2 miles north of Stafford Courthouse. The contributing drainage area of the proposed reservoir is only 2.5 square-miles, providing a safe yield of 1.0 mgd. A useable storage of 2.8 BG is anticipated.

#### 8.2.2.2(b) Aquia Creek

Aquia Creek is a large stream that drains a 14.0 square-mile watershed at the location of the proposed reservoir. The stream is a tributary of the Potomac River. The proposed reservoir would be sited upstream of Smith Lake in Stafford County. A safe yield of 3.5 mgd and a useable storage of 0.9 BG are expected.

#### 8.2.2.2(c) Potomac Run

Potomac Run is a headwater stream that drains a 4.2 square-mile watershed. The stream is located in the western section of Stafford County and is a tributary of Long Branch Creek. The proposed reservoir would provide a safe yield of 1.5 mgd and a useable storage of 1.4 BG.

#### 8.2.2.2(d) Long Branch Creek

The proposed reservoir on Long Branch Creek is located in the headwater section of the stream, above the Potomac Run tributary discharge point, in the western section of Stafford County. Long Branch Creek is a tributary of Potomac Creek, which discharges into the Potomac River. The reservoir would impound water from a 4.8 square-mile contributing drainage area. This alternative would provide a safe yield of 1.5 mgd and a useable storage of 1.8 BG.

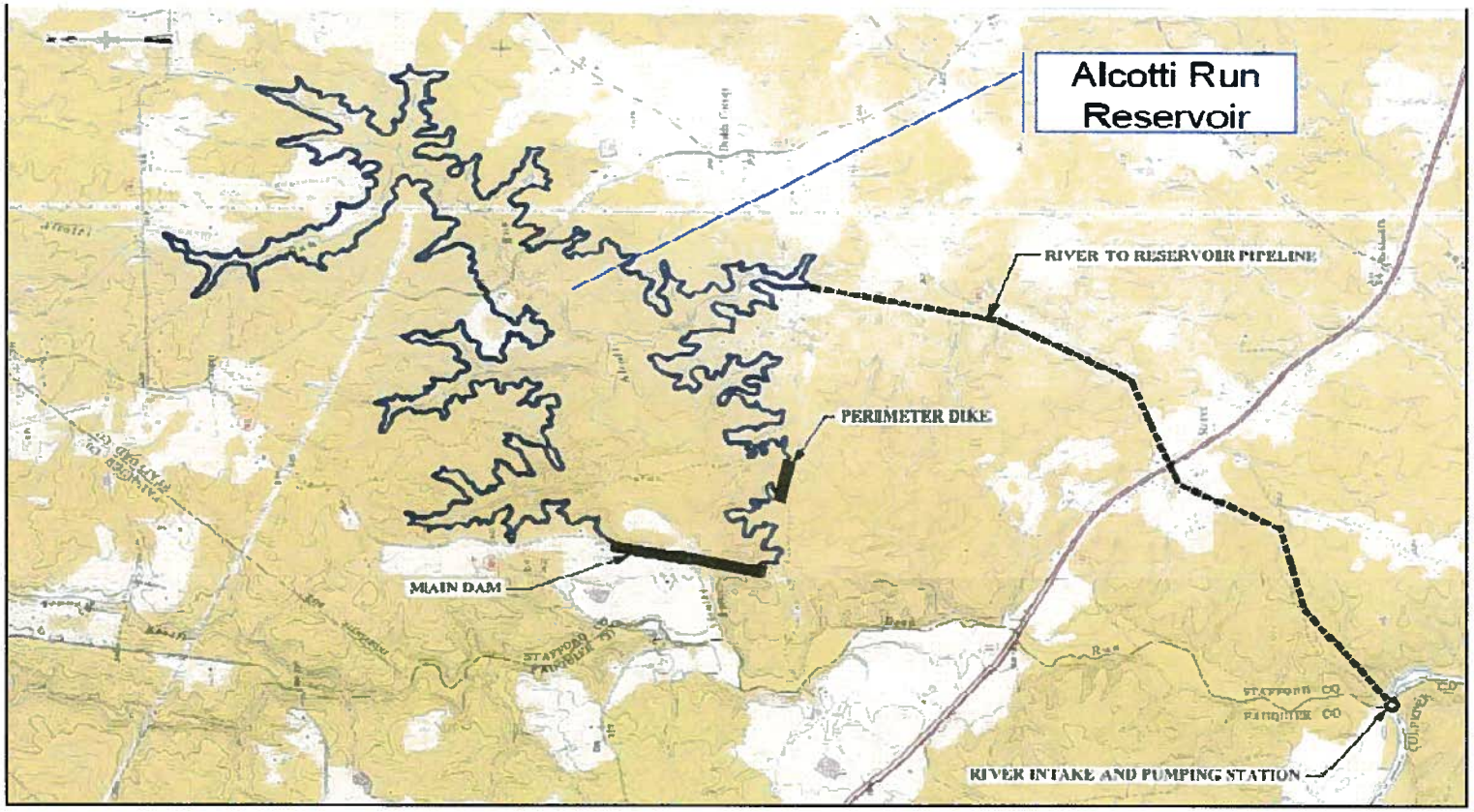
#### 8.2.2.2(e) Alcotti Run

Alcotti Run is described in more detail in the next section as a pumped storage reservoir. The on-stream reservoir configuration would impound 7.8 BG from a 7.1 square-mile contributing drainage area. A safe yield of 4.5 mgd is projected.

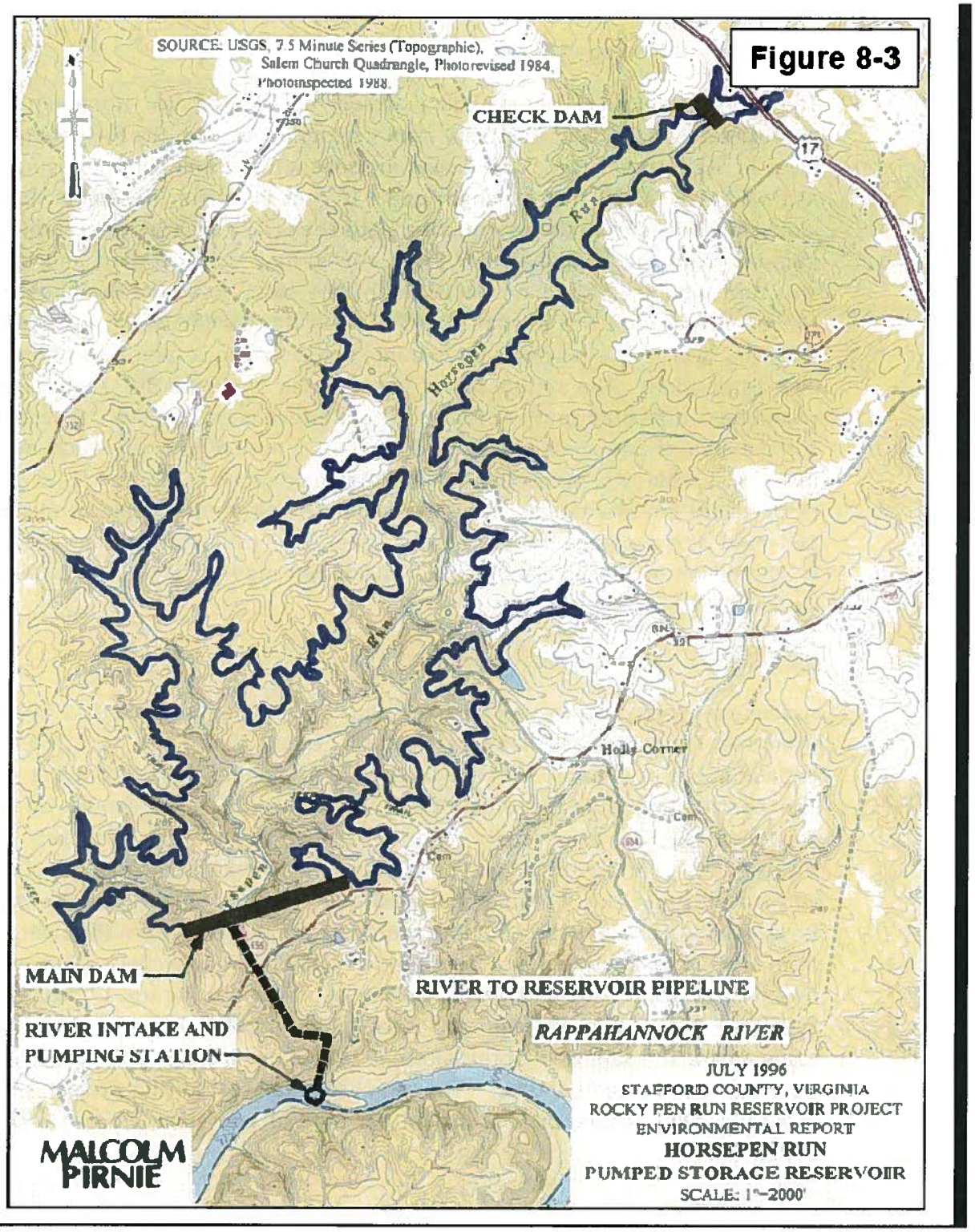
### 8.2.2.3 Pumped Storage Reservoirs

#### 8.2.2.3(a) Alcotti Run

The construction of an earth-fill dam on Alcotti Run would create an impoundment approximately 10,000 feet upstream of its confluence with the Rappahannock River in Stafford County. The dam would be approximately 3,000 feet in length and 105 feet in height at its maximum section. Reservoir storage would be derived from both the contributing watershed and water pumped from the Rappahannock River. A 135-mgd pump station and river intake structure would be constructed on the northern bank of the Alcotti Run confluence with the Rappahannock River. Associated transmission pipelines would convey raw water to the reservoir and subsequently to treatment and distribution. The reservoir site and pipeline routes are depicted on Figure 8-2. A perimeter dike would also be constructed 2,000 feet northeast of the dam to prevent reservoir spillage into a neighboring watershed. At a normal pool elevation of 300 msl, a reservoir surface area of 760 acres is expected. A safe yield of 21.0 mgd and a usable storage volume of 5.8 BG are estimated. The safe yield can be increased to 23.4 mgd if a storage transfer to Abel Lake is made available. A total project cost in 1990 dollars of $125 million is estimated. This translates to a project cost of $6 million per mgd of safe yield (O'Brien & Gere, 1991).




MALCOLM PIRNIE | Alcotti Run Pumped Storage Reservoir Location Map | FIGURE 8-2


SOURCE: USGS, 7.5 Minute Series (Topographic), Salem Church Quadrangle, Photorevised 1984, Photoinspected 1988.
Figure 8-3
CHECK DAM
17
Run
Horsepen
Run
Holly Corner
MAIN DAM
RIVER TO RESERVOIR PIPELINE
RIVER INTAKE AND PUMPING STATION
RAPPAHANNOCK RIVER
MALCOLM PIRNIE
JULY 1996
STAFFORD COUNTY, VIRGINIA
ROCKY PEN RUN RESERVOIR PROJECT
ENVIRONMENTAL REPORT
HORSEPEN RUN
PUMPED STORAGE RESERVOIR
SCALE: 1"=2000'

### 8.2.2.3(b) Horsepen Run

The Horsepen Run Reservoir dam would be located on Horsepen Run approximately 3,000 feet upstream from its confluence with the Rappahannock River in Stafford County. The design includes an earth-fill dam configuration approximately 2,800 feet in length and 110 feet in height. Reservoir storage would be derived from the contributing watershed (7.78 square miles) and water pumped from the Rappahannock River. An 80-mgd pump station and intake structure would be sited on an island in the river, near the confluence of Horsepen Run with the Rappahannock River. Raw water would be pumped from the river to the reservoir for storage, and from the reservoir to treatment and distribution. The system layout is presented on Figure 8-3. A check dam would be constructed south of Route 17 to improve water quality. A reservoir surface area of 570 acres would be created at a normal pool elevation of 250 msl. A usable storage volume and safe yield of 3.7 BG and 14.0 mgd, respectively, are estimated. The safe yield of this alternative could be raised to 16.7 mgd with a storage transfer to Abel Lake. The estimated total project cost is $94 million in 1990 dollars, or $6.7 million per mgd of safe yield (O'Brien & Gere, 1991).

### 8.2.2.3(c) Richland Run

A roller-compacted concrete dam across Richland Run, approximately 1,200 feet from the Rappahannock River in Stafford County would create a 750-acre impoundment at 280 msl with the assistance of pumped water from the river. The contributing drainage area of the reservoir watershed would be 6.22 square-miles. The dam length and height would be 850 and 135 feet, respectively. A 110-mgd pump station and intake structure would be constructed near the Richland Run discharge location on the Rappahannock River. Raw water pipelines would be routed to the reservoir from the river, and from storage to treatment and distribution. Two additional check dams would be constructed to enhance water quality south of the Route 17 causeway. Estimates for usable storage and safe yield are 4.9 BG and 17.5 mgd, respectively. The safe yield of this alternative could be increased to 20 mgd with a storage transfer to Abel Lake. The estimated total cost for this project is $103 million in 1990 dollars, or $5.2 million per mgd of safe yield (O'Brien & Gere, 1991).

Through review of the O'Brien and Gere design concept, it was determined that the proposed reservoir could not support a pool elevation above 250 feet msl. The aforementioned estimates for usable storage and safe yield are therefore inflated; however, O'Brien and Gere did not develop safe yield and cost estimates for a normal pool elevation of 250 feet msl. The system configuration at a normal pool elevation of 250 feet msl is delineated on Figure 8-4. This downsized design scheme requires only one water quality check dam below Route 17.

#### 8.2.2.3(d) Rocky Pen Run

The Rocky Pen Run Reservoir would be impounded by the construction of a dam approximately 2,000 feet upstream of the mouth of Rocky Pen Run, north of the Rappahannock River in Stafford County. Roller-compacted concrete construction was originally proposed for the dam. The dam would be 130 feet in height and 1,200 feet in length. Approximately 1,200 feet of State Route 654 would be raised above the reservoir flood pool by construction of an earth embankment dike. The reservoir would be filled by a combination of runoff from the reservoir watershed and water pumped from the Rappahannock River. A 40-mgd Rappahannock River Pump Station would be located on the north shore of the river at river mile 118.6, approximately 10,000 feet upstream of the mouth of Rocky Pen Run. This pump station would draw water from the river and pump it to an outfall on the reservoir shoreline through a 48-inch diameter, 2,600-foot raw water pipeline. The reservoir project location and associated transmission and treatment facilities are shown in Figure 2-5.

The Rocky Pen Run Reservoir safe yield model was used to develop raw water safe yield estimates based on a 97-year simulation period (October 1907 through September 2004). A 25 percent dead storage assumption was incorporated into the analysis. The estimated total volume of the reservoir is 5.29 billion gallons (BG) at a normal pool elevation of 230 feet msl based on the results of dimensional analysis performed using detailed 2-foot contour mapping of the reservoir site. All scenarios considered unusable volume to be 25 percent of the 5.29 BG total volume. The estimated surface area of the reservoir when full is 503.5 acres based on the results of dimensional analysis, and a regression equation was used to relate reservoir surface area to volume in the safe yield model.

The analysis assumed compliance with Rappahannock River minimum in-stream flow (MIF) levels similar to those defined in the Virginia Department of Environmental Quality March 21, 1995 Virginia Water Protection Permit (VWPP) for Spotsylvania County's Hunting Run Reservoir. However, based on the DEQ VWPP issued to Stafford County, these MIF levels were modified to incorporate 100 Tennant levels from March through May under normal conditions when the reservoir is nearly full. This change is based on Embry Dam having now been removed. The MIF levels were further modified by adding a 44 mgd allowance to each monthly MIF level that is based on a 6 mgd water treatment plant capacity for Fredericksburg, plus a 14 mgd maximum Rappahannock River withdrawal for Spotsylvania County, plus a 24 mgd maximum Rapidan River withdrawal for Spotsylvania County. These allowances were made for maximum withdrawals by Fredericksburg and Spotsylvania County to assure that their allowable withdrawals would not be affected by Stafford County's proposed withdrawals.

The Rocky Pen Run Reservoir raw water safe yield estimate is 13.04 mgd with a normal pool elevation of 230 feet msl and a Rappahannock River withdrawal capacity of 40 mgd. Generalized cost estimates for a Rocky Pen Run Reservoir alternative were developed as part of the **Comprehensive Water Supply Study** (O'Brien & Gere, 1991). The specific alternative for which estimates were prepared included the reservoir, a pump station on the Rappahannock River at an unspecified location, and a transmission pipeline to the reservoir. The cost estimates were prepared to facilitate comparison of alternatives and were not designed to be sufficient for planning funding requirements.

O'Brien & Gere (1991) estimated the total project cost of Rocky Pen Run Reservoir to range from $63 million to $134 million. With an assumed normal pool elevation of 230 feet msl, the total project cost was estimated at approximately $72 million. Although the specific locations of the pump station and pipeline routes described above for this alternative are not used in developing the O'Brien & Gere (1991) cost estimates, the reservoir configuration is the same. Therefore, it is assumed that the estimates represent a reasonable approximation of costs for this alternative. With a safe yield estimate of 13.04 mgd, the cost per mgd of safe yield is $5.5 million.

#### 8.2.2.4 Vulcan Quarry Offline Storage Reservoir

In June 2005, Draper Aden Associates prepared the Draft Stafford County Quarry Evaluation Report which addressed the feasibility of using the Vulcan Quarry as a supplemental storage capacity reservoir for the county's water supply system. Vulcan Quarry is located approximately 4 miles west of I-95 and north of Garrisonville Road (Route 610). The County identified Vulcan Quarry as a potential water supply source where water would be diverted from Aquia Creek and stored in the quarry until it was needed to supplement the existing water supply at Smith Lake and/or Abel Lake. The proposed alignments of the two possible quarry water storage projects are shown on Figure 8-5. An analysis was performed to determine the supplemental capacity that this quarry could provide. In addition to the capacity analysis, a preliminary geological evaluation was performed based on available information.

This alternative looked at utilizing Vulcan Quarry as an offline storage reservoir and evaluated two possible scenarios:

- Scenario 1: Pump from Aquia Creek to Vulcan Quarry when Smith Lake is full and downstream conditions are met. Pump from quarry to **Smith Lake** when reservoir is less than 80% full.
- Scenario 2: Pump from Aquia Creek to Vulcan Quarry when Smith Lake is full and downstream conditions are met. Pump from quarry to **Abel Lake** when reservoir is less than 80% full.

A mass-balance was performed to predict the effects of water diversion to and from the quarry. Results of the simulation model indicated that the use of the quarry as offline water storage prevented the water level in the Smith Lake reservoir from dropping below the sediment pool level during the period of study (June 1976 through December 1996). The results also indicated that for the Smith Lake scenario, the average flow available for consumption was effectively increased from 8.4 mgd without the quarry to 10.9 mgd with the quarry - an increase of 2.5 mgd. For the Abel Lake scenario, the average flow available for consumption was effectively increased from 5.9 mgd to 8.3 mgd – and increase of 2.4 mgd.

This model was based on the most recent 30 years of stream gage data, and therefore was not necessarily the "drought of record." In conclusion, the additional 2.5 mgd flow in Smith Reservoir available with the quarry and the additional 2.4 mgd flow in Abel Reservoir is not considered a safe yield analysis since it is not necessarily the drought of

record. However, it does offer a representative idea as to the potential benefit that may be realized for each reservoir.

Based on the assumption and data used in the computer model, the scenario which would yield the greatest supplemental capacity is the Smith Lake scenario where the water from the quarry is diverted to the water treatment plant resulting in a supplemental capacity available for consumption of no more than 2.5 mgd.

Costs for the two options are as follows:

- Scenario 1: Quarry to Smith Lake via Garrisonville Road (Route 610) and Route 659 – This option would require many utility easements along the entire alignment and would pass through a highly developed portion of Route 610. This option would cost approximately $12.3 million.

- Scenario 2: Quarry to Abel Lake via Route 659, Route 658, and Route 627 - This option would also require many utility easements although it would avoid the highly developed portion of Route 610. In addition, the Abel Lake water treatment plant would need to be upgraded to be able to treat the additional flow. This option would cost approximately $16.8 million.

#### 8.2.2.5 Potomac Estuary Desalination

This alternative includes the development of the tidal Potomac Estuary as a water supply source. Brackish water could be removed from the estuary by a 30 mgd raw water intake structure and pumping station, or a series of shallow groundwater wells. The water would be transported to a reverse osmosis (RO) desalting facility providing a 75 percent product recovery. The plant would be sized to meet total dissolved solids (TDS) concentrations greater than 5,000 ppm, which exist during drought conditions. The total electrical demand for a plant of this size is estimated to be 7.5 KW/kgal at 5,000 mg/1 TDS. Actual electrical demands would vary according to the operating pressure applied. It is estimated that a maximum operating pressure of 400 psi would be needed at 5,000 ppm TDS. At a lower TDS value, the operating pressure could be reduced to less than 200 psi. Seasonal variations in operation and maintenance costs for the Potomac Estuary source would therefore be expected. The Potomac Estuary desalting alternative would produce finished water without an intermediate raw water storage step. Water would be supplied directly through the water distribution system, and the alternative would rely on

the Potomac Estuary as a constant source of feed water. Assuming brackish water is drawn directly from the Potomac Estuary, the total construction cost for a 20-mgd safe yield plant (30 mgd peak capacity) is $108 million or $5.4 million per mgd of safe yield. Alternatively, the withdrawal of brackish groundwater in the immediate vicinity of the Potomac Estuary would cost approximately $115 million or $5.7 million per mgd of safe yield (O'Brien & Gere, 1991).

#### 8.2.2.6 Groundwater Development

This alternative would include the construction of well fields and interconnecting pipes in Stafford County. The region is underlain by two distinct geologic provinces: The Piedmont and the Coastal Plain. The primary groundwater recharge source in the area is precipitation. The two provinces are separated by the Fall Line, which runs north to south in the County. The Piedmont contains a basement rock surface overlain by a nearly continuous layer of loosely weathered material (referred to as *regolith*). Groundwater within the Piedmont is stored in the regolith pore spaces and in the fractures of the crystalline bedrock. These fractures act as conduits for groundwater movement. Productive wells are positioned to exploit fracture locations. According to the O'Brien & Gere (1991) **Comprehensive Water Supply Study,** the aquifer recharge in the Piedmont Province is approximately 64 mgd, which translates to a 0.01 mgd yield per well. This refers to the total amount of water present in the aquifer, not the volume that is actually recoverable. The total project cost was estimated at $12.6 million per mgd for well development in the Piedmont. The Coastal Plain consists of a water table aquifer and eight confined aquifers separated by aquitards (impermeable layers along an aquifer). The Middle Potomac Aquifer is the most favorable for development. The yield per well is 0.5 mgd with an assumed total yield for aquifer development equivalent to 5 to 10 mgd. A total project cost of $3.4 million per mgd was estimated for well development in the Coastal Plain.

In the Stafford County Groundwater Management Plan (Draper Aden, October 2004), the total yield of all aquifers within the County was conservatively estimated at 40 mgd, again referring to the total water volume present in the aquifer, not the recoverable volume. The estimate is based on 10 to 15 inches of recharge annually over the outcrop (recharge) areas of the Piedmont and Coastal Plain formations.

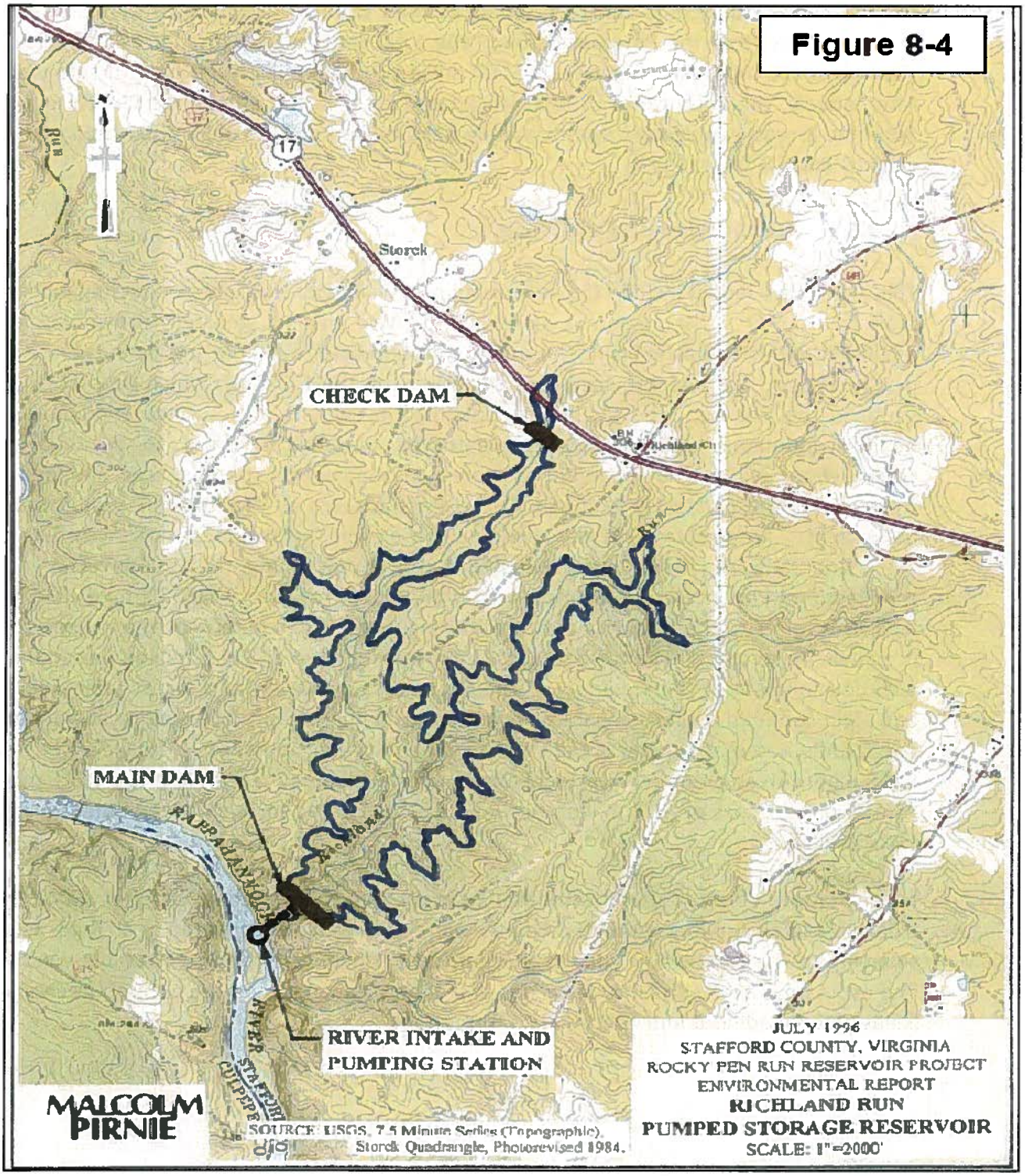


Figure 8-4
17
Storck
CHECK DAM
MAIN DAM
RAPPAHANNOCK
RIVER INTAKE AND
PUMPING STATION
MALCOLM PIRNIE
SOURCE: USGS, 7.5 Minute Series (Topographic), Storck Quadrangle, Photorevised 1984.
JULY 1996
STAFFORD COUNTY, VIRGINIA
ROCKY PEN RUN RESERVOIR PROJECT
ENVIRONMENTAL REPORT
RICHLAND RUN
PUMPED STORAGE RESERVOIR
SCALE: 1"=2000'

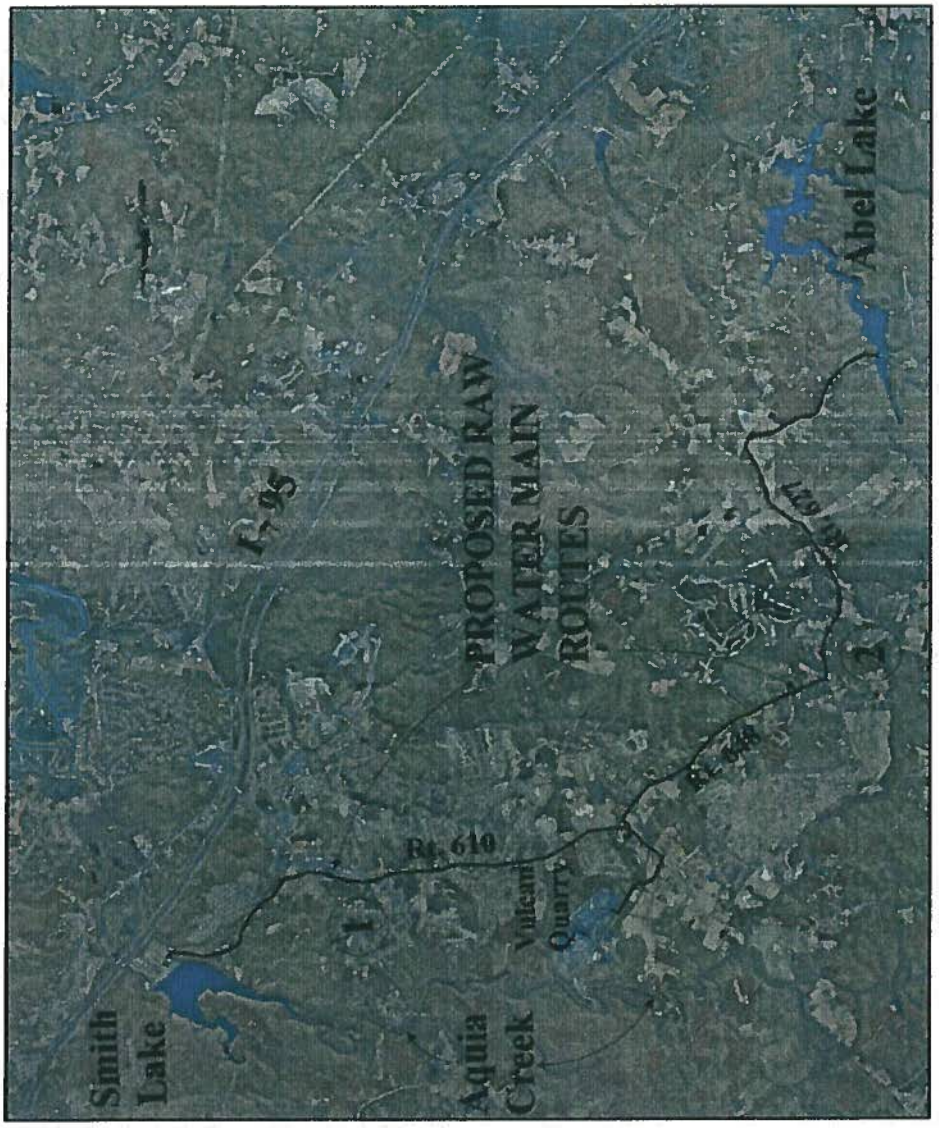



FIGURE 8-5

Vulcan Quarry Pumped Storage Reservoir Alternative
Location Map

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#### 8.2.2.7 No Action

The Council on Environmental Quality (CEQ) National Environmental Policy Act (NEPA) regulations specify that the alternative of "No Action" be included in the analysis of project alternatives (40 CFR § 1502.14). Under the "No Action" alternative, Stafford County would do nothing to provide additional raw water supply or curtail water use in the county. If potable water supplies are not available within the service area to support new development, it is possible that development could occur at a higher rate in more rural areas of the county than is predicted by county planners. New development in these rural areas would result in additional strains on groundwater supplies and development of large lots to support septic fields. These unplanned growth patterns, or urban sprawl, would be in conflict with the county's Comprehensive Plan, which could result in environmental impacts. The potential environmental impacts of the "No Action" alternative are addressed in Section 8.2.4.

In addition, to limit growth within the primary service area, water purveyors could place moratoriums on new hook-ups. As a result, new industry and other water users requiring potable water supply might be unable to locate in the region due to a lack of treated water supply.

### 8.2.3 Practicability Comparison for Alternatives

The proposed project alternatives described in Section 8.2.2 are compared in this section with respect to the practicability criteria discussed in Section 8.2.1. A discussion is presented on the relative technical merits of each alternative. Based on this analysis, practicable alternatives will be carried forward for environmental impact analysis in Section 8.2.4.

#### 8.2.3.1 Safe Yield/Availability

Table 8-1 presents the estimated safe yields of each alternative described in Section 8.2.2, with the exception of the Vulcan Quarry Pumped Storage Reservoir, because a true safe yield analysis for this alternative was not performed. Neither expansion of Abel Lake nor any of the Run-of River Reservoir alternatives would singly be capable of providing the necessary safe yield to meet the Year 2050 deficit discussed in Section 8.1. It is possible that any of these alternatives could be combined with others to meet the projected deficit; however, evaluation of these alternatives with respect to the other practicability criteria eliminates them from further analysis. The Alcotti Run Run-of-River Reservoir

alternative was eliminated from analysis based on its low expected safe yield. Alcotti Run was evaluated as a pumped storage reservoir.

As discussed in Section 8.2.1, an alternative can be deemed unavailable if legal, regulatory or institutional issues are insurmountable. The development of the Austin Run Run-of-River Reservoir alternative would require the relocation of 50 to 100 homes while providing a safe yield of only 1.0 mgd (O'Brien & Gere, 1991). The required relocation of this number of homes is excessive in comparison to the anticipated safe yield expected. Therefore, this alternative has been deemed impracticable in terms of availability.

As indicated in Draper Aden's Groundwater Management Plan (2004), sufficient groundwater is available to support projected residential growth in the outlying areas of the county beyond the planned county water system expansion. This is the case for both the Piedmont and Coastal Plain Physiographic Provinces, although groundwater yields are greater and more reliable in the Coastal Plain. These greater yields in the Coastal Plain will also likely be able to support limited residential and commercial growth in the areas beyond the public water supply system. The Groundwater Development alternative includes potential supplemental development of either the Piedmont or Coastal Plain aquifers to augment the public water supply.

The western part of Stafford County is underlain by the Piedmont Physiographic Province, which generally does not yield large public groundwater supplies. The eastern part of Stafford County lies in the Coastal Plain Physiographic Province, which is underlain by several important hydrogeologic units including the Aquia, Middle Potomac, and Lower Potomac aquifers. These aquifers, however, are highly unlikely to provide a safe yield benefit approaching the magnitude of the county's projected deficit (i.e., approaching about 15 mgd) due to their relative thinness in Stafford County, which results in low aquifer transmissivity.

In the easternmost part of Stafford County, a USGS groundwater-flow model of the Virginia Coastal Plain used maximum transmissivities of about 1,000 $ft^2$/day, 6,000 $ft^2$/day, and 2,000 $ft^2$/day for the Aquia, Middle Potomac, and Lower Potomac aquifers, respectively (Harsh and Laczniak, 1990). Actual transmissivities may be significantly less. For example, pumping tests performed on wells in Stafford County resulted in an average transmissivity estimate of only 450 $ft^2$/day for the Middle Potomac Aquifer (Foundation and Materials Engineering, Inc., 1987).

**TABLE 8-1**

| | Drainage Area (square miles) | Safe Yield (mgd) | Useable Storage (BG) |
|---|---|---|---|
| Expansion of Abel Lake | 30.5 | 1.6 | 0.8 |
| Run-Of-River Reservoirs | | | |
| Austin Run | 2.5 | 1.0 | 2.8 |
| Aquia Creek | 14.0 | 3.5 | 0.9 |
| Potomac Run | 4.2 | 1.5 | 1.4 |
| Long Branch Creek | 4.8 | 1.5 | 1.8 |
| Alcotti Run | 7.1 | 4.5 | 7.8 |
| Pumped Storage Reservoirs | | | |
| Alcotti Run | 7.1 | 21.0 | 5.8 |
| Horsepen Run | 7.8 | 14.0 | 3.7 |
| Richland Run | 6.2 | 17.5 | 4.9 |
| Rocky Pen Run | 5.2 | 13.04 | 4.0 |
| Potomac Estuary Desalination | N/A | 20 | N/A |
| Groundwater Development | N/A | 5 to 10 | N/A |
| No Action | N/A | 0 | N/A |

Source: *Environmental Impact Report for Rocky Pen Run Reservoir*, Malcolm Pirnie, October 1999.

* Use restrictions were estimated to produce a safe yield benefit of 1.4 mgd when applied only to Rocky Pen Run Reservoir. It is estimated that the safe yield benefit from use restrictions could increase by another 1.3 mgd if use restrictions were also in place on the existing County water supply system (i.e., including Abel Lake and Smith Lake).

Based on the aquifer transmissivities used in the Coastal Plain model, the USGS has stated that the groundwater system in adjacent Spotsylvania County is unlikely to provide an 8 mgd supply even after extensive evaluation (G.S. Anderson, USGS, personal communication, 1989). Stafford County has a similar hydrogeologic setting as Spotsylvania County, and so the availability of a 15 mgd supply in Stafford County is even less likely. In communications with Malcolm Pirnie, USGS hydrologists reemphasized that a large scale supply (on the order of the county's projected deficit) is probably not available from the aquifers beneath Stafford County (E.R. McFarland, USGS, personal communication, 1997; D.L. Nelms, USGS, personal communication, 1997).

Available data indicate that large-scale groundwater development of the Piedmont or Coastal Plain provinces in either Stafford County or Spotsylvania County would be very difficult, if not impossible. Therefore, the Groundwater Development alternative has been deemed impracticable as the sole source for supply to meet the county's projected demands. However, groundwater development may be utilized as a supplement to the county's system to supply outlying areas that will not be served by the proposed water system expansion as indicated in the county's Groundwater Management Plan (Draper Aden, 2004).

There are several major factors which affect the feasibility of utilizing the Vulcan Quarry for water storage at this time. One of the critical items is the availability of the quarry. The owner of the quarry, Vulcan Materials Company, wrote a letter to Stafford County in March 2005 stating the "utilization of any significant portion of the pit for water storage purposes would be incompatible with our current operations." If this quarry were to be available in the future, a detailed hydrogeologic study would be needed to assess the hydrogeologic character of the quarry. Obtaining a water withdrawal permit could also delay the use of the quarry due to the recent issuance of the Rocky Pen Run Reservoir permit. Due to the present unavailability of the Vulcan Quarry, this alternative was deemed impracticable and therefore has been eliminated as a current resource for providing additional water storage capacity for the county's water system.

#### 8.2.3.2 Technological Reliability

Construction of a Run-of-River Reservoir on Aquia Creek upstream of the existing Smith Lake could affect the safe yield of Smith Lake (O'Brien & Gere, 1991). As a result, the reliability of Smith Lake to provide its existing safe yield would be compromised. Therefore, this alternative is considered impracticable in terms of reliability.

Previous analysis of the Potomac Estuary Desalination alternative has indicated that the quality of water supplied by this alternative during drought conditions would be poor. In addition, future water quality of the source is unpredictable (O'Brien & Gere, 1991). Widely fluctuating salinity levels of the source as a result of tidal processes would be expected. Treatment of water from a highly variable estuary source to drinking water standards has not been accomplished on a permanent basis anywhere at any scale. Any process for treating water from such a source must therefore be considered experimental. Due to the raw water quality variability and treatment control concerns, and the lack of experience in treating water from a source of this type, this alternative is considered impracticable in terms of reliability, as well as cost.

As part of the Vulcan Quarry Evaluation Draft Report, Draper Aden researched the geologic setting and mining activities of the quarry in an attempt to establish the "water holding" characteristics of the quarry. During a fracture trace analysis, Draper Aden identified numerous fracture traces associated with the northern portion of the quarry. The existence of such fractures indicates potentially unfavorable "water holding" characteristics for the rock. In addition, the inspector of the quarry from the Virginia Division of Mines, Minerals and Energy (DMME) stated that the Vulcan Quarry utilizes pumps to remove groundwater that seeps into the mining area. A detailed hydrogeologic study would need to be performed in order to accurately evaluate the hydrogeologic character of the quarry for use as a reservoir. In addition, it was determined that a grouting program to reduce water seepage from the quarry may be required, which could range in cost from $500,000 to $1,000,000. However, utilization of the Vulcan Quarry as a water storage reservoir was already deemed impracticable due to the present unavailability of the quarry.

#### 8.2.3.3 Cost

Construction cost estimates for potential alternatives are presented in Table 8-2. No specific cost estimates for the Expansion of Abel Lake alternative have been developed. This alternative is expected to require excessive expenditures to raise the dam and protect the existing water treatment plant for a nominal increase in safe yield (O'Brien & Gere, 1991). Therefore, at this time, this alternative is considered impracticable.

Cost estimates for the Potomac Run and Long Branch Creek Run-of-River Reservoir alternatives are included in Table 8-2. These alternatives are relatively costly on a per mgd basis and would result in only small increases in safe yield. Therefore, Potomac Run and Long Branch Run are considered impracticable in terms of safe yield and cost.

The four Pumped Storage Reservoir alternatives were each considered practicable. The costs per mgd of the Pumped Storage Reservoir alternatives range from $5.2 million to $6.7 million based on O'Brien & Gere's cost estimates.

#### 8.2.3.4 Summary

Based on the practicability analysis presented above, the following practicable alternatives are evaluated with respect to their relative environmental impacts in Section 8.2.4. These include:

- Alcotti Run Pumped Storage Reservoir
- Horsepen Run Pumped Storage Reservoir
- Richland Run Pumped Storage Reservoir
- Rocky Pen Run Pumped Storage Reservoir

The No Action alternative is not considered a feasible alternative; however, it has been carried forward for environmental impact analysis pursuant to the Council on Environmental Quality's (CEQ) NEPA regulations (see Section 8.2.2).

### 8.2.4 Impact Comparison for Practicable Alternatives

The potential environmental impacts of the four pumped-storage reservoir alternatives were compared in order to select the least environmentally damaging alternative. These potential impact criteria include open water and vegetated wetlands, stream length and fisheries habitat, uplands, and land use and infrastructure. Table 8-3 presents the results of this impact comparison. The following sections examine each environmental impact criterion. Impacts of the No Action alternative are also discussed in this section.

#### 8.2.4.1 Open Water and Vegetated Wetlands

A wetlands delineation at the Rocky Pen Run Reservoir project area was conducted by Malcolm Pirnie in August 1995. Based on the field delineation and subsequent mapping, approximately 7.4 acres of vegetated wetlands and open water would be inundated by the Rocky Pen Run Reservoir. The breakdown of Waters of the United States is presented in Table 8-4.

## TABLE 8-2

## COST ESTIMATES FOR ALTERNATIVES (a)

| Alternative | Total Project Construction Cost (1990 dollars, millions) | Cost per mgd (Million $) |
|---|---|---|
| Expansion of Abel Lake | (b) | (b) |
| Run-Of-River Reservoirs | | |
| Austin Run | (c) | (c) |
| Aquia Creek | (d) | (d) |
| Potomac Run (e) | 11.9 | 7.9 |
| Long Branch Creek (e) | 14.5 | 9.7 |
| Alcotti Run | (f) | (f) |
| Pumped Storage Reservoirs | | |
| Alcotti Run | 125 | 6 |
| Horsepen Run | 94 | 6.7 |
| Richland Run | 103 | 5.2 |
| Rocky Pen Run | 72 | 5.5 |
| Potomac Estuary Desalination | | |
| Direct Withdrawal Option | 108 | 5.4 |
| Shallow Groundwater Withdrawal Option | 115 | 5.7 |
| Groundwater Development | (c) | (c) |
| Use Restrictions | (g) | (g) |
| No Action | (f) | (f) |

(a) Source of specific cost estimates: O'Brien & Gere (1991)
(b) No specific cost estimates developed. Eliminated based on excessive expenditures expected for nominal increase in safe yield.
(c) Alternative is impracticable based on availability criterion. No cost estimates developed.
(d) Alternative is impracticable based on technological reliability criterion. No cost estimates developed.
(e) Cost estimates for these alternatives were developed by Malcolm Pirnie using cost data for similar alternatives provided by O'Brien & Gere (1991).
(f) Alternative is impracticable based on safe yield criterion. No cost estimates developed.
(g) The cost of implementing use restrictions has not been quantified. Use restrictions would reduce the operating costs of the water utility by reducing the demand for water.

Estimates of wetlands for the project areas within Horsepen Run, Richland Run and Alcotti Run were made from existing published soil and wetlands maps. The estimates of hydric soils were based on the soil maps for Stafford County published by the United States Department of Agriculture, Soil Conservation Service in 1974 (USDA, 1974). A hydric soil is a soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions that favor the growth and regeneration of hydrophytic vegetation (plant life that thrives in wet conditions) (USCOE, 1987). The maps, therefore, can provide an indication of the location of vegetated wetlands. Wetland estimates were based on the mapped wetlands on the National Wetland Inventory (NWI) maps published by the United States Department of the Interior in 1977. Limited field reconnaissance was conducted to verify the wetland mapping.

The Stafford County soils maps indicated 166 acres of hydric soils within the proposed Horsepen Run project area. The NWI mapped wetlands in the project area totaled 90 acres.

Based on the field verification, it was concluded that the actual area of wetlands occurring within the pool area was less than that mapped on the NWI maps. The largest wetland in the project area, mapped as a 35-acre palustrine (inland, lacking flowing water, containing ocean-derived salts in concentrations less than 0.05% and non-tidal) forested wetland, was examined in the field. This was not one contiguous wetland as mapped, but an area where the stream split, creating wetland/upland mosaics between the streams. In addition, several areas contained smaller forested/scrub-shrub wetlands created by beaver dams. A conservative estimate of the total wetlands within the project area is that approximately 30 percent of the 90 acres mapped, or 27 acres, are jurisdictional wetlands.

The County soil maps indicated approximately 307 acres of hydric soils within the proposed project area at Richland Run. The NWI maps identified approximately 19 acres of wetlands within the project area. Based on field verification, the wetland boundaries mapped within the project area were reasonably accurate. The two wetlands verified, 7.8 and 7.1 acres respectively are accurate or larger than mapped.

The County soil maps indicated approximately 234 acres of hydric soils within the proposed project area at Alcotti Run. The NWI maps identified approximately 32 acres of wetlands within the project area. Based on field verification, the wetland boundaries mapped within the project area were reasonably accurate. The borders of three adjacent wetlands verified in the field, totaling approximately 8.5 acres, were accurate as mapped. When considering only the acreage for those wetlands field-verified for each alternative,

each of the three alternatives has a greater amount of vegetated and open water wetlands in the impoundment areas than those within the Rocky Pen Run impoundment area. Since only a few of the mapped wetlands for each alternative were field verified, it is anticipated that more detailed examination of the mapped wetlands for the alternatives would result in wetland area estimates which even more greatly exceed the 7.4 acres at Rocky Pen Run. Therefore, the project at Rocky Pen Run is clearly the least damaging to vegetated and open water wetlands.

#### 8.2.4.2 Fisheries Habitat

Rocky Pen Run is a narrow (approximately 12 feet), shallow stream with steep slopes surrounded by fields, pastures and wooded areas. The area at the north end of the main stem is currently being developed into an industrial park and shows heavy siltation. The stream substrate has various combinations of silt, sand, gravel, cobble, boulder, and bedrock. There is some scour and deposition, bar formation and channelization. Occasional riffle and bend complexes and bottom contours provide some fish habitat. The reservoir would impact approximately 4.5 miles of stream length (based on USGS Quadrangle Maps). Subsequent more detailed field mapping of Rocky Pen Run yielded 9.2 miles of stream. However, for comparison to other systems also evaluated using USGS Quad Maps, the 4.5 mile number was used.

Horsepen Run is a wider (approximately 25 feet), shallow stream, with some beaver dams and wetlands occurring within the stream. The area adjacent to the stream is predominantly wooded with some new residential development close to the Run. Stream substrate is composed of sand, gravel and cobbles with good cover available for fish. There is adequate depth in pool and riffle complexes for habitat and refuge during the winter. The reservoir would impact approximately 4.5 miles of stream length, not including wetlands occurring within the stream.

Richland Run is approximately 30 feet wide and contains some wetland complexes within the stream. The area around the stream is predominantly wooded with some rural residential areas. The uplands within the project area are largely undisturbed which reduces the possibility of siltation and contamination of the stream. The stream substrate is mostly sand with silt, boulder, cobble, and gravel. The stream provides fisheries habitat through cover and adequate depth in riffle and pool complexes. The reservoir would impact approximately 7.3 miles of stream length, excluding the wetlands occurring within the stream.

Alcotti Run is an approximately 22 feet wide shallow, slow-moving stream with several large wetland complexes occurring within the stream. The area adjacent to the stream is predominantly rural residential. The stream substrate is sand with small amounts of gravel and cobbles. The stream provides habitat for fish through undercut banks and adequate depth in its riffle and pool complexes. The reservoir would inundate approximately 5.8 miles of stream, excluding the wetland areas within the stream.

None of the streams in the potential reservoir sites support fish populations large enough to attract sportsmen. The types of fish likely to occur within each of them are those preferring small streams with few riffle and pool complexes. It is likely that anadromous fish such as river herring will use Rocky Pen Run, Horsepen Run and Richland Run, particularly near the mouths of the streams, to some extent for spawning. Fish are least likely to use the Alcotti Run impoundment area because of its distance from the Rappahannock. Implementation of any of the alternatives would retain some portion of spawning habitat near the mouths of the streams. The design of intake screen size and entry velocity, as well as the timing of pumping operations, is directed at minimizing the impacts to either active spawning or the presence of anadromous fish eggs and larvae during the springs.

### 8.2.4.3 Uplands

The area of inundation for each reservoir alternative was estimated based on USGS maps. Uplands within the inundation area are generally either deciduous forest, evergreen forest or mixed hardwood/evergreen forests. The inundation areas for the four reservoir alternatives are shown in Table 8-3.

Rocky Pen Run has the smallest area of inundation (503 acres). The project at Horsepen Run would inundate 820 acres, Richland Run would inundate 1,010 acres, and Alcotti Run would inundate 1,015 acres. Based on aerial photo interpretation, Rocky Pen Run also has the least amount of large contiguous blocks of deciduous forest, which are becoming increasingly rare in Virginia. Mature deciduous forests are particularly valuable for interior dwelling *neotropical* migratory avian species (those that migrate to South and Central America, the Mexican lowlands, the Caribbean islands and south Florida) and those wildlife species sensitive to forest fragmentation. Both Horsepen and Richland Runs currently have large contiguous blocks of deciduous forest within the areas of inundation. Because of the large amount of wetlands associated with both of these streams, the wildlife value of the mature deciduous forests is further increased. The upland forests

in the inundation area at Alcotti Run have lower wildlife value than those at Horsepen Run or Richland Run, because they are more mixed pine and are punctured by rural residential development.

The project at Rocky Pen Run would inundate the smallest amount of uplands. Based on field observations and aerial photo interpretations, the proportion of cut-over forest stands to stands in later successional stages, is greater in Rocky Pen Run than in the other drainages.

#### 8.2.4.4 Land Use and Infrastructure

The watershed associated with Rocky Pen Run is the most disturbed of the four reservoir alternatives.

Traditional land uses occurring near the run have included logging, farming and raising cattle. Often, land was disturbed right up to the banks of the run, causing heavy sedimentation loads in the stream. Current land uses in the watershed include agriculture, rural residential, light industrial, and logging. Approximately 1,023 acres of the 3,315 acres in the watershed (31 percent) have been cleared or developed. The implementation of the project at Rocky Pen Run would require the relocation of approximately 18 houses.

Horsepen Run is the least developed watershed, but is currently undergoing the most residential development. Approximately 1,180 acres of the 5,180 acre watershed (23 percent) are disturbed, much of which is near Route 17. Predominant land uses are agricultural and rural residential. However, large undisturbed tracts of deciduous forest still exist. Implementation of a reservoir at Horsepen Run would require the relocation of approximately eight houses and the construction of check dams downstream of Route 17.

## TABLE 8-3

## ENVIRONMENTAL IMPACT COMPARISON
## STAFFORD COUNTY RESERVOIR ALTERNATIVES

| Environmental Parameter | Rocky Pen Run | Horsepen Run | Richland Run | Alcotti Run |
|---|---|---|---|---|
| Open Water and Vegetated Wetlands (acres) | 7.4[1] | 30[2] | 18.7[2] | 31.7[2] |
| Stream Length[3] (miles) | 4.5[8] | 4.5 | 7.3 | 5.8 |
| Inundation Area[6] (acres) | 503 | 820 | 1,010 | 1,015 |
| Watershed Area[7] (acres) | 3,315 | 4,982 | 3,980 | 4,592 |
| Acres of Disturbance within Watershed[4] (acres) | 1,023 | 1,180 | 1,060 | 1,010 |
| Percent of Watershed Currently Disturbed (%) | 31 | 24 | 25 | 22 |
| Dwellings Impacted (houses) | 18[5] | 8[4] | 10[4] | 19[4] |

1 Based on field delineation
2 Based on NWI and County soil maps
3 Measured from USGS maps (1" = 2000')
4 Determined from aerial photography
5 Determined from detailed topographic maps used in wetland delineation (1" = 200')
6 Obtained from *Comprehensive Water Supply Study* (O'Brien and Gere, 1991)
7 Obtained from Stafford County Planning Commission, *Stafford County 1994 Land Use Plan*
8 More detailed field measurements resulted in an estimate of 9.2 miles. Comparable field-based estimates are not available for other reservoir alternatives.

TABLE 8-4
BREAKDOWN OF WATERS OF THE UNITED STATES
INUNDATED BY ROCKY PEN RUN RESERVOIR

| Waters of the U.S. | Acreage |
|---|---|
| Vegetated Wetlands | 4.0 |
| *Forested* | *1.3* |
| *Scrub-Shrub* | *0.4* |
| *Emergent* | *2.3* |
| Open Water Wetlands [1] | 3.4 |
| Streams [2] | 7.6 |
| **Total** | **15.0** |

1 Based on planimeter measurements of detailed wetland delineation.
2 Calculated using 1"=100' scale, two-foot interval contour mapping, field measurements of stream width and mapwheel.

Richland Run is a moderately disturbed watershed with approximately 1,060 acres of the 4,000 acre watershed (27 percent) disturbed due to residential, agricultural, or light industrial development. Much of the development in the watershed is concentrated near and to the north of Route 17. The proposed pool area is largely undisturbed or is rural residential land. The implementation of a reservoir at Richland Run would cause the relocation of approximately 10 houses, the implementation of check dams south of Route 17, and would require the raising of Route 17.

Alcotti Run has a relatively undeveloped watershed with the majority of disturbance due to residential development. Approximately 1,010 acres of the 4,150 acre watershed (24 percent) are disturbed. Predominant land uses within the watershed are rural residential and agricultural. Although the overall percentage of disturbance in the watershed is lower than other alternatives, the disturbance is distributed throughout the watershed, as opposed to concentrated in a relatively small portion of the watershed. The implementation of the reservoir at Alcotti Run would require the relocation of approximately 19 houses and possible relocation of a portion of an electrical transmission line.

### 8.2.4.5 Impact Summary for Practicable Alternatives

Based on the environmental impact criteria, a reservoir at Rocky Pen Run is the least environmentally damaging alternative. Based on having the least amount of wetland and upland impact, Rocky Pen Run stands out as the preferred alternative. In addition, Rocky Pen Run has the most disturbed watershed and will therefore impact the least amount of pristine woodland habitat valuable for sensitive species. For these reasons, Rocky Pen Run was selected as the environmentally preferred alternative for Stafford County's water supply.

### 8.2.4.6 Impact Summary for "No Action" Alternative

The impacts of the "No Action" alternative were evaluated pursuant to the CEQ's NEPA regulations. If the "No Action" alternative were taken, existing water supply sources would be relied on more heavily to meet increasing demand. Stafford County's existing reservoirs would be increasingly drawn down to extremely low levels for extended periods of time potentially causing eutrophic conditions resulting from excessive nutrients, algal blooms and decreased water quality. This alternative would also result in build-out of currently rural areas causing an increase in the use of septic systems and well fields.

If no action is taken, existing sources would be relied on more heavily, and cumulative impacts on the regional aquifer system could result. As reservoirs are drawn down further, and groundwater use increases, some undesirable impacts on groundwater resources would be expected.

Expected build-out of currently rural areas with the "No Action" alternative could result in degradation or destruction of endangered and threatened species habitat. At a minimum, development would spread through the rural portions of the County, causing substantial impacts to fish and wildlife habitat. Impacts to habitat would also occur from more frequent and severe draw down of existing reservoirs. Likewise, substantial degradation of wetlands would likely occur in the County. Impacts would also be expected on wetlands associated with existing reservoirs and systems driven by groundwater seepage.

# Chapter 9 SUMMARY

## 9.1 Future Water Needs

As discussed in Section 8.1, Stafford County is projected to experience a water supply deficit sometime between the years 2010 and 2015. Based on this analysis, new water supplies capable of providing at least 14.7 mgd of additional treated water safe yield are needed to meet the county's projected Year 2050 demand of 27.7 mgd (with additional conservation). Accounting for estimated raw water transmission and treatment losses of 6 percent, at least 15.6 mgd of additional raw water safe yield is needed to meet projected Year 2050 demand.

## 9.2 Planned Alternatives

Stafford County is currently planning to address its projected demand shortage through the construction of the Rocky Pen Run Reservoir and associated water treatment facility, and implementation of additional conservation measures. Additional water distribution system improvements such as new water mains, storage tanks and pumping stations will also be needed to ensure that the expanded supplies can be delivered to customers in the county's growing service area.

### 9.2.1 Rocky Pen Run Reservoir and Rappahannock River Withdrawals

Based on the environmental impact analysis that was performed on all of the potential alternatives for supplementing the county's supply, a reservoir at Rocky Pen Run is the least environmentally damaging practicable alternative. In addition, Rocky Pen Run has the most disturbed watershed and will, therefore, impact the least amount of pristine woodland habitat valuable for sensitive species. For these reasons, Rocky Pen Run with withdrawals from the Rappahannock River was selected as the environmentally preferred alternatives for Stafford County's water supply.

The Rocky Pen Run Reservoir is currently in the design phase and major permits have been obtained. As permitted, the pumped storage reservoir will supply an additional 13.04 mgd of safe yield to the existing water system. This safe yield is based on a reservoir normal pool elevation of 230 feet msl and a Rappahannock River withdrawal capacity of 40 mgd. The 503-acre reservoir is planned to be open by 2010 and will hold 5.29 billion gallons of water at the normal pool elevation.

### 9.2.2 Conservation

Stafford County is in the process of implementing a county-wide water conservation program aimed at saving water and reducing water losses within the distribution system. It is projected that future water savings (not including water loss reduction) will eventually approach 8 percent. The future water savings, as a percentage of total potable demand on the county's system, are projected to increase in linear fashion to 8 percent by 2030 and remain constant during the remainder of the planning horizon. These water savings would be accomplished through installation of water efficient plumbing fixtures in new constructions as well as from retrofitting older construction. Active conservation programs such as public education programs, rate structures and other billing incentives should also contribute to future savings. Still other potential water savings will likely come as a result of the U. S. Department of Energy's recently issued clothes washer energy conservation standards (Federal Register, January 12, 2001).

Stafford County projects water losses within the system to decrease from 20 percent to 15 percent by 2020 and remain at 15 percent during the remainder of the planning horizon. It is expected that reduction will be achieved through leak detection and repair programs, eliminating dead end lines within the system to minimize the need for flushing, and revising its flushing program to more efficiently serve the system.

## 9.3 Potential Future Water Sources

Stafford County also may utilize limited groundwater development to meet the demands of residential, commercial and agricultural use in areas that are outside of the future service area. As discussed in Section 8.0, groundwater resources are not a viable option to meet the total future demands of the county, but do not represent an option to supplement the water supply needs in outlying areas. Wells may be installed to supply residential developments, commercial or agricultural users outside the county's service area.

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§ 62.1-44.38:1. Comprehensive water supply planning process; state, regional and local water supply plans.

A. The Board, with the advice and guidance from the Commissioner of Health, local governments, public service authorities, and other interested parties, shall establish a comprehensive water supply planning process for the development of local, regional and state water supply plans consistent with the provisions of this chapter. This process shall be designed to (i) ensure that adequate and safe drinking water is available to all citizens of the Commonwealth, (ii) encourage, promote, and protect all other beneficial uses of the Commonwealth's water resources, and (iii) encourage, promote, and develop incentives for alternative water sources, including but not limited to desalinization.

B. Local or regional water supply plans shall be prepared and submitted to the Department of Environmental Quality in accordance with criteria and guidelines developed by the Board. Such criteria and guidelines shall take into account existing local and regional water supply planning efforts and requirements imposed under other state or federal laws. The criteria and guidelines established by the Board shall not prohibit a town from entering into a regional water supply plan with an adjacent county.

(2003, c. 227; 2006, c. 18.)

# TITLE 9. ENVIRONMENT

## STATE WATER CONTROL BOARD

Title of Regulation: **9 VAC 25-780. Local and Regional Water Supply Planning (adding 9 VAC 25-780-10 through 9 VAC 25-780-190).**

Statutory Authority: §§ 62.1-44.15 and 62.1-44.38:1 of the Code of Virginia.

Effective Date: November 2, 2005.

Agency Contact: Scott Kudlas, Department of Environmental Quality, P.O. Box 1105, Richmond, VA 23218, telephone (804) 698-4456, FAX (804) 698-4347, or e-mail scott.kudlas@deq.virginia.gov.

Summary:

*The regulation establishes a planning process and criteria that all local governments will use in the development of local or regional water plans. These plans will be reviewed by the Department of Environmental Quality and a determination will be made by the State Water Control Board on whether the plans comply with this regulation. Within five years of a compliance determination by the board, the plans will be reviewed to assess adequacy and significant changes will require the submission of an amended plan and review by the board. All local programs will be reviewed, revised and resubmitted to the Department of Environmental Quality every 10 years after the last approval.*

Summary of Public Comments and Agency's Response: A summary of comments made by the public and the agency's response may be obtained from the promulgating agency or viewed at the office of the Registrar of Regulations.

*CHAPTER 780.*
*LOCAL AND REGIONAL WATER SUPPLY PLANNING.*

***9 VAC 25-780-10. Application.***

*A. All counties, cities and towns (hereinafter "local governments") in the Commonwealth of Virginia shall submit a local water supply plan or shall participate in a regional planning unit in the submittal of a regional water supply plan to the board in accordance with this chapter.*

*B. The provisions of this regulation shall not affect any water supply project for which a permit application was submitted prior to January 1, 2003, to any state or federal agency. The provisions of this regulation shall not affect any water supply project for which an application for grant, loan or other funding has been made to a state or federal agency prior to January 1, 2003. All projects shall remain subject to applicable federal and state regulatory requirements.*

*C. Nothing in this chapter shall be construed as altering or authorizing any alteration of any existing surface, ground water or common law water rights of any property owner within the Commonwealth, except as required by federal or state law.*

*D. The review required by 9 VAC 25-780-140 shall not be a prerequisite for applying for a permit from the Commonwealth of Virginia for a water supply project.*

***9 VAC 25-780-20. Purpose of chapter.***

*The purpose of this chapter is to establish a comprehensive water supply planning process for the development of local, regional, and state water supply plans. This process shall be designed to (i) ensure that adequate and safe drinking water is available to all citizens of the Commonwealth; (ii) encourage, promote, and protect all other beneficial uses of the Commonwealth's water resources; and (iii) encourage, promote, and develop incentives for alternative water sources, including but not limited to desalinization.*

*This chapter establishes the required planning process and criteria that local governments shall use in the development of the local and regional plans.*

***9 VAC 25-780-30. Definitions.***

*Unless otherwise defined in this chapter or unless the context clearly indicates otherwise, the terms used in this regulation shall have the meanings ascribed to them by the State Water Control Law, Chapter 3.1 (§ 62.1-44.2 et seq.) of Title 62.1 of the Code of Virginia; the Ground Water Management Act of 1992, Chapter 2.5 (§ 62.1-254 et seq.) of Title 62.1 of the Code of Virginia; the Virginia Water Protection Permit Regulation, 9 VAC 25-210 (2004); and the Surface Water Management Area Regulation, 9 VAC 25-220 (2004), including any general permits issued thereunder.*

*"Beneficial use" means both in-stream and off-stream uses. In-stream beneficial uses include, but are not limited to, the protection of fish and wildlife habitat, maintenance of waste assimilation, recreation, navigation, and cultural and aesthetic values. Off-stream beneficial uses include, but are not limited to, domestic (including public water supply), agricultural, electric power generation, and commercial and industrial uses.*

*"Board" means the State Water Control Board.*

*"Community water system" means a waterworks that serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents, and is regulated by the Virginia Department of Health Waterworks Regulation (12 VAC 5-590).*

*"Conservation" means practices, techniques, and technologies that improve the efficiency of water use.*

*"Department" means the Department of Environmental Quality.*

*"Local government" means a city, incorporated town or county.*

*"Local program" means the combined water plan, resource conditions, and drought response and contingency plan developed in compliance with this regulation. The term "local program" will be used in this regulation to mean either local or regional programs. The term "program" implies the institution of a continuous planning process for maintenance of these documents.*

*"Planning area" means the geographical area as defined by local government boundaries that is included in a local or regional water supply plan.*

*"Planning period" means the 30- to 50-year time frame used by the locality to project future water demand in accordance with 9 VAC 25-780-100 B.*

*"Regional planning unit" means a collection of local governments who have voluntarily elected to develop and submit a regional water plan. A regional planning unit may be composed of all local governments located within the bounds of a planning district, any subset of local governments within the bounds of a planning district, or any group of local governments within multiple planning districts.*

*"Regional water plan" means a water plan developed and submitted by two or more cities or counties or both. A town and an adjacent county may develop a regional water plan. Two or more towns may develop and submit a regional water plan where the plan results in the proposed development of future water supply projects that supply the water supply demands of the affected towns. Such plans developed by two or more towns may be included in regional water plans developed and submitted by counties or cities. Regional water plans shall be developed and submitted in conjunction with all public service authorities operating community water systems within the regional planning unit, if applicable.*

*"Self-supplied user" means any person making a withdrawal of surface water or ground water from an original source (e.g., a river, stream, lake, aquifer, or reservoir fed by any such water body) for their own use. Self-supplied users do not receive water from a community water system.*

*"Service area" means the geographical area served by a community water system.*

*"Technical evaluation committee" means a committee of state agencies, including but not limited to the Department of Health, the Department of Conservation and Recreation, the Marine Resources Commission, the Department of Historic Resources, and the Department of Game and Inland Fisheries, convened by the Department of Environmental Quality in accordance with subdivision 8 of 9 VAC 25-780-60 to provide comments on the impacts to or conflicts among in-stream and off-stream uses resulting from proposed alternatives for meeting projected water demands.*

*"Unaccounted for losses" means the difference between a community water system's billing records for volumes of water distributed and production records for volumes of water treated.*

*"Water demand management" means plans for water conservation, reuse, and reducing unaccounted for water losses contained in a local program.*

*"Water plan" means a document developed in compliance with this regulation. The term "water plan" will be used in this regulation to mean either local or regional water plans.*

*"Water sources" means wells, stream intakes, and reservoirs that serve as sources of water supplies.*

***9 VAC 25-780-40. Program development.***

*Local governments shall develop programs for local or regional water plans that are necessary to comply with this chapter. Local governments shall consult and coordinate with all community water systems in the planning area during the preparation of local or regional programs. Community water systems within the planning area shall cooperate and participate with the locality during preparation of the local program. Counties, cities, and towns are encouraged to develop regional programs. Local programs shall be designed to (i) ensure that adequate and safe drinking water is available, (ii) encourage and protect all beneficial uses, (iii) encourage and promote alternative water sources, and (iv) promote conservation.*

***9 VAC 25-780-50. Preparation and submission of a program.***

*A. Local governments must adopt a local program as defined in this section, including any revisions to comprehensive plans, water supply plans, water and sewer plans, and other local authorities necessary to implement this chapter. A local public hearing consistent with § 15.2-1427 of the Code of Virginia is required during the development of the local program. The public hearing may be combined with other public hearings that may be required.*

*B. All local governments shall submit a local program to the department in accordance with the following schedule:*

*1. Local governments with populations in excess of 35,000 persons based on the most recent U.S. Census shall do so no later than November 2, 2008.*

*2. Local governments with populations in excess of 15,000 persons but no more than 35,000 persons based on the most recent U.S. Census shall do so no later than November 2, 2009.*

*3. Local governments with populations less than or equal to 15,000 persons based on the most recent U.S. Census shall do so no later November 2, 2010.*

*4. Notwithstanding the above, local governments may elect to participate in the submittal of regional water supply plans By November 2, 2008, local governments participating in a regional plan shall provide notice to the department of the intent to participate in a regional plan and shall include the names of the other participating localities. Such regional plans shall be submitted no later November 2, 2011.*

*Nothing in this section shall be construed as limiting the submittal of local or regional water supply plans before the date when such plans are due.*

*C. Local programs shall contain the elements listed below. This information may be derived from existing, readily available information and additional detailed studies shall not be required.*

*1. A description of existing water sources in accordance with the requirements of 9 VAC 25-780-70;*

*2. A description of existing water use in accordance with the requirements of 9 VAC 25-780-80;*

*3. A description of existing water resource conditions in accordance with the requirements of 9 VAC 25-780-90;*

*4. An assessment of projected water demand in accordance with the requirements of 9 VAC 25-780-100;*

*5. A description of water management actions in accordance with the requirements of 9 VAC 25-780-110 and 9 VAC 25-780-120;*

*6. A statement of need in accordance with the requirements of 9 VAC 25-780-130;*

*7. An alternatives analysis that identifies potential alternatives to address projected deficits in water supplies in accordance with the requirements of 9 VAC 25-780-130;*

*8. A map or maps identifying important elements of the program that may include existing environmental resources, existing water sources, significant existing water uses, and proposed new sources;*

*9. A copy of the adopted program documents including any local plans or ordinances or amendments that incorporate the local program elements required by this chapter;*

*10. A resolution approving the plan from each local government that is party to the plan; and*

*11. A record of the local public hearing, a copy of all written comments and the submitter's response to all written comments received.*

*D. All local programs shall be reviewed no later than five years after a compliance determination by the board in accordance with 9 VAC 25-780-140 F. Revised plans shall be submitted when this review indicates that circumstances have changed or new information has been made available that will result in water demands that will not be met by alternatives contained in the water plan. These circumstances may be caused by changes in demands, the availability of the anticipated source, cumulative impacts, in-stream beneficial uses, or other factors. In the case where the review by the local government or regional planning unit indicates that the circumstances have not changed sufficiently to warrant a revision of the water plan after five years, the locality shall notify the department that the existing plan is still in effect.*

*E. Notwithstanding subsection D of this section, all local programs shall be reviewed, revised and resubmitted to the department every 10 years after the date of last approval.*

***9 VAC 25-780-60. State role in program preparation.***

*To assist local governments in the development of local programs, the board will:*

*1. Provide technical and financial assistance;*

*2. Provide guidance on compliance options;*

*3. Facilitate acquisition of existing resource conditions (the department shall prepare and post on its website a list of readily available sources for the items identified in 9 VAC 25-780-90 B);*

*4. Facilitate acquisition of existing use information that has been reported to the department;*

*5. Facilitate acquisition of water management information (the department shall prepare and post on its website a list of acceptable practices that are used with regard to the topics in 9 VAC 25-780-110);*

*6. Identify acceptable methods for the projection of future water demands as per 9 VAC 25-780-100;*

*7. Provide any information regarding known conflicts relating to the development of alternatives;*

*8. At the request of the applicant, convene a technical evaluation committee meeting; and*

*9. Provide notice of local public hearings on the local program upon notification by the locality.*

***9 VAC 25-780-70. Existing water source information.***

*A. A water plan shall include current information on existing water sources.*

*B. A water plan shall include, for community water systems using ground water, the name and identification number of the well or wells, the well depth, the casing depth, the screen depth (top and bottom) or water zones, the well diameter, the design capacity for the average daily withdrawal and maximum daily withdrawal, the system capacity permitted by Department of Health, and the annual and monthly permitted amounts contained in ground water withdrawal permits for all wells located within ground water management areas.*

*C. A water plan shall include, for community water systems using surface water reservoirs, the name of the reservoirs, the sub-basins in which the reservoirs are located, the drainage area, the amount of on-stream storage available for water supply, the design capacity for average daily and maximum daily withdrawals from the reservoirs, the safe yield of the reservoirs, the capacity of any associated water treatment plant, the Department of Health permitted capacity of the systems, and any limitations on withdrawal established by permits issued by the board. For a community water system that operates a system of interconnected reservoirs, the reporting of the design capacity for withdrawals, designed average daily withdrawal, the designed maximum daily withdrawal and the safe yield may be for the entire system or may be reported as subsets of the system. The plan shall designate which reservoirs and which intakes constitute a system for the purposes of this paragraph. The plan must report the drainage area and amount of storage available for water supply from each reservoir independently.*

*D. A water plan shall include, for community water systems using stream intakes, the name of the stream or river, the drainage area of the intake, the sub-basin in which the intake is located, the design capacity for average daily and designed maximum daily withdrawal from the stream, the safe yield, the lowest daily flow of record the design capacity of the pump station, the design capacity of the water treatment plant, the capacity of the system permitted by the Department of Health, and any limitation on withdrawals established by permits issued by the board.*

*E. To the extent that information is available, a water plan shall include a list of all self-supplied users of more than 300,000 gallons per month of surface water for nonagricultural uses, the name of the water body utilized, the design capacity for the average daily and maximum daily withdrawal, and any limitation on withdrawals established by permits issued by the board, the Department of Health or any other agency.*

*F. To the extent that information is available, a water plan shall include, for all self-supplied users of more than 300,000 gallons per month of ground water for nonagricultural uses, the name and identification number of the well or wells, the well depth, the casing depth, the screen depth (top and bottom) or water zones, the well diameter, the design capacity for the average daily and maximum daily withdrawal and any limitation on withdrawal established by permits issued by the board.*

*G. A water plan shall include the amount of ground or surface water to be purchased from water supply systems outside the geographic boundaries of the planning area on a maximum daily and average annual basis, any contractual limitations on the purchase of the water including but not limited to the term of any contract or agreement, the recipient(s) or areas served by the water purchased, and the name(s) of the supplier(s).*

*H. A plan shall include the amount of water available to be purchased outside the planning area from any source with the capacity to withdraw more than 300,000 gallons per month of surface and ground water, reported on a maximum daily and average annual basis and any contractual limitations on the purchase of the water including but not limited to the term of any contract or agreement, the geographic region(s) that receive the water purchased, and the name(s) of the supplier(s).*

*I. A water plan shall include, to the extent possible, a list of agricultural users who utilize more than 300,000 gallons per month, an estimate of total agricultural usage by source, whether the use is irrigation or nonirrigation, and whether the source is surface or ground water.*

*J. A water plan shall include an estimate of the number of residences and businesses that are self-supplied by individual wells withdrawing less than 300,000 gallons per month and an estimate of the population served by individual wells.*

*K. When available, a water plan shall include a summary of findings and recommendations from applicable source water assessment plans or wellhead protection programs.*

***9 VAC 25-780-80. Existing water use information.***

*A. A water plan shall include, at a minimum, current information documenting existing water use as listed below. Water use information shall be obtained from Department of Health waterworks permit compliance reports, the department ground water permit compliance reports or department water use reports. Information shall be reported for the most recent previous annual compilation of such data that is available on the date of submission of the water plan.*

*B. A water plan shall include the following information for community water systems:*

*1. The population within the planning area served by each community water system.*

*2. The number of connections within the planning area for each community water system.*

*3. The average and maximum daily withdrawal for each community water system within the planning area.*

*4. The amount of water used within the planning area on an annual average basis, and on an average monthly basis for each community water system expressed in terms of million gallons per day.*

*5. The peak day water use by month for each community water system within the planning area.*

*6. An estimate of the water used on an average annual basis by self-supplied nonagricultural users of more than 300,000 gallons per month of surface and ground water within the service area of each community water system.*

*7. An estimate of the amount of water used on an average annual basis by self-supplied agricultural users of more than 300,000 gallons per month of surface and ground water within the service area of each community water supply.*

*8. An estimate of the number of self-supplied users of less than 300,000 gallons per month of ground water and an estimate of the total amount of water used by them on an annual average basis within the service area of each community water supply.*

*9. For each community water system included in the water plan, the plan shall include an estimate of the disaggregated amounts of water used in categories of use appropriate for the system. Typical categories may include:*

*a. Residential use;*

*b. Commercial institutional and light industrial (CIL) use;*

*c. Heavy industrial use;*

*d. Military water use;*

*e. Water used in water production processes;*

*f. Unaccounted for losses;*

*g. Sales to other community water systems and the names of such systems; or*

*h. Subtotals of the above categories for all community water systems*

*10. To the extent that information is available pursuant to 9 VAC 25-780-60 and other sources, for each community water system included in the water plan using stream intakes, the plan shall include a qualitative description of existing in-stream beneficial uses within the planning area or outside the planning area that may be affected by the point of stream withdrawal.*

*C. A water plan shall include an estimate of the water used on an average annual basis by self-supplied nonagricultural user of more than 300,000 gallons per month of surface and*

*ground water outside the service areas of community water systems.*

*D. A water plan shall include an estimate of the amount of water used on an average annual basis by self-supplied agricultural users of more than 300,000 gallons per month of surface and ground water outside the service areas of community water systems.*

*E. A water plan shall include an estimate of the number of self-supplied users of less than 300,000 gallons per month of ground water and an estimate of the total amount of water used by them on an annual average basis outside the service areas of community water systems.*

***9 VAC 25-780-90. Existing resource information.***

*A. A program shall include a description of existing geologic, hydrologic, and meteorological conditions within the planning area, and in proximity to the point of withdrawal if it is outside the planning area.*

*B. A program shall include a description of existing environmental conditions that pertain to, or may affect, in-stream flow, in-stream uses, and sources that provide the current supply. This description of conditions may be provided in a distinct section of the plan document or as a part of the existing water sources information required pursuant to 9 VAC 25-780-70. This information may be derived from existing, readily available information and additional detailed studies shall not be required. The description of conditions shall include the following items, as they are applicable:*

*1. State or federal listed threatened or endangered species or habitats of concern;*

*2. Anadromous, trout and other significant fisheries;*

*3. River segments that have recreational significance including state scenic river status;*

*4. Sites of historic or archaeological significance;*

*5. Unusual geologic formations or special soil types;*

*6. Wetlands;*

*7. Riparian buffers and conservation easements;*

*8. Land use and land coverage including items such as percentage of impervious cover within a watershed and areas where new development may impact water quality of the source;*

*9. The presence of impaired streams and the type of impairment;*

*10. The location of point source discharges; and*

*11. Potential threats to the existing water quantity and quality, other than those from above.*

***9 VAC 25-780-100. Projected water demand information.***

*A. A water plan shall include projections of future water demand as listed below. Population in aggregate and disaggregate formulations should be estimated according to information from the U.S. Census Bureau, Bureau of Economic Analysis, the Virginia Employment Commission, or other accepted source of population information, including but not limited to, local or regional sources. Demand projection methodologies should be consistent with those outlined in the American Water Works Association or American Society of Civil Engineers manuals. Sources of information and methodologies used in projecting future water demand shall be documented.*

*B. A water plan shall estimate water demand within the planning area for a minimum of 30 to a maximum of 50 years into the future. While not required, localities are encouraged to plan for the maximum planning period to ensure that the most appropriate and sustainable alternatives are identified.*

*C. A water plan shall include an estimated future water use projected at the beginning of each decade (2010, 2020, 2030, etc.) within the planning period.*

*D. A water plan shall include the following projections for community water systems:*

*1. An estimate of population within the planning area served by each community water system;*

*2. A map depicting the proposed service area of each existing or proposed community water system;*

*3. Estimated water demand for each existing or proposed community water system on both an annual average and peak monthly basis;*

*4. Estimated water demand for each existing or proposed community water system disaggregated into categories of use appropriate for the system. Typical categories may include:*

*a. Residential use;*

*b. Commercial institutional and light industrial (CIL) use;*

*c. Heavy industrial use;*

*d. Military water use;*

*e. Water used in water production processes;*

*f. Unaccounted for losses;*

*g. Sales to other community water systems and the names of such systems; or*

*h. Subtotals of the above categories for all community water systems; and*

*5. Total projected water demand for all existing or proposed community water systems disaggregated into the categories used in subdivision 4 of this subsection.*

*E. A water plan shall include a projection of water demand within the planning area on an annual average basis for each existing and any proposed self-supplied nonagricultural user of more than 300,000 gallons per month of surface and ground water located outside the service areas of community water systems.*

*F. A water plan shall include a projection of the amount of water use on an annual average basis for each existing and any projected self-supplied agricultural user of more than*

*300,000 gallons per month of surface and ground water located outside the service areas of community water systems.*

*G. A water plan shall include a projection of the number of self-supplied users of less than 300,000 gallons per month of ground water and a projection of the amount of water used on an annual average basis outside the service areas of community water systems.*

*H. A water plan shall include, if available, any cumulative demand, use conflict, or in-stream flow information developed pursuant to 9 VAC 25-780-140 G.*

*I. A water plan shall explain how the projected needs of domestic consumption, in-stream uses, and economic development have been accounted for in the demand projection for the planning period.*

***9 VAC 25-780-110. Water demand management information.***

*A. As part of a long-term strategy, a water plan shall address conservation as a part of overall water demand management in accordance with the following requirements:*

*1. A water plan shall include information that describes practices for more efficient use of water that are used within the planning area. The type of measures to be described may include, but are not limited to, the adoption and enforcement of the Virginia Uniform Statewide Building Code sections that limit maximum flow of water closets, urinals and appliances; use of low-water use landscaping; and increases in irrigation efficiency.*

*2. A water plan shall include information describing the water conservation measures used within the planning area to conserve water through the reduction of use. The types of measures to be described may include, but are not limited to, technical, educational and financial programs.*

*3. A water plan shall include information that describes, within the planning area, the practices to address water loss in the maintenance of water systems to reduce unaccounted for water loss. The types of items to be described may include, but are not limited to: leak detection and repair and old distribution line replacement.*

*B. Current conservation practices, techniques, and technologies shall be considered in projecting water demand pursuant to 9 VAC 25-780-100 D.*

***9 VAC 25-780-120. Drought response and contingency plans.***

*A program that includes community water systems and self-supplied users who withdraw more than an average of 300,000 gallons per month of surface water and ground water shall contain drought response and contingency plans in accordance with the following requirements:*

*1. Drought response and contingency plans shall be structured to address the unique characteristics of the water source that is being utilized and the nature of the beneficial use of water.*

*2. Drought response and contingency plans shall contain, at a minimum, the following three graduated stages of responses to the onset of drought conditions:*

*a. Drought watch stage responses are generally responses that are intended to increase awareness in the public and private sector to climatic conditions that are likely to precede the occurrence of a significant drought event. Public outreach activities shall be identified to inform the population served by a community water system of the potential for drought conditions to intensify and potential water conservation activities that may be utilized.*

*b. Drought warning stage responses are generally responses that are required when the onset of a significant drought event is imminent. Voluntary water conservation activities shall be identified with the goal of reducing water use by 5-10%.*

*c. Drought emergency stage responses are generally responses that are required during the height of a significant drought event. Mandatory water conservation activities shall be identified with the goal of reducing water use by 10-15%.*

*3. Drought response and contingency plans shall include references to local ordinances, if adopted, and procedures for the implementation and enforcement of drought response and contingency plans.*

***9 VAC 25-780-130. Statement of need and alternatives.***

*A. A water plan shall determine the adequacy of existing water sources to meet current and projected demand by preparing a clear statement of need that is derived from an evaluation of the information required by 9 VAC 25-780-70 through 9 VAC 25-780-110. The statement of need shall contain, at a minimum, a determination of whether the existing source(s) is adequate to meet current and projected demands.*

*B. If the determination is that the existing source is inadequate to meet projected demands during the planning period, the program shall include an alternative analysis of potential sources that includes the following information:*

*1. A description of potential water savings from water demand management actions including an estimated volume for each action;*

*2. A description of potential sources for new supplies including an estimated volume from each source; and*

*3. A description of potential resource issues or impacts, identified in accordance with 9 VAC 25-780-140 G, known for each potential new source that any future water project will need to consider in its development.*

*C. Potential alternatives considered shall include water demand management alternatives as well as more traditional means of increasing supply, i.e., wells, reservoirs, impoundments and stream intakes. Where appropriate, the program shall consider nontraditional means of increasing supplies such as interconnection, desalination, recycling and reuse. The analysis of potential alternatives may include a*

*combination of short-term and long-term alternatives. The result of this analysis shall be provided as part of the submission required by 9 VAC 25-780-50 C 7.*

***9 VAC 25-780-140. Review of local programs.***

*A. The board shall review all programs to determine compliance with this regulation and consistency with the State Water Resources Plan. The board will review adopted elements of a local program according to review policies adopted by the board. Copies of the adopted local program documents and subsequent changes thereto shall be provided to the board.*

*B. To assist in the review of the program, the board shall provide the Department of Health and other agencies listed in 9 VAC 25-780-150 B along with any other agency the board deems appropriate, 90 days to evaluate the program. Comments must be received from the Department of Health or other agency by the deadline stipulated in the written notification from the board.*

*C. The board will assess the compliance of submitted programs with these regulations. The board shall prepare a tentative statement of findings on whether the program has demonstrated compliance with the following:*

*1. All elements of a local program identified in 9 VAC 25-780-50 have been submitted;*

*2. The program was developed through a planning process consistent with this chapter;*

*3. The results of any evaluation conducted pursuant to subsection G of this section have been appropriately accommodated;*

*4. The existing sources information complies with 9 VAC 25-780-70;*

*5. The existing water use information complies with 9 VAC 25-780-80;*

*6. The existing resources information complies with 9 VAC 25-780-90;*

*7. The projected water demand is based on an accepted methodology and complies with 9 VAC 25-780-100;*

*8. The water demand management information complies with 9 VAC 25-780-110;*

*9. The drought response and contingency plan complies with 9 VAC 25-780-120;*

*10. The statement of need complies with 9 VAC 25-78-130 A;*

*11. When required, the alternatives comply with 9 VAC 25-780-130;*

*12. The local program is consistent with 9 VAC 25-390-20, § 62.1-11 of the Code of Virginia and Chapter 3.2 (§ 62.1-44.36 et seq.) of Title 62.1 of the Code of Virginia.*

*D. If the board's tentative decision is to find the local program in compliance with subsection C of this section, the board shall provide public notice of its findings pursuant to 9 VAC 25-780-150.*

*E. If the tentative decision of the board is to find the local program in noncompliance with subsection C of this section, the board shall identify (i) the reason for the finding of noncompliance, (ii) what is required for compliance, and (iii) the right to an informational proceeding under Article 3 (§ 2.2-4018 et seq.) of Chapter 40 of the Virginia Administrative Process Act.*

*F. The board shall make a final decision on whether the local program is in compliance with this chapter after completing review of the submitted program, any agency comments received, and any public comment received from a public meeting held pursuant to 9 VAC 25-780-160.*

*G. In conjunction with the compliance determination made by the board, the state will develop additional information and conduct additional evaluation of local or regional alternatives in order to facilitate continuous planning. This additional information shall be included in the State Water Resources Plan and used by localities in their program planning. This information shall include:*

*1. A cumulative demand analysis, based upon information contained in the State Water Resources Plan and other sources;*

*2. The evaluation of alternatives prepared pursuant to 9 VAC 25-780-130 B and C;*

*3. The evaluation of potential use conflicts among projected water demand and estimates of requirements for in-stream flow; and*

*4. An evaluation of the relationship between the local plan and the State Water Resources Plan.*

*H. The board may facilitate information sharing and discussion among localities when potential conflicts arise with regard to demands upon a source.*

*I. A local program's information shall be included in the State Water Resource Plan when determined to be in compliance by the board.*

***9 VAC 25-780-150. Public notice and public comment period.***

*A. The board shall give public notice on the department website for every tentative and final decision to determine local program compliance.*

*B. The board shall give public notice to the Department of Health, the Department of Conservation and Recreation, the Marine Resources Commission, the Department of Historic Resources, and the Department of Game and Inland Fisheries for every tentative and final decision on program compliance. The agencies shall have 90 days to submit written comment. At the request of the applicant, the board will convene a technical evaluation committee meeting to facilitate receipt of these comments.*

*C. The board shall provide a comment period of at least 30 days following the date of the public notice for interested persons to submit written comments on the tentative or final*

*decision. All written comments submitted during the comment period shall be retained by the board and considered during its final decision.*

*D. Commenters may request a public meeting when submitting comments. In order for the board to grant a public meeting, there must be a substantial public interest and a factual basis upon which the commenter believes that the proposed program might be contrary to the purposes stated in 9 VAC 25-780-20.*

*E. The contents of the public notice of a proposed program compliance determination shall include:*

*1. Name(s) and address(es) of the locality(ies) that submitted the local or regional water plan;*

*2. Brief synopsis of the proposed plan including any identified future alternatives;*

*3. The name(s) of the principal water supply sources;*

*4. A statement of the tentative determination to certify or deny consistency with the regulation;*

*5. A brief description of the final determination procedure;*

*6. The address, e-mail address and phone number of a specific person at the state office from whom further information may be obtained; and*

*7. A brief description on how to submit comments and request a public meeting.*

***9 VAC 25-780-160. Public meetings.***

*A. Public notice of any public meeting held pursuant to 9 VAC 25-780-150 shall be circulated as follows:*

*1. Notice shall be published on the department website;*

*2. Notice shall be published once in a newspaper of general circulation in the county, city, or town where the local or regional water plan is in effect; and*

*3. Notice of the public meeting shall be sent to all persons and government agencies that requested a public meeting or have commented in response to the public notice.*

*B. Notice shall be effected pursuant to subdivisions A 1 through 3 of this section at least 30 days in advance of the public meeting.*

*C. The content of the public notice of any public meeting held pursuant to this section shall include at least the following:*

*1. Name and address of the localities who prepared the program;*

*2. The planning area covered by the program;*

*3. A brief reference to the public notice issued for the comment period including the date of issuance unless the public notice includes the public meeting notice;*

*4. Information regarding the time and location for the public meeting;*

*5. The purpose of the public meeting;*

*6. A concise statement of the relevant water resources planning, water quality, or fish and wildlife resource issues raised by the persons requesting the public meeting;*

*7. Contact person and the address, e-mail address and phone number of the department office at which the interested persons may obtain further information or request a copy of the draft statement of findings prepared pursuant to 9 VAC 25 780-140 D; and*

*8. A brief reference to the rules and procedures to be followed at the public meeting.*

***9 VAC 25-780-170. Appeals.***

*All appeals taken from actions of the board or the director relative to the provisions of this chapter shall be governed by the Virginia Administrative Process Act (§ 2.2-4000 et seq. of the Code of Virginia).*

***9 VAC 25-780-180. Enforcement.***

*Enforcement of this chapter will be in accordance with §§ 62.1-44.15, 62.1-44.23, and 62.1-44.32 of the Code of Virginia.*

***9 VAC 25-780-190. Delegation of authority.***

*The executive director, or his designee, may perform any action of the board provided under this chapter, except as limited by § 62.1-44.14 of the Code of Virginia.*

R11-224

PROPOSED

BOARD OF SUPERVISORS
COUNTY OF STAFFORD
STAFFORD, VIRGINIA

RESOLUTION

At a regular meeting of the Stafford County Board of Supervisors (the Board) held in the Board Chambers, Stafford County Administration Center, Stafford, Virginia, on the 15th day of November, 2011:

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MEMBERS: VOTE:
Mark Dudenhefer, Chairman
Paul V. Milde III, Vice Chairman
Harry E. Crisp II
Gary F. Snellings
Cord A. Sterling
Susan B. Stimpson
Robert "Bob" Woodson

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On motion of , seconded by , which carried by a vote of , the following was adopted:

A RESOLUTION ADOPTING A WATER SUPPLY PLAN FOR STAFFORD COUNTY

WHEREAS, the Local and Regional Water Supply Planning Regulations (9 VAC 25-780-10 *et seq.*) require that all counties, cities, and towns in Virginia submit a local water supply plan, or participate in a regional planning unit in the submittal of a regional water supply plan, to the State Water Control Board; and

WHEREAS, a Water Supply Plan meeting this requirement has been developed and presented to the Board for consideration; and

WHEREAS, the Board has conducted a public hearing to receive comments concerning the Water Supply Plan; and

WHEREAS, the Board has carefully considered the merits of the Water Supply Plan, recommendations of staff, and testimony at the public hearing; and

WHEREAS, the Board finds that adopting the Water Supply Plan promotes the health, safety, and general welfare of the County and its citizens;

NOW, THEREFORE, BE IT RESOLVED by the Stafford County Board of Supervisors on this the 15th day of November, 2011, that it be and hereby does adopt a Water Supply Plan for Stafford County; and

BE IT FURTHER RESOLVED that the County Administrator or his designee shall submit a copy of the County's Water Supply Plan to the State Water Control Board through the Department of Environmental Quality (DEQ).

AJR:HLC:cdg