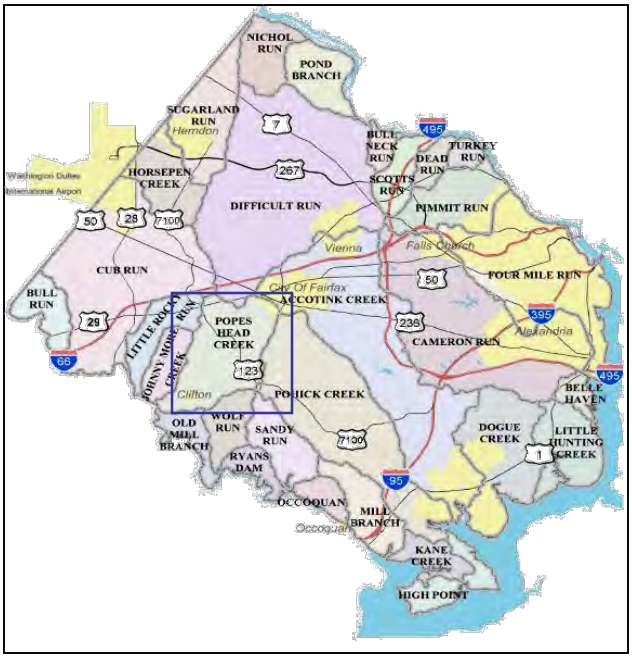
Chapter 2:
Watershed Condition

2. 1 General Watershed Information

The Popes Head Creek Watershed drains into the Occoquan Reservoir and eventually to the Chesapeake Bay, and is located in the southwestern part of Fairfax County, Virginia, as shown on Map 2.1. It is bounded to the east by the Pohick Creek Watershed, to the south by the Wolf Run and Old Mill Branch Watersheds, to the west by the Johnny Moore and Little Rocky Run Watersheds, and to the north by the Difficult Run and Accotink Creek Watersheds.



Map 2.1 Location of the Popes Head Creek Watershed

The Popes Head Creek Watershed encompasses 12,137 acres (18.96 square miles) and is located in the piedmont physiographic province, a region characterized by gently rolling hills, deeply weathered bedrock, and very little solid rock at the surface.

The headwaters of Popes Head Creek are in the southwest portion of the City of Fairfax, located at the northeast border of the watershed. The creek flows in a southwesterly direction to its confluence with Bull Run in Hemlock Overlook Regional Park. Bull Run then flows into the Occoquan Reservoir.

The Fairfax County Parkway (Route 7100) bisects the center of the watershed and is the most heavily traveled roadway in the watershed. Other heavily traveled roads in the watershed include: Ox Road (Route 123), located along the eastern boundary of the watershed; Lee Highway (Route 29), located in the northern portion of the watershed and Braddock Road, located south of Route 29 in the north central area of the watershed.

The Popes Head Creek Watershed is part of the Chesapeake Bay Preservation Area (CBPA), and the entire main stream corridor of the Popes Head Creek Watershed is located in the County's designated Resource Protection Area (RPA). The RPA is designated around all water bodies with perennial flows to protect the quality of water flowing to the Chesapeake Bay. The RPA totals approximately 1,610 acres, or 2.5 square miles, in the Popes Head Creek Watershed. The remainder of the watershed area is part of the County's Designated Resource Management Area (RMA), which is designed to protect water quality by preserving or enhancing the functional value of the RPA.

2.2 History of the Watershed

Popes Head Creek first appeared on maps of the Northern Neck Grants in 1710. The name "Popes Head" was possibly taken from a street name in London. A street near the Royal Exchange in London was named Popes Head Alley and was renamed during Henry VIII's reign as Kings Head Alley. The alley was renamed back to Popes Head Alley during Bloody Mary's reign. Many pubs in London were named Popes Head and renamed Kings Head or Bishops Head after the Reformation.

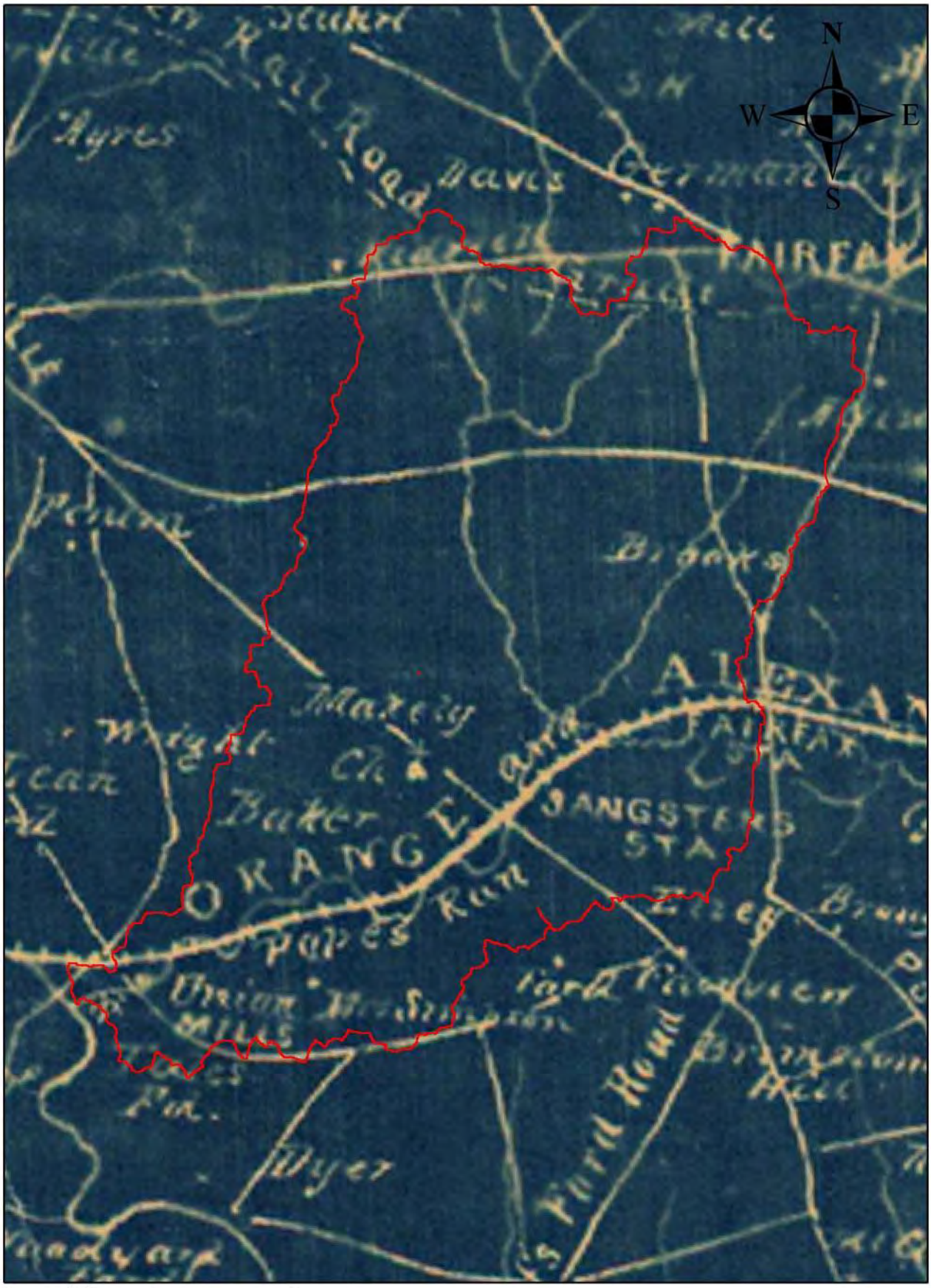
Historical records document that the Hope Park Plantation owned by Edward Payne was located in the watershed. This plantation was located along present day Popes Head Road. In 1765, the election for the Vestry of Truro Parish resulted in the selection of a group which included George Washington of Mount Vernon, George Mason of Gunston Hall, and Edward Payne of Hope Park "in the Forrest." The plantation included over 1,200 acres of land and eighteen outbuildings including a grist mill. The landscape was dramatically changed by widespread logging and the conversion of forest land into agricultural land as settlement continued. Most of the forest that exists now in the watershed is second growth forest.

In 1850-1851, the Orange and Alexandria Railway (now the Norfolk Southern Railroad) was constructed from Alexandria to Manassas Station and beyond. The route ran down Popes Head Creek to its mouth and then along Bull Run before crossing into Prince William County. During the Civil War there was heavy occupation extending south from Centreville through the current site of the Hemlock Overlook Regional Park and a fortified line of trenches were constructed. Control of the Orange and Alexandria Railroad was critical to both the Union and the Confederacy. The railroad consumed many wood products, leading to increased logging in the watershed. Map 2.2 shows a historical map of the watershed, circa 1863.

The Town of Clifton sprang up in the late 1800s on land owned by the Beckwith family. Clifton was a prosperous town that grew and thrived because of local lumbering operations and transportation available on the Southern Railway, which ran through the center of Town. The greatest growth in the Clifton area occurred between 1890 and 1920. Map 2.3 shows a historical map of the watershed circa 1915. Although the station was removed in 1958, the town is noted for its late-19th century architecture. Clifton was declared a National Historic District by the U.S. Department of Interior in 1984.

Hemlock Overlook Regional Park is located at the mouth of Popes Head Creek. The land for the park was purchased by the Fairfax County Park Authority in January 1962 who then sold the property to the Northern Virginia Regional Park Authority (NVRPA) in August 1962. The NVRPA purchased the property to add to its existing holdings acquired for the protection of the Occoquan Watershed. Until 1984, the primary purpose of the Hemlock Overlook camp was to provide local schools access to outdoor recreation. The NVRPA entered into a joint operating agreement with George Mason University in 1984. George Mason University continues to operate an Outdoor Education Center and current programs offered include team development, environmental education, overnight retreats, summer camps and corporate training programs.

Map 2.2: Popes Head Creek Watershed, circa 1863



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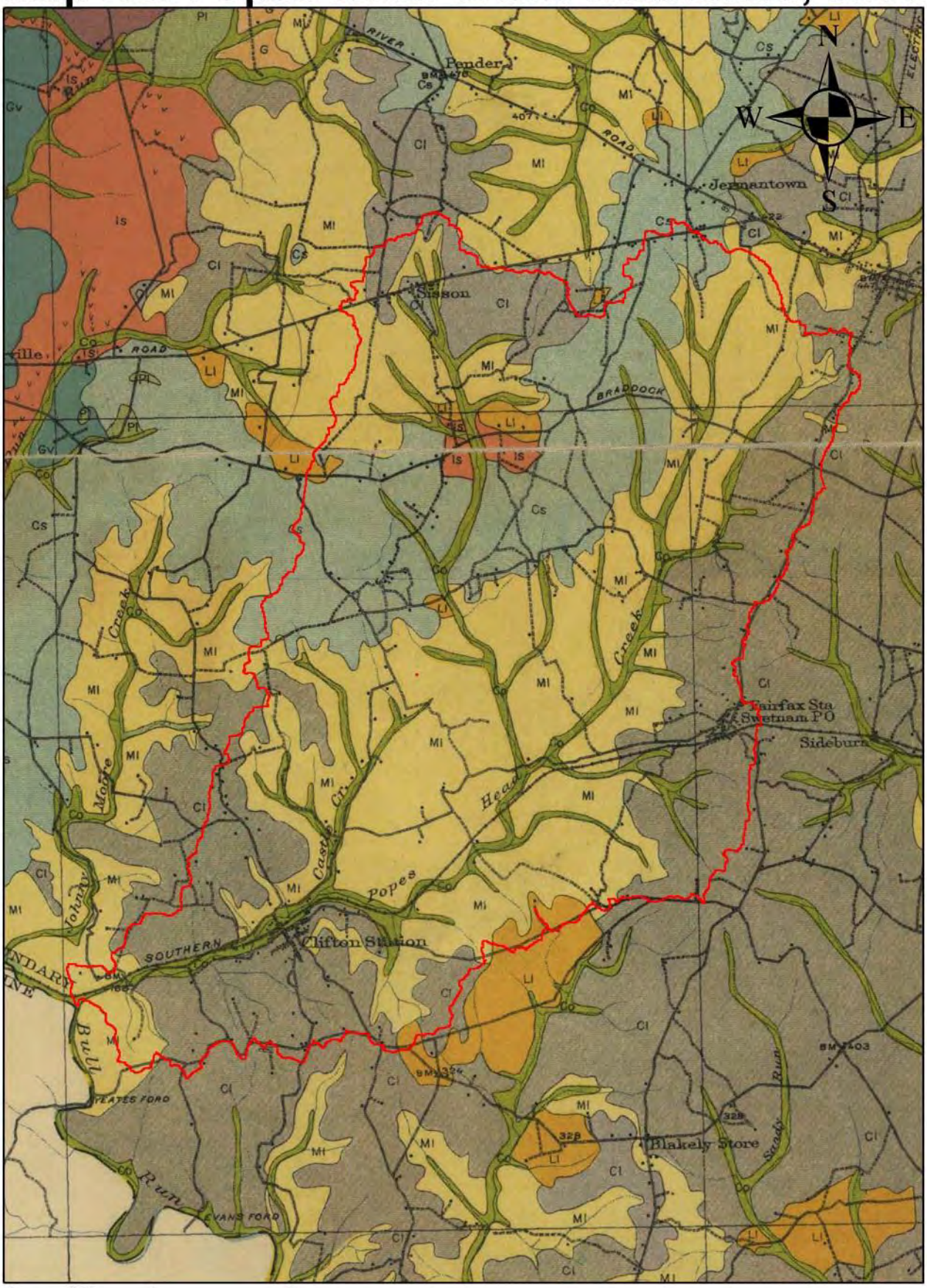
Source: Library of Congress, Geography and Map Division

Map 2.3: Popes Head Creek Watershed, circa 1915



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Source: Library of Congress, Geography and Map Division

The Country Club of Fairfax is located along the East Fork of Popes Head Creek. Originally known as the Court House Country Club of Fairfax, the Club was founded in 1947 when a group of Fairfax residents felt there was a need for a private Country Club in the Fairfax area. After exploring the territory, an option was taken on the Haight Dairy Farm and the land was purchased on September 17, 1947. The name was changed officially to the Country Club of Fairfax in 1986. The Country Club offers an 18-hole golf course, swimming pool, and 12 tennis courts including a year-round tennis bubble.

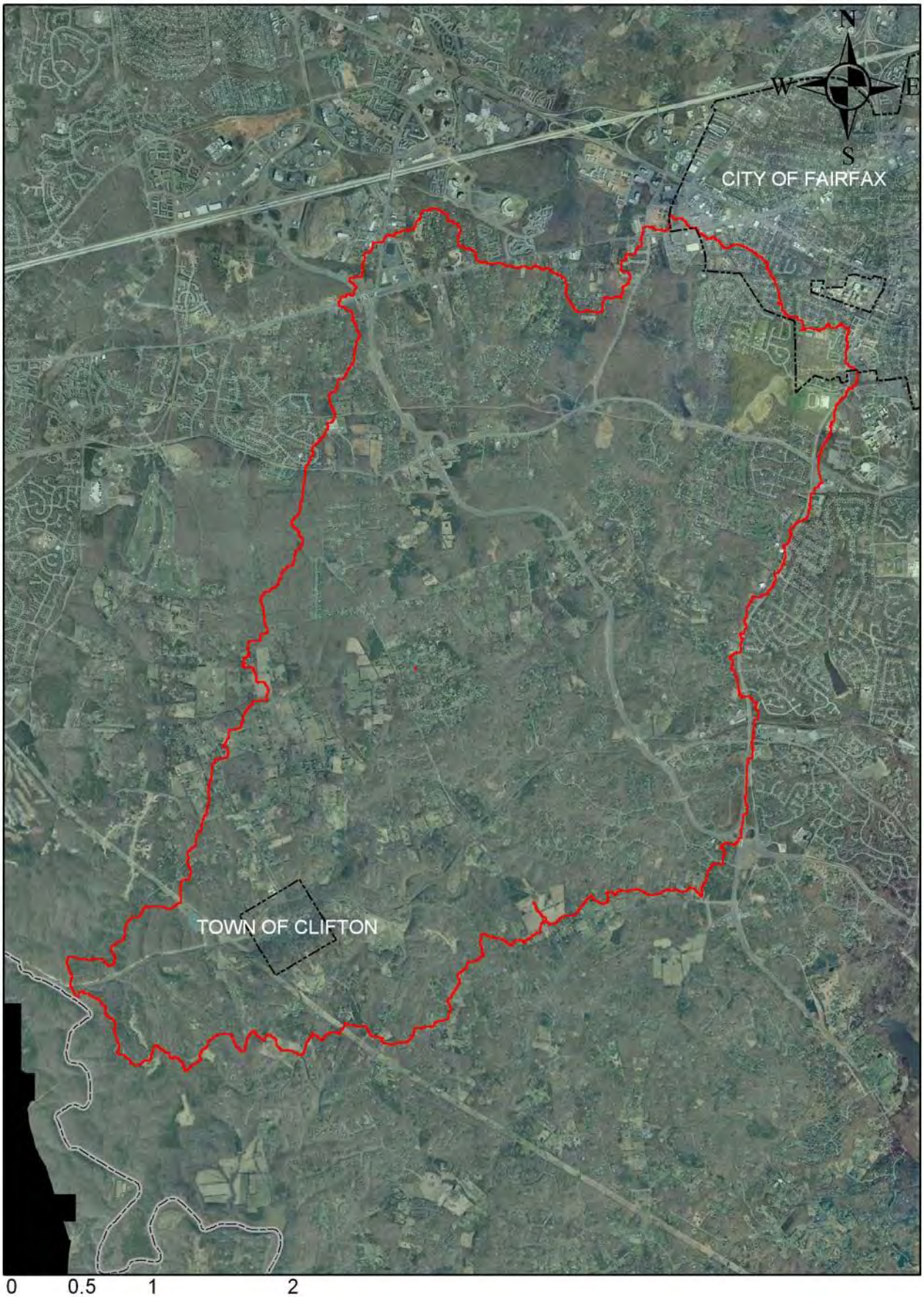
A portion of George Mason University is located in the upper reaches of the Popes Head and East Fork watersheds, north of Braddock Road. The university began as the Northern Virginia branch of the University of Virginia in 1957. The Town (now City) of Fairfax purchased 150 acres in 1958 and donated it to the University of Virginia for a permanent branch campus. In March 1966, the General Assembly authorized the expansion to a four-year, degree-granting institution. In late 1966, the local jurisdictions of Fairfax County, Arlington County and the cities of Alexandria and Falls Church agreed to appropriate money to purchase land adjacent to the existing site to provide for a 600-acre campus. This adjacent property was obtained in 1969 and 1970. In 1972 the Board of Visitors of the University of Virginia recommended that the college separate from its parent institution and on April 7, 1972, the governor signed the legislation that established George Mason University as an independent member of the Commonwealth's system of colleges and universities. Construction of the field house, located in the watershed, began in 1980. Map 2.4 shows a recent map of the watershed, circa 1997.

2.3 Land Use and Impervious Cover

Residential and commercial development in the northern portion of the Popes Head watershed began in the late 1950s. Commercial development in the upper Piney Branch watershed started in the mid-1980s. The central and southern portions of the watershed consist primarily of large lot residential development. On July 26, 1982, the Fairfax County Board of Supervisors approved a rezoning of more than 41,000 acres in the Occoquan Watershed in order to protect the Occoquan Reservoir, which supplies drinking water to the County. Land in the rezoned area is classified as Residential-Conservation (R-C) District, designating a maximum density of one dwelling unit per 5 acres. Approximately 86% of the Popes Head Creek Watershed is located in this rezoned area. The rezoned area is shown on Map 2.5.

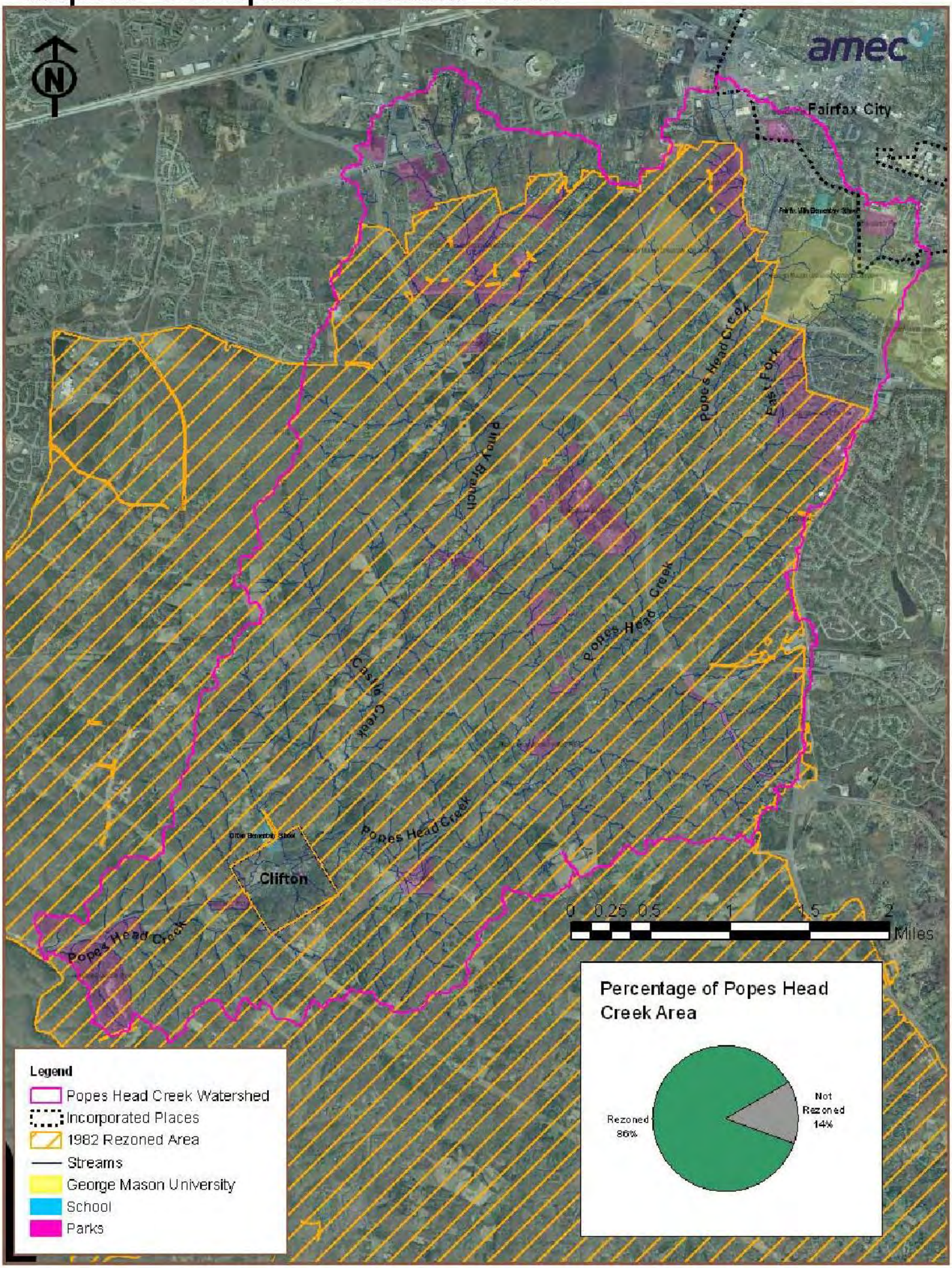
The total impervious area in the watershed is approximately 1,142 acres (9% of the total area). The percentage of each land use category that comprises the total impervious area is shown in Table 2.1. The existing impervious area was delineated from the County's Geographic Information System (GIS) coverages of buildings, roads and parking lots. The County's line coverages for railroads and sidewalks were used to estimate these impervious areas. Driveway impervious area was estimated by using typical values for driveways measured in the watershed for several residential density types. The future impervious cover reflects imperviousness associated with the future land use condition, as shown in Table 2.2. The land use data was derived from the County's 2002 GIS data.

Map 2.4: Popes Head Creek Watershed circa 1997



Source: Library of Congress, Geography and Map Division

Map 2.5 Occoquan "Rezoned" Area



Popes Head Creek Watershed Imperviousness

Land Use	% of Total Impervious Area
Roads/Sidewalks/Railroad	46%
Residential	21%
Driveways	21%
Commercial/Industrial/Parking Lots	12%

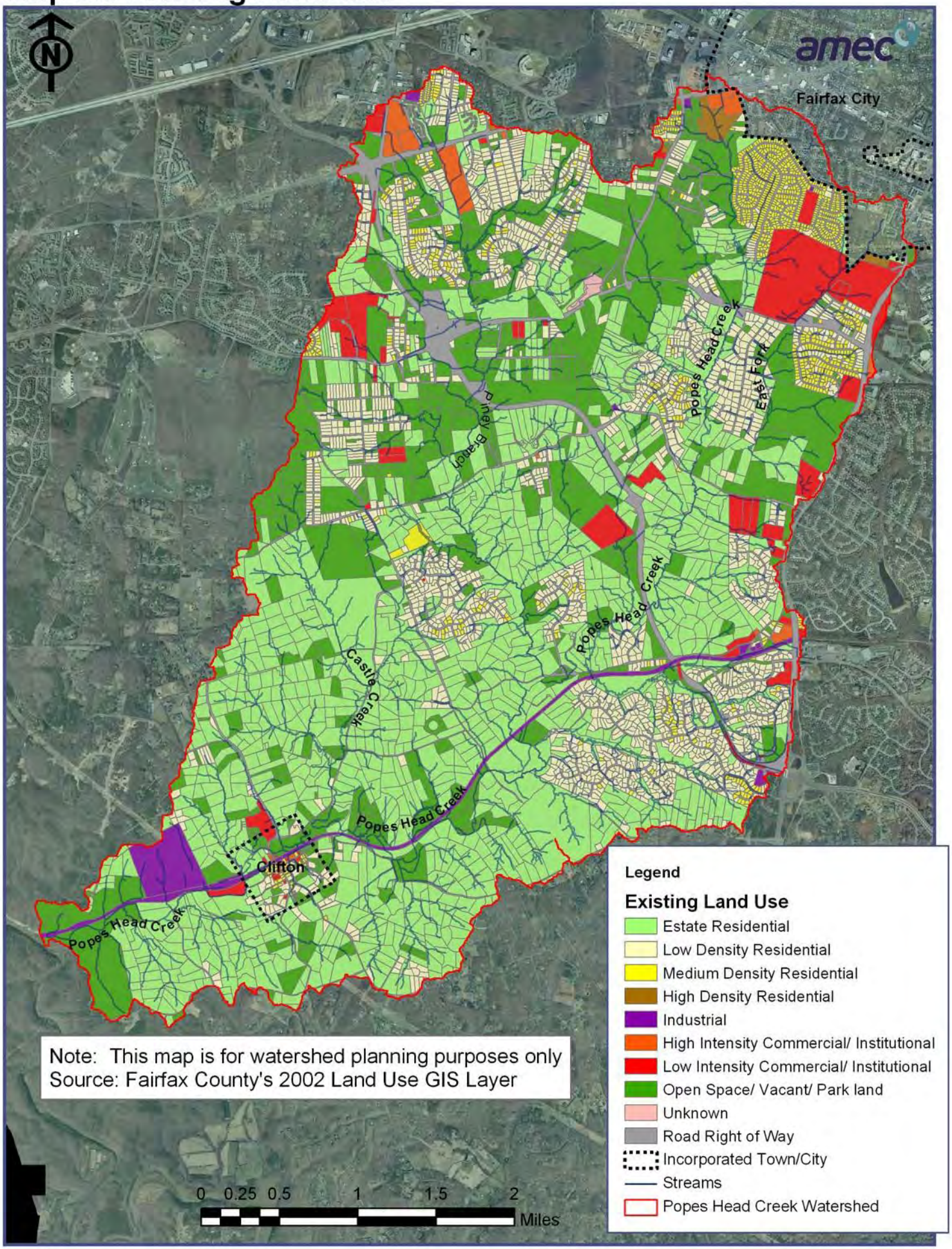
The predominant existing land use in the watershed is estate residential, as shown in Table 2.2, with 45% of the watershed area consisting of this density of a minimum of 5 acres per dwelling unit. The next major land use consists of undeveloped areas in the watershed. The land use descriptions are based upon groupings in the County's *Stormwater Model and GIS Interface Guidelines*, as described in *Technical Memorandum No. 3*, and are for use in the watershed management studies. For ultimate future buildout of the watershed, estate residential land use may increase to 59% and the future watershed imperviousness may increase to 11.4%. The future impervious cover reflects imperviousness associated with the future land use condition. The existing and future land use in the watershed is shown on Maps 2.6 and 2.7.

Table 2.2 Existing and Future Land Use in the Popes Head Creek Watershed

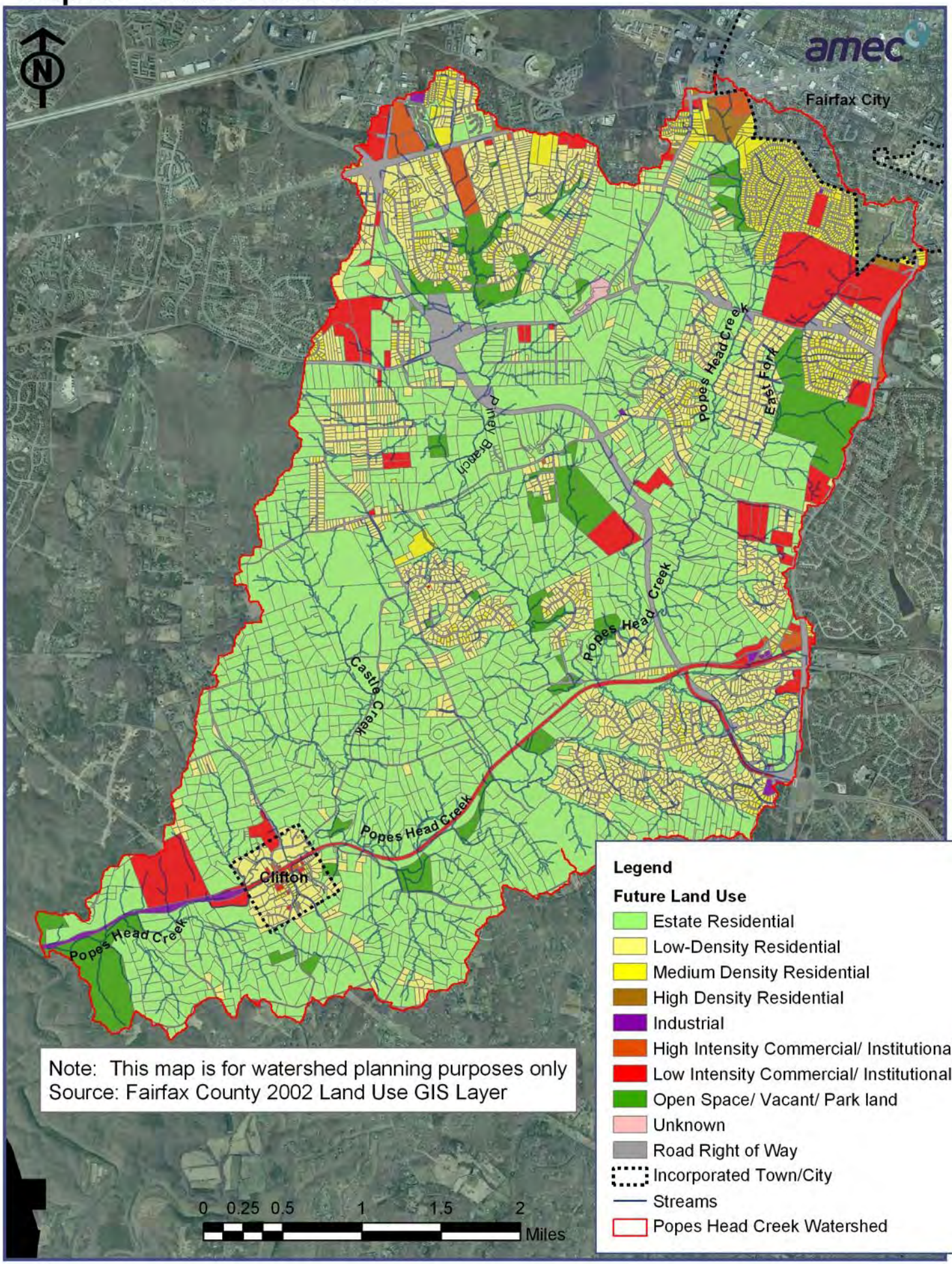
Land Use Description	Existing		Future	
	Area (acres)	%	Area (acres)	%
Open space, parks and recreational areas	728	6	640	5
Estate residential	5,431	45	7,152	59
Low Density residential	1,836	15	2,028	17
Medium-density residential	396	3	498	4
High-density residential	47	0	48	0
Low-intensity commercial/institutional	516	4	698	6
High-intensity commercial/institutional	97	1	99	1
Undeveloped	1,961	16	0	0
Industrial	191	2	40	0
City of Fairfax	185	2	185	2
Unknown	12	0	12	0
Road right-of-way (including shoulder areas)	737	6	737	6
TOTAL	12,137	100	12,137	100

Note: *Based upon Fairfax County's 2002 Land Use GIS Layers.*

Map 2.6 Existing Land Use



Map 2.7 Future Land Use



The locations of vacant and underutilized parcels in the watershed are shown on Map 2.8. The vacant parcel data was obtained from the County's 2002 database and the underutilized parcel information was obtained from the County's 1999 database. Underutilized parcels have a potential zoning density greater than the existing land use on the parcel. The majority of the planned land use for vacant and underutilized parcels is estate residential.

2.4 Subwatersheds and Tributaries

For the purposes of this watershed plan, the Popes Head Creek Watershed was divided into seven subwatersheds, as shown on Map 2.9, to make it easier to evaluate the characteristics of the area draining to each of the major tributaries. The subwatersheds were delineated using the topographic data from the county's GIS and are described in Table 2.3. Table 2.3 also shows the length of the major tributaries in the Popes Head Creek watershed.

Table 2.3 Subwatershed Area and Major Tributary Length

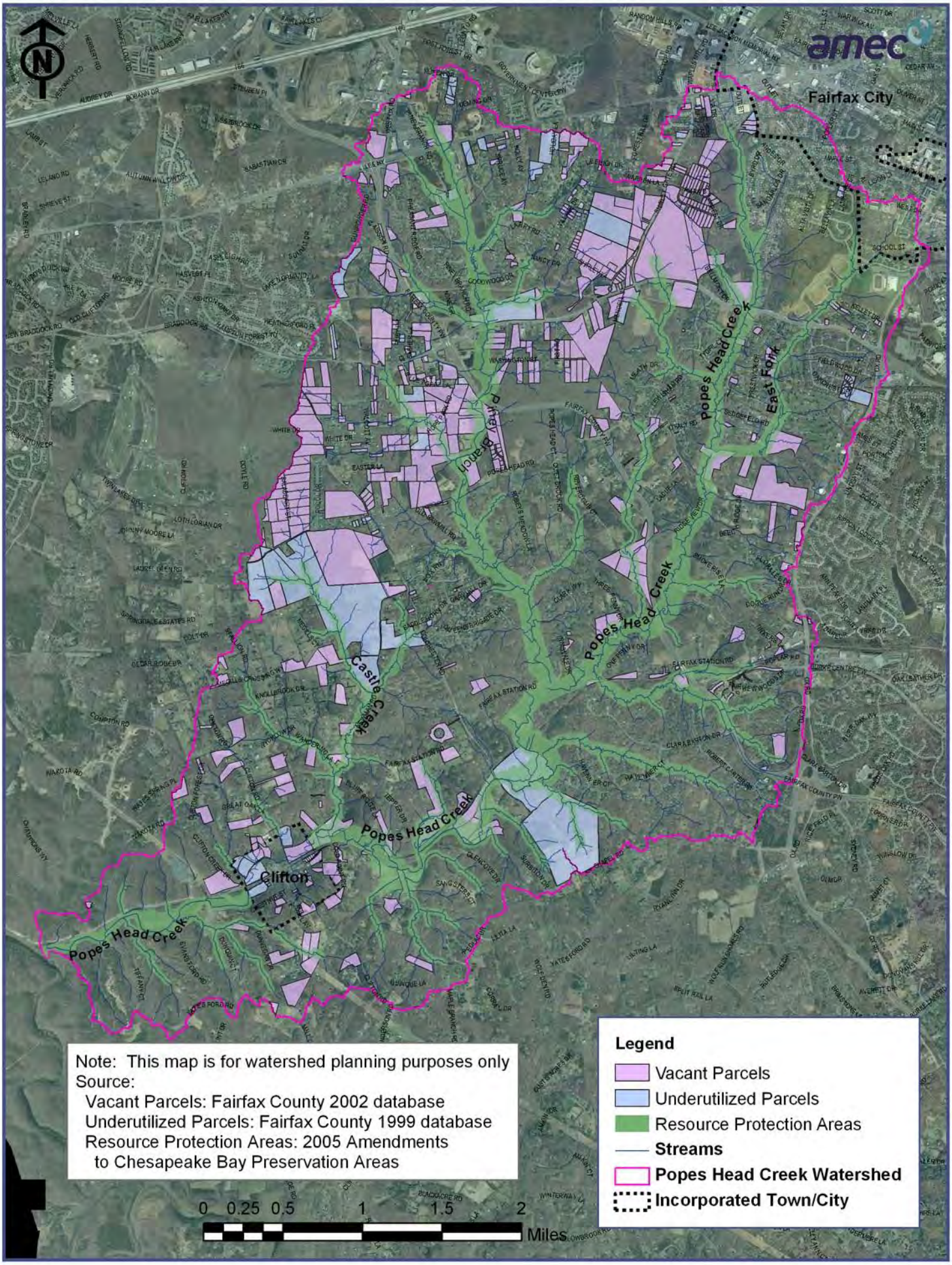
Subwatershed Name	Area (acres)	Tributary Name	Major Tributary Length (miles)
Upper Popes Head	1,430	Popes Head Creek	1.53
East Fork	847	East Fork Popes Head	1.87
Popes Head 2	1,732	Popes Head Creek	2.61
Piney Branch	3,389	Piney Branch	3.98
Popes Head 3	1,870	Popes Head Creek	3.06
Castle Creek	1,477	Castle Creek	2.22
Lower Popes Head	1,392	Popes Head Creek	2.46
TOTAL	12,137		17.73

2.5 Summary of Existing Reports and Data

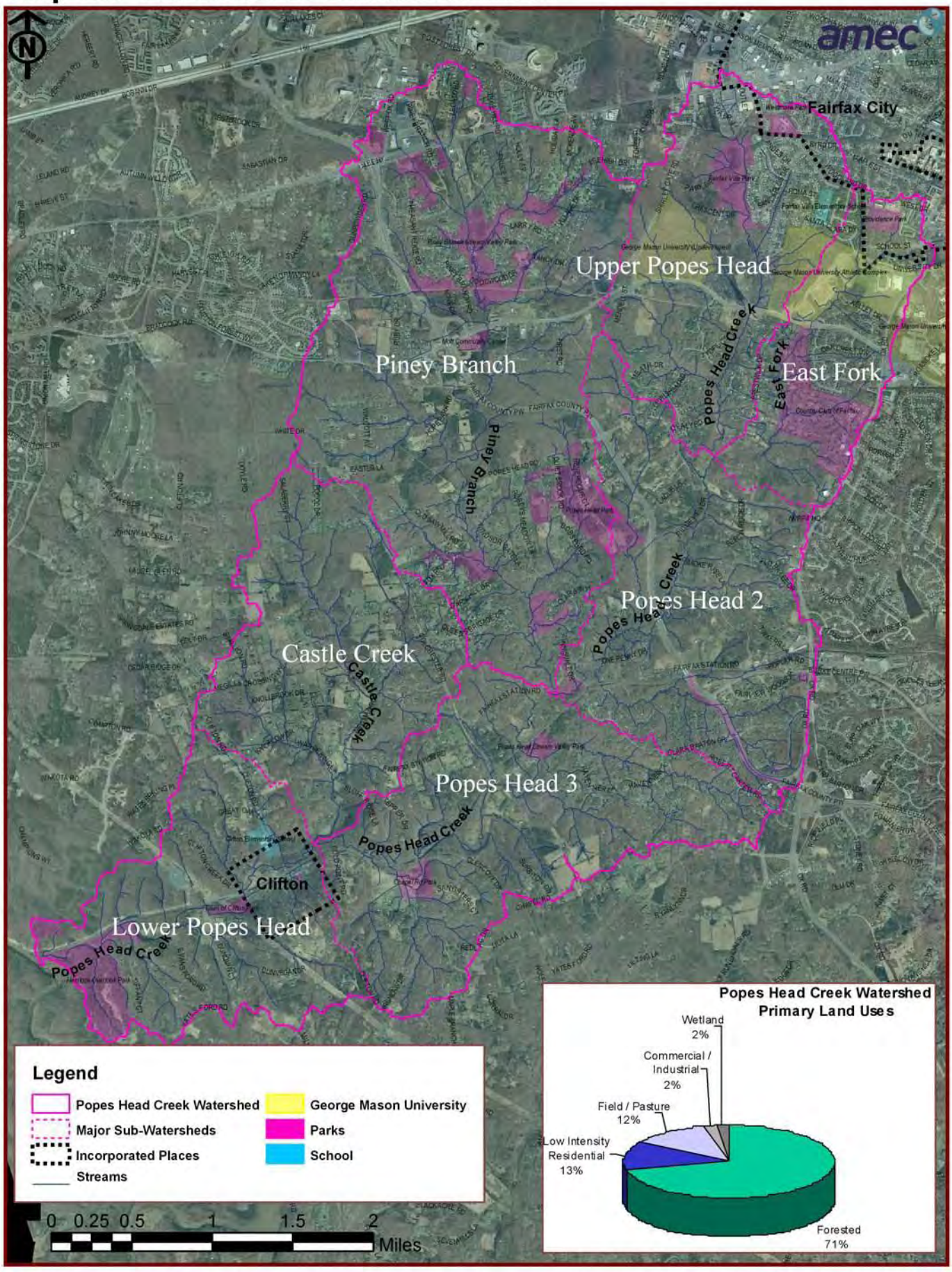
2.5.1 Stream Water Quality Report

The Fairfax County Health Department formerly monitored stream water quality at 84 sampling sites throughout the County. Three water quality sampling sites were located in the Popes Head Creek Watershed and are shown on Map 2.10. Sites 26-02 and 26-05 are located on Popes Head Creek and site 26-03 is located on Piney Branch. In 2002, 18 water samples were collected from each of these sites and evaluated for fecal coliform, dissolved oxygen, nitrated nitrogen, pH, phosphorous, temperature, and heavy metals. These parameters indicate the amount of pollution contributed from manmade sources and help to evaluate the quality of the aquatic environment. Information regarding the parameters and data collected for the *Fairfax County 2002 Stream Water Quality Report* can be found at http://www.co.fairfax.va.us/ service/hd/resourcewater.htm.

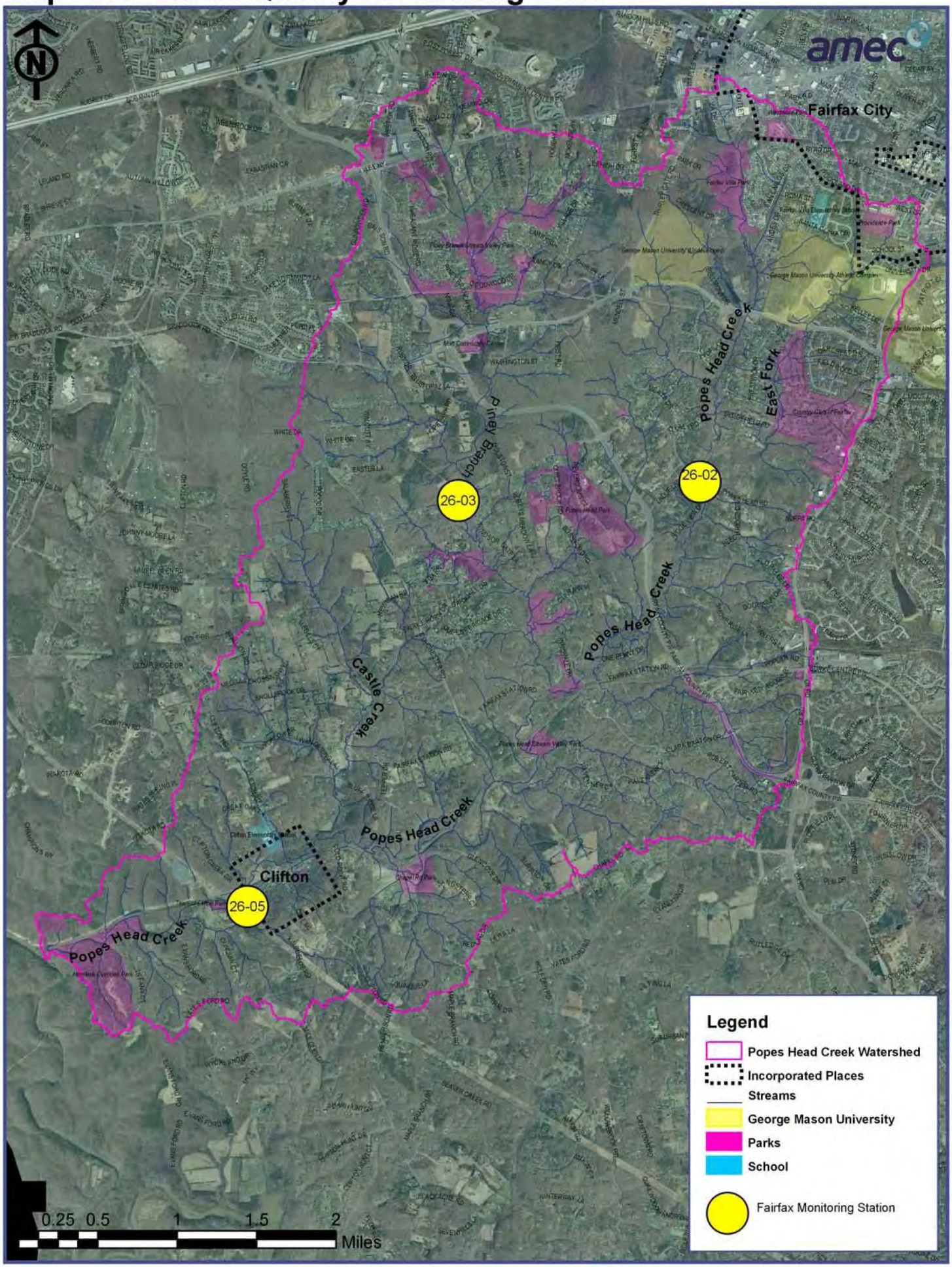
Map 2.8 Vacant and Underutilized Parcels



Map 2.9 Location of Subwatersheds



Map 2.10 Water Quality Monitoring Sites



Five percent of samples collected from sites 26-02 and 26-05 on Popes Head Creek showed a dissolved oxygen concentration of less than 4.0 mg/l, which is the minimum standard considered suitable for aquatic life. None of the samples for site 26-03 on Piney Branch had dissolved oxygen concentration less than 4.0 mg/l. The average dissolved oxygen concentration for all three sites in the watershed were between 9 and 10 mg/l, which is above the minimum standard. Low stream flows due to low rainfall can affect the dissolved oxygen levels.

For sites 26-02, 26-03 and 26-05, fecal coliform counts in 2002 were greater than 1,000/100 ml for 22%, 28% and 33% of the samples, respectively. Countywide, 25% of the samples in 2002 exceeded fecal coliform counts of 1,000/100 ml. For fecal coliform, a count less than 200/100 ml is considered good water quality and a count of 250,000/100 ml is considered a direct sewage discharge. In 2002, an average of 9% of the samples in the watershed met the good water quality criteria as opposed to an average of 15% in 2001. Figure 2.1 shows the values for the geometric mean of fecal coliform from 1993 to 2002. The geometric mean is used to measure the central tendency of the data. The geometric mean is calculated by multiplying a series of numbers and taking the *nth* root of the product where *n* is the number of items in the series.

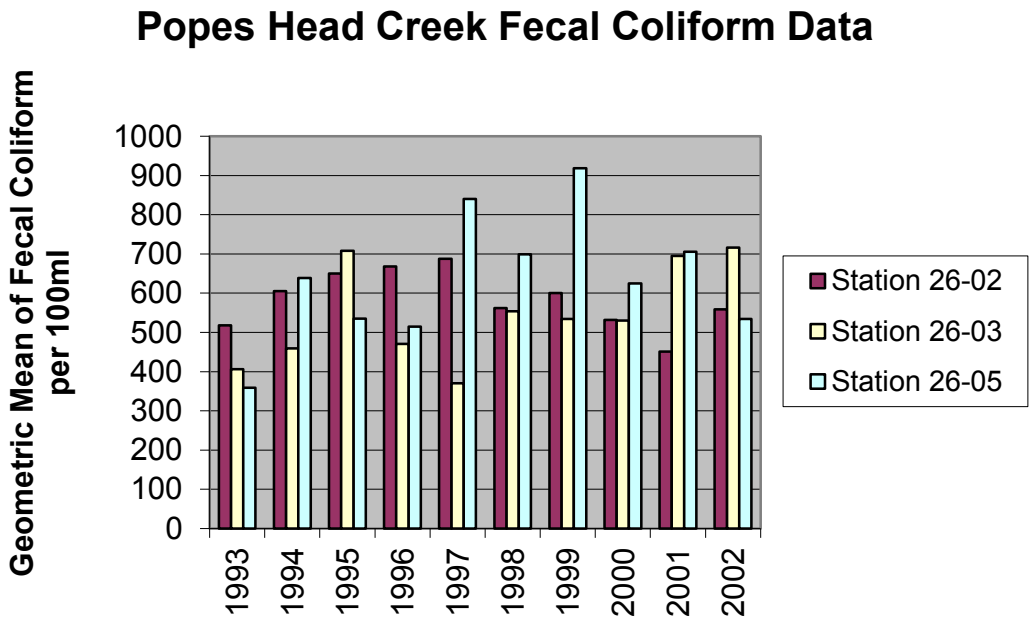


Figure 2.1 Yearly Geometric Mean of Fecal Coliform for Popes Head Creek

2.5.2 Environmental Baseline Report

The *Occoquan Environmental Baseline Report* was written by Parsons, Brinkerhoff, Quade and Douglas in February 1978. The report presented a comprehensive view of the environmental baseline conditions for the 11 watersheds in the southern area of the County that drain into Bull Run and the Occoquan Reservoir. The stream water quality in the Popes Head Creek watershed was assessed in very good condition. To compare to the fecal coliform data presented above, the sampling for this report done in 1976 showed a geometric mean of fecal coliform for the same three stations to be between 36 and 59 per 100 ml. This is significantly lower than the data for 1993 through 2002.

The *Occoquan Environmental Baseline Report* also addressed the aquatic environment by surveying the aquatic fauna at 5 sites in the Popes Head Creek watershed. Two sites were on

Piney Branch at Braddock Road and at Fairfax Station Road, one site was on Castle Creek at Newman Road and two sites were on Popes Head Creek at Popes Head Road and Chapel Road. The stream fauna quality was ranked “very good” on Piney Branch at Braddock Road and “good” on Piney Branch at Fairfax Station Road, Castle Creek at Newman Road and Popes Head Creek at Popes Head Road. The stream fauna quality at the most downstream site on Popes Head Creek at Chapel Road was ranked “fair to poor”. The report states that faunal diversity at this site was fairly low, and only a few pollution-sensitive species were collected.

Severe erosion was noted as several locations on Popes Head Creek and its tributaries. On Popes Head Creek, severe erosion was noted in one area upstream of Braddock Road, three areas between Fairfax Station Road and Popes Head Road, five areas upstream of Clifton Road and one area downstream of Clifton Road. An unnamed tributary to Popes Head Creek located downstream of Fairfax Station Road had seven areas with severe erosion. Piney Branch had three areas of severe erosion located downstream of Popes Head Road. The stream physical assessment performed in 2002 showed that approximately 50% of stream banks in the Popes Head Creek watershed are moderately unstable (40-70% erosional areas). However, no stream banks in the watershed were classified as unstable in the 2002 stream physical assessment (greater than 70% erosional areas).

The *Occoquan Environmental Baseline Report* noted severe sedimentation at two locations on Popes Head Creek, one upstream of Fairfax Station Road and one at the railroad crossing upstream of Clifton Road. The 2002 stream physical assessment results showed that approximately 5% of streams in the watershed were rated poor for embeddedness, that is, the streambeds are75-100% covered by sediment or sunken into sediment. The majority of these poor areas are located in the Castle Creek watershed. Approximately 50% of the streams were rated marginal (50-75% of the streambed was covered by sediment).

2.5.3 Proposed Drainage Plan

The *Proposed Drainage Plan, The Occoquan Watersheds* was written by Parsons, Brinckerhoff, Quade and Douglas in April 1979. The report identified 21 projects for the Popes Head Creek Watershed at an estimated cost of $1,515,000. The various projects included 17 culvert/road improvement projects and four stream stabilization projects. The purpose of these projects includes alleviating roadway flooding and abating bank erosion. Five of the culvert/road improvement projects have been constructed and one stream stabilization project is active with partial funding. The remaining 11 projects are inactive with no funding.

2.5.4 Fairfax County Master Plan Drainage Projects

Fairfax County currently has a 27 master plan drainage projects designated for the Popes Head Creek Watershed. This list includes the projects identified in the *Proposed Drainage Plan* Report. Ten of the master plan drainage projects have been completed. There are two active projects: floodproofing a house in the East Fork subwatershed and a channel stabilization project in the Brecon Ridge subdivision. Fifteen projects are inactive due to a lack of funding.

2.5.5 Fulfilling the Promise: The Occoquan Watershed in the New Millennium

The New Millennium Occoquan Watershed Task Force prepared the *Fulfilling the Promise* report in January 2003. The Board of Supervisors established the Task Force to provide an assessment of issues facing the Fairfax County portion of the Occoquan Watershed; to examine gaps in programs not being carried out by local, State and regional agencies; to define the role of volunteer organizations that have interests in the watershed; and to provide a vision for the future management of the watershed. The report presents recommendations on: the reservoir, streams and ecosystems, land use and open space, tree preservation, Erosion and Sediment Control and Stormwater Management, onsite sewage disposal, citizen involvement and regional coordination.

The following paraphrased recommendations will be addressed by the Popes Head Creek Watershed Management Plan. For a full text listing of the Report Recommendations, please see Appendix C.

Reservoir Recommendations:

1. *Promote existing programs and policies aimed at maintaining acceptable levels of water quality in the Reservoir;*

3 *Reduce nutrient and sediment contributions to the Reservoir above and beyond those being achieved through existing policies and ordinances;*

4 *Actively participate in State and federal regulatory and/or policy initiatives that might result in requirements for additional nutrient and sediment reductions;*

Streams and Ecosystems Recommendations:

1. *Rigorously maintain the integrity of the Occoquan downzoning;*
2. *Continue regular long-term stream assessments by the Stream Protection Strategy staff;*
3. *Fully develop and implement the Stormwater Planning Division's watershed management planning process in the Occoquan Watershed;*
4. *Study and adopt new stormwater management designs that have been demonstrated to protect or improve the health of stream ecosystems;*
5. *Encourage the use of those LID techniques that have been proven effective under local conditions, both where new development is planned and, to the extent feasible, for retrofitting of existing development;*

Land Use and Open Space Recommendations:

1. *Continue the County's commitment to the successful strategy for water quality protection of Occoquan Reservoir;*
2. *Establish a broad-based advisory committee, to include stakeholders, County staff, and one or more members of the County's Planning Commission, to review standards and guidelines associated with Special Permit, Special Exception, and public uses that may be approved in the R-C District in the Occoquan Watershed and to report its findings and recommendations to the Board of Supervisors;*
3. *Establish a more proactive easements program that provides for outreach efforts to owners of land in the Occoquan Watershed that contains environmentally sensitive resources;*
4. *Fully fund watershed management planning efforts as well as the implementation of adopted plan measures;*
5. *Complete the ongoing review of impediments to the application of low impact site design techniques and identify disincentives and policy/regulatory conflicts associated with the implementation of these techniques.*

Tree Preservation Recommendations:

1. *Continue to press for tree preservation and preservation enabling legislature;*
2. *Establish tree canopy goals for the Occoquan Watershed and determine appropriate implementation measures for attaining those goals;*
3. *Encourage the revegetation of lost riparian stream buffers with native woody vegetation by identifying potential reforestation areas, providing citizen education, and encouraging citizen reforestation efforts.*

Erosion and Sediment Control and Stormwater Management Recommendations:

1. *Support the stormwater management findings of the study and urge implementation;*
2. *Ensure the frequency of County inspections is sufficient to enforce the Erosion and Sediment Control ordinances.*

Citizen Involvement Recommendations:

1. *Strengthen partnerships with public and citizen organizations to broaden participation in education and stewardship activities;*
2. *Encourage growth of the network of organizations and citizen groups concerned with and/or actively involved in watershed and water quality issues, and seek assistance on methods of reaching more citizens to seek participation in stewardship activities;*
3. *Sponsor programs, meetings, seminars and festivals on water quality and natural resource protection that attract people who may become active volunteers in existing or new programs and help to educate others on the value of good stewardship;*
4. *Support the expansion of existing outreach and education programs, such as those sponsored by the Northern Virginia Soil and Water Conservation District, the Audubon Naturalist Society, and the Fairfax County Park Authority;*
5. *Investigate proactive outreach to property owners who have property in or abutting Resource Protection Areas (RPAs) and/or other stream valley areas;*
6. *Develop a strategy for strengthening the role of citizens in code and ordinance enforcement.*

Regional Coordination Recommendations:

1. *Continued support of regional approaches to Occoquan Watershed Protection.*

2.5.6 Infill and Residential Development Study

The Fairfax County *Infill and Residential Development Study, Draft Staff Recommendations Report* was written by the County in July 2000. Any residential development that will occur proximate to or within already established neighborhoods is referred to as infill development. The primary focus of this study is the identification of recommendations to better address issues associated with the impacts of new residential development on its immediate surroundings. The issues that have been cited most frequently as problems associated with infill development with respect to the immediate environs were divided into four main categories on which staff presented recommendations: Site Design and Neighborhood Compatibility (SC), Traffic and Transportation (TR), Tree Preservation (TP), and Stormwater Management and E&S Control (SW). This issue may be a factor in the upper parts of the watershed where the most development has already taken place.

The following paraphrased recommendations will be addressed by the Popes Head Creek Watershed Management Plan. For a full-text listing of the Study Recommendations, please see Appendix C.

- SC 5: *Allow cluster development by right;*
- SC 6: *Review the Zoning Ordinance and Comprehensive Plan provisions related to open space;*
- TR 1(a): *Modify requirements for horizontal and vertical alignment and street width, including allowance for "traditional street design;"*
- TP 1: *Reduce grading to increase tree preservation;*
- TP 3: *Request conservation easements where appropriate;*
- SW 1: *Improve the awareness, planning, and financial resolution capability of the County for land disturbing projects upstream of sensitive sites*;
- SW2: *Enhance the enforcement of violations including, in certain egregious instances, revoking of land disturbing permits;*
- SW3: *Enhance, through educational programs, the knowledge and awareness of staff, the development industry, and citizens regarding the importance and capabilities of an Erosion and Sedimentation control program;*
- SW4: *Improve the design and installation of Erosion and Sedimentation control silt fences and super silt fences by improving the design standards in the County's regulations;*
- SW5: *Improve the effectiveness of temporary erosion and sedimentation inlet controls on construction sites by reducing the allowable area that may be drained to them;*
- SW6: *Allow the use of an optional 'Faircloth Floating Skimmer' as a dewatering device in temporary sediment traps to increase sediment removal efficiency;*
- SW7: *Allow the use of chemical erosion prevention products on exposed and highly sensitive soils at construction sites in order to reduce erosion which may occur between the time that the exposed area is seeded and mulch and when the grass is fully established;*
- SW8: *Allow the use of bonded fiber matrix products on exposed highly sensitive soils on steep slopes at construction sites in order to reduce erosion which may occur between the time that the exposed area is seeded and mulch and when the grass is fully established;*
- SW9: *Require additional conditions associated with stormwater detention/water quality waivers to address potential problems associated with land disturbance;*
- SW10: *Require reports from applicants that identify baseline data for properties downstream, corrective measures planned for implementation in the event that impacts occur, and a commitment to implement those measures;*
- SW11: *Enhance the use of Best Management Practices (BMP) through additional guidance on BMP selection and enhanced design standards in the PFM;*
- SW12: *Amend the Public Facilities Manual to 1) include technical definitions pertaining to the adequate outfall of stormwater from developments; 2) require a formal adequate outfall analysis in conjunction with review of proposed construction plans; 3) give the Director discretion to require additional measures where a proposal will discharge into an inadequate channel; and 4) better define the design procedure for pipe outlets and suggest consideration*

of the recent Virginia Department of Conservation and Recreation proposal pertaining to hydrologic design stormwater design;

- SW13: *Modify requirements and procedures as they relate to the consideration of stormwater management during the zoning process.*

2.5.7 Natural Resource Management Plan

The Natural Resource Management Plan was prepared by the Fairfax County Park Authority in January 2004, and describes the system-wide resource preservation vision of the Park Authority for 2004 through 2008. The plan recognizes the impacts that urbanization and development place tremendous stress on natural areas. Among those impacts are stormwater runoff, water and air pollution, invasive plants, wildlife conflicts and encroachment by adjoining property owners. The plan contains strategies for seven elements: Natural Resource Management Planning, Vegetation, Wildlife, Water Resources, Air Quality, Human Impacts on Parklands, and Education.

The following paraphrased strategies will be addressed by the Popes Head Creek Watershed Management Plan. For a full text listing of the Report Recommendations, please see Appendix C.

Plan Element: Natural Resource Planning

Issue 1: Natural Resource Inventories and Planning

- Strategy 1.9: Promote partnerships and volunteer participations in resource management inventories, plans and management.
- Strategy 1.12: Pursue opportunities through open space easements, proffered dedications, acquisitions and partnerships to preserve and protect additional open space – particularly land with significant natural, cultural or horticultural resources. Educate citizens about their opportunities to participate in these programs and to protect natural resources on their land.
- Strategy 1.13: Participate in County revitalization projects to identify areas appropriate for resource and open space preservation, as well as passive recreation.

Plan Element: Wildlife

Issue 3: Resolving Conflicts with Wildlife

- Strategy 3.3: Provide information to increase citizen and staff awareness of the benefits and dangers of wildlife, the role of wildlife management and methods to peacefully coexist with wildlife.

Plan Element: Water Resources

Issue 2: Baseline Inventories for Water Resources

- Strategy 2.1: Continue to expand partnerships with DPWES, NVSWCD, ANS, DEQ, Fairfax County Public Schools and others to involve Park Authority volunteers in producing certified water quality monitoring data from park sites. Seek expanded coordination of data and information among participating organizations and volunteers.

- Strategy 2.2: Complete inventory and assessment of stormwater management facilities on parklands to determine their condition and effectiveness, as well as maintenance actions required and responsibility for ongoing maintenance.
- Strategy 2.3: For parks with water bodies, include water quality physical and biological assessments in natural resource baseline inventories as part of park master plans.
- Strategy 2.4: In cooperation with DWPES, begin an assessment of stormwater outfalls on or directly adjacent to parkland to identify locations of greatest concern for erosion and related damage. Explore options to mitigate damage at the sites of greatest concern.
- Strategy 2.5: Review the stream assessment data compiled by DPWES that is available for park stream valleys, identify problem areas on parklands, and develop a prioritized action plan for the most critical needs (including cost estimates for each project).

Issue 3: Protecting Water Resources

- Strategy 3.1: Participate in and closely monitor the Fairfax County Watershed Planning process being coordinated by DPWES.
- Strategy 3.2: As Fairfax County Watershed Plans are adopted by the Board of Supervisors, incorporate their requirements and recommendations in park master planning, design and construction in those watersheds and as may be applicable countywide.
- Strategy 3.5: Seek partnership opportunities and volunteer projects with the Potomac Conservancy, the Virginia Department of Forestry, the Northern Virginia Conservation Trust, DPWES, Department of Planning and Zoning, the Northern Virginia Regional Park Authority, the Fairfax County Tree Commission, and others to enhance riparian buffers and other aquatic habitats.
- Strategy 3.6: Pursue opportunities to utilize Best Management Practices (BMPs) and Low-Impact Development (LID) such as green buildings, rain gardens, and other innovative techniques to reduce water quality and other impacts of new or renovated Park Authority facilities.

2.5.8 Virginia Department of Environmental Quality Water Quality Data

Popes Head Creek is listed as an impaired waterbody in the 2004 305(b)/303(d) Water Quality Assessment Integrated Report prepared by the Virginia Department of Environmental Quality (DEQ). It was initially listed in 1998 after biological monitoring at Route 645 (Clifton Road) determined that the benthic community, composed of aquatic macroinvertebrates that live on the stream bottom, is moderately impaired. In addition, a citizen monitoring station, located in Chapel Road Park, finds medium probability of adverse conditions for biota. Macroinvertebrates are tiny animals that lack a backbone, such as aquatic insects, leaches, mollusks and worms, which have varying tolerances to pollution, and therefore are used as an indicator of water quality. In 2004, Popes Head Creek was also listed as fecal coliform impaired based on water quality data collected at the same DEQ sampling location. The source of the fecal coliform and the benthic impairment are both unknown. The impaired segment begins at the confluence of Popes Head Creek to Bull Run and continues upstream to the confluence of Piney Branch, approximately one quarter mile downstream of Route 660 (Fairfax Station Road). As a result of the biological and bacteria listings, the segment was assessed as not supporting the Clean Water Act's Recreation and Aquatic Life Use goals.

Once a waterbody has been listed as impaired, a Total Maximum Daily Load (TMDL) report identifying the sources causing the water quality problem and the reductions needed to resolve it must be developed and submitted to the United States Environmental Protection Agency (EPA) for approval. Upon approval, DEQ must develop a TMDL Implementation Plan to restore water quality. Because the impaired segment begins at the mouth of Popes Head Creek, the TMDL will include the creek's entire watershed. DEQ has scheduled TMDLs for both listings to be submitted to EPA in May 2006 and began TMDL development in March 2005. When the TMDL is complete, the loading reductions will be incorporated into Fairfax County's Virginia Pollutant Discharge Elimination System (VPDES) permit to discharge stormwater into Waters of the State (including Popes Head Creek). As a result, the loading reductions will become mandatory for the County at that time. While the Popes Head Creek listings are not explicitly addressed in this watershed plan, it is anticipated that actions to control stormwater and reduce pollutant loads proposed in the plan will help reach water quality goals set by future TMDL and VPDES requirements.

2.5.9 Virginia Natural Heritage Resource

The Virginia Natural Heritage Resources Database describes the status and rank of rare plant and animal species for subwatersheds in Virginia. The Lower Bull Run/Popes Head Creek subwatershed had no rare plant or animal species identified in the database.

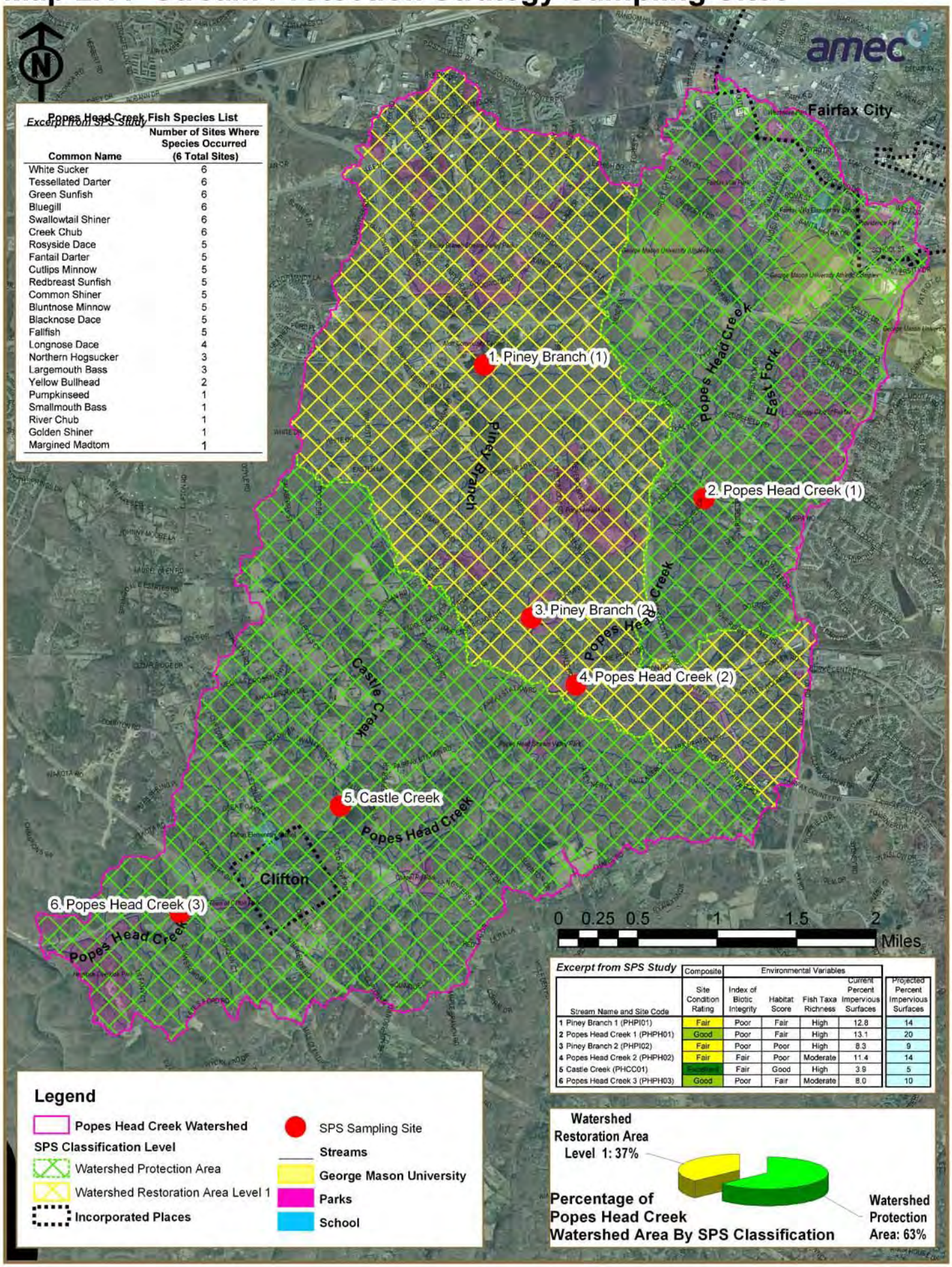
2.5.10 Stream Protection Strategy

The January 2001 *Fairfax County Stream Protection Strategy (SPS) Baseline Study* evaluated the quality of streams throughout the County. Popes Head Creek received "good" composite site condition ratings in the upper and lower watershed and a "fair" rating in the central portion of the watershed. Piney Branch received "fair" composite site condition ratings, while Castle Creek received "excellent" composite site condition ratings. These ratings were based on environmental parameters such as an index of biotic integrity, stream physical assessment, habitat assessment, fish taxa richness, and percent imperviousness. Table 2.4 provides information regarding the macroinvertebrate and fish species at the six testing sites. Map 2.11 shows the location of the six stream protection strategy sampling sites.

Table 2.4 Macroinvertebrate Assessment and Fish Species

Stream Name and Location	Macroinvertebrate Assessment	No. of Fish Species
Popes Head Creek downstream of Popes Head Road	Poor	High
Popes Head Creek downstream of Fairfax Station Road	Fair	Moderate
Popes Head Creek downstream of Clifton	Poor	Moderate
Piney Branch downstream of Braddock Road	Poor	High
Piney Branch upstream of Fairfax Station Road	Fair	Moderate
Castle Creek downstream of Newman Road	Fair	High

Map 2.11 Stream Protection Strategy Sampling Sites



Popes Head Creek Fish Species List
Excerpt from SPS Study

Common Name	Number of Sites Where Species Occurred (6 Total Sites)
White Sucker	6
Tessellated Darter	6
Green Sunfish	6
Bluegill	6
Swallowtail Shiner	6
Creek Chub	6
Rosyside Dace	5
Fantail Darter	5
Cutlips Minnow	5
Redbreast Sunfish	5
Common Shiner	5
Bluntnose Minnow	5
Blacknose Dace	5
Fallfish	5
Longnose Dace	4
Northern Hogsucker	3
Largemouth Bass	3
Yellow Bullhead	2
Pumpkinseed	1
Smallmouth Bass	1
River Chub	1
Golden Shiner	1
Margined Madtom	1

Excerpt from SPS Study

Stream Name and Site Code	Composite: Site Condition Rating	Environmental Variables: Index of Biotic Integrity	Habitat Score	Fish Taxa Richness	Current Percent Impervious Surfaces	Projected Percent Impervious Surfaces
1 Piney Branch 1 (PHPI01)	Fair	Poor	Fair	High	12.8	14
2 Popes Head Creek 1 (PHPH01)	Good	Poor	Fair	High	13.1	20
3 Piney Branch 2 (PHPI02)	Fair	Poor	Poor	High	8.3	9
4 Popes Head Creek 2 (PHPH02)	Fair	Fair	Poor	Moderate	11.4	14
5 Castle Creek (PHCC01)	Excellent	Fair	Good	High	3.9	5
6 Popes Head Creek 3 (PHPH03)	Good	Poor	Fair	Moderate	8.0	10

Legend

- Popes Head Creek Watershed
- SPS Classification Level
  - Watershed Protection Area
  - Watershed Restoration Area Level 1
  - Incorporated Places
- SPS Sampling Site
- Streams
- George Mason University
- Parks
- School

Percentage of Popes Head Creek Watershed Area By SPS Classification

Polluted stormwater runoff affects the number and diversity of macroinvertebrate and fish species. For the macroinvertebrate assessment, the number of unique species and the balance between pollution-tolerant and intolerant species were measured. The rankings ranged between excellent, good, fair, poor, and very poor. A fair rating indicates a marked decrease in intolerant species and a shift to an unbalanced community; a poor rating indicates decreased diversity with intolerant species being rare or absent. For the number of unique fish species collected, the ratings were high, moderate, low, or very low.

In the *SPS Baseline Study*, the upper and lower Popes Head Creek Watershed was classified as a watershed protection area with the goal of preserving biological integrity by taking active measures to identify and protect, as much as possible, the conditions responsible for the current high-quality rating of these streams. The central portion of the Popes Head Creek Watershed and the Piney Branch subwatershed are classified as a watershed restoration level I with the goal of re-establishing healthy biological communities by taking active measures to identify and remedy causes of stream degradation.

2.5.11 Stream Physical Assessment

The County initiated a stream physical assessment for all of its watersheds in August 2002. The stream physical assessment included a habitat assessment, infrastructure inventory, stream characterization, and stream geomorphologic assessment. The stream physical assessment data is described for each of the subwatersheds in the following sections.

Habitat Assessment

As part of the stream physical assessment, the following items were evaluated to determine the stream habitat quality for each stream reach:

- Instream cover (fish)
- Epifaunal substrate (benthic)
- Embeddedness
- Channel/bank alteration
- Frequency of riffles
- Channel flow status (drought & normal flow)
- Bank vegetative protection
- Bank stability
- Vegetated buffer zone width

Based on the evaluation scores in the assessment, classifications were designated for embeddedness, bank stability and vegetated buffer zone width for each stream reach as shown in Table 2.5. Maps provided in the following subwatershed sections show the classification of stream reaches for these items.

Table 2.5 Description of Stream Reach Data

Impact	Description
Embeddedness	
Poor	75-100% of streambed area covered by or sunken into sediment
Marginal	50-75% of streambed area covered by or sunken into sediment
Suboptimal	25-50% of streambed area covered by or sunken into sediment
Optimal	0-25% of streambed area covered by or sunken into sediment

Impact	Description
Vegetated Buffer Width	
Poor	0 – 5 foot buffer
Low	5-20 foot buffer
Moderate	20-40 foot buffer
Good	40-60 foot buffer
Excellent	> 60 foot buffer
Stream Bank Stability	
Unstable	>70% erosional areas
Moderately unstable	40-70% erosional areas
Moderately stable	5-40% erosional areas
Stable	< 5% erosional areas

The scores assessed for the various physical parameters representing the stream habitat conditions were combined for each stream segment to obtain a total habitat score with the majority of the stream habitat assessed as fair. Table 2.6 describes the percentage of length for each habitat quality rating for the streams according to the total score. Map 2.12 shows the habitat quality of each stream segment in the watershed.

Table 2.6 Summary of Stream Habitat Quality

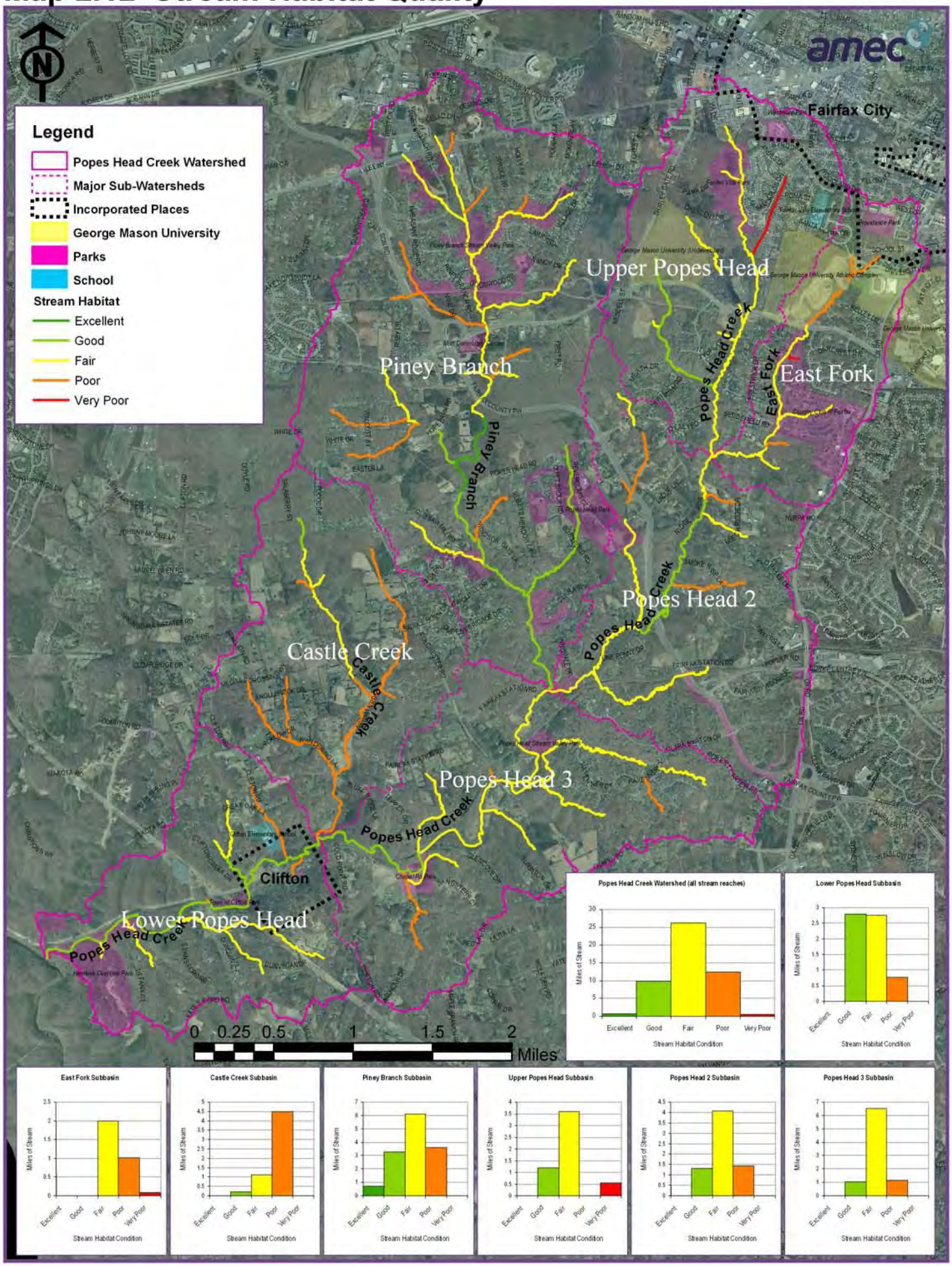
Stream	Percent of Stream Length				
	Very Poor	**Poor**	**Fair**	**Good**	**Excellent**
Popes Head Creek	2%	12%	63%	23%	0%
East Fork Popes Head	3%	33%	64%	0%	0%
Piney Branch	0%	26%	45%	24%	5%
Castle Creek	0%	77%	19%	4%	0%
Total Watershed	**1%**	**25%**	**53%**	**20%**	**1%**

Buffer Loss

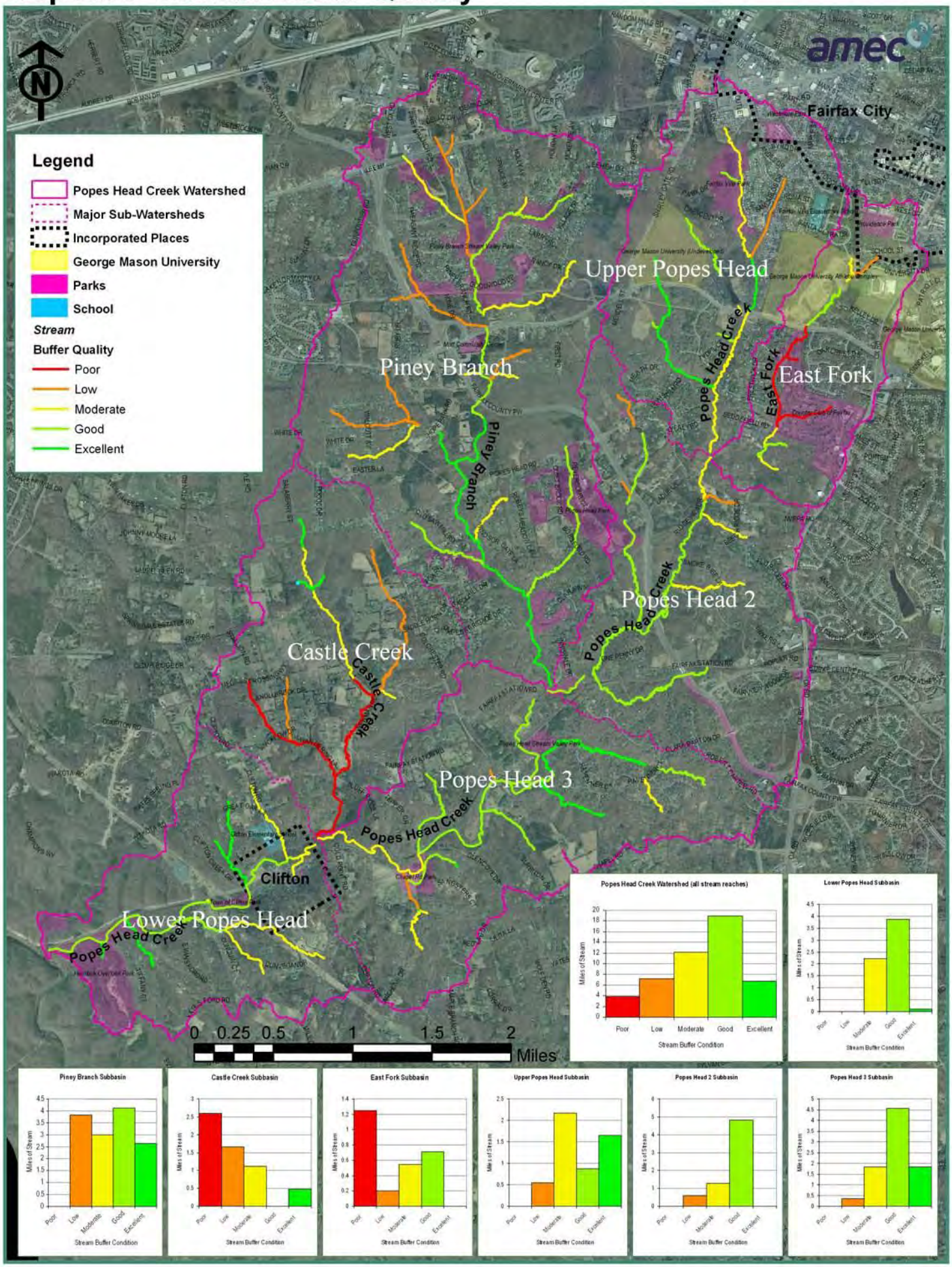
Approximately 48% of stream buffers in the Popes Head Creek watershed are of moderate or lower quality while 52% of stream buffers are of good or excellent quality. The primary cause (63% or 13 miles of stream buffers) for stream buffer loss in this watershed is clearing for lawns. The buffer quality in the Popes Head watershed is shown on Map 2.13.

Streams without sufficient buffers show significant stream degradation as stream banks fail and the stream becomes wider and shallower. The impact continues downstream as sediment from failing stream banks affects downstream stream reaches.

Map 2.12 Stream Habitat Quality



Map 2.13 Stream Buffer Quality



Sedimentation

The stream assessment documented the degree of streambed embeddedness. Embeddedness, referring to the degree to which cobbles and gravel on the streambed are covered with or sunken into sediment, is a measure used to quantify the impact of sedimentation on stream habitat. As the streambed becomes more embedded, the habitat of bottom dwelling organisms is increasingly impaired. Embeddedness is a critical issue in the Popes Head Creek watershed, with roughly 55% of stream reaches exhibiting high levels of embeddedness, thus resulting in marginal to poor habitat for bottom dwelling organisms. This supports the findings of the *Stream Protection Strategy* study, which found that measures of benthic macroinvertebrate community integrity were generally below average. Map 2.14 shows the streambed embeddedness in the Popes Head Creek watershed.

Infrastructure Inventory

The stream physical assessment also identified and characterized the following items at point locations:

- Deficient buffer vegetation
- Dumpsites
- Erosion locations
- Head cuts
- Obstructions
- Pipe and ditch outfalls
- Public utility lines
- Roads and other crossings

An impact score was assigned to those inventory items causing a negative impact to the stream. Based on the impact score, the degrees of impact were classified into four groups: minor, moderate, severe and extreme. Table 2.7 describes the impact ranges for each of the stream inventory items. The maps in the subwatershed sections show the locations and severity of impact for the inventoried items.

Table 2.7 Description of Impacts

Impact	Description
Deficient Buffer Vegetation (within 100 feet of stream bank)	
Extreme	Impervious/commercial area in close proximity to a stream. The stream banks may be modified or engineered. The stream character (bank/bed stability, sediment deposition, and/or light penetration) is obviously degraded by adjacent use.
Severe	Some impervious areas and/or turf located up to the bank and water. Very little vegetation aside from the turf exists within the 25-foot zone. Home sites may be located very close to the stream. The stream character is probably degraded by adjacent use.
Moderate	Encroachment mostly from residential uses and yards. There is some vegetation within the 25-foot zone, but very little aside from turf exists within the remainder of the 100-foot zone. The stream character may be changed slightly by adjacent use.
Minor	Vegetated buffer primarily consists of native meadow (not grazed).

Impact	Description
Dumpsites	
Severe to Extreme	Active and/or threatening sites. The materials may be considered toxic or threatening to the environment (concrete, petroleum, empty 55-gallon drums, etc.) or the site is large (greater than 2,500 square feet) and appears active.
Moderate	Dumpsite less than 2,500 square feet with non-toxic material. It does not appear to be used often, but clean-up would definitely be a benefit.
Minor	Dumpsite appears small (less than 1,000 square feet) and the material stable (will not likely be transported downstream by high water). This site is not a high priority.
Erosion Locations	
Extreme	Impending threat to structures or infrastructure
Severe	Large area of erosion that is damaging property and causing obvious instream degradation. The eroding bank is generally five feet or greater in height.
Moderate	A moderate area of erosion that may be damaging property and causing instream degradation. The eroding bank is generally two feet or greater in height.
Minor	A minor area of erosion that is a low threat to property and causes no noticeable instream degradation.
Head Cuts	
Severe to Extreme	Greater than two-foot head cut height
Moderate	One- to two-foot head cut height
Minor	One-half to less than one-foot head cut height
Obstructions	
Severe to Extreme	The blockage is causing a significant erosion problem and/or the potential for flooding that can cause damage to infrastructure. The stream is usually almost totally blocked (more than 75% blocked).
Moderate to Severe	The blockage is causing moderate erosion and could cause flooding. The stream is partially blocked, but obstructions should probably be removed or the problem could worsen.
Minor to Moderate	The blockage is causing some erosion problems and has the potential to worsen. It should be looked at and/or monitored.

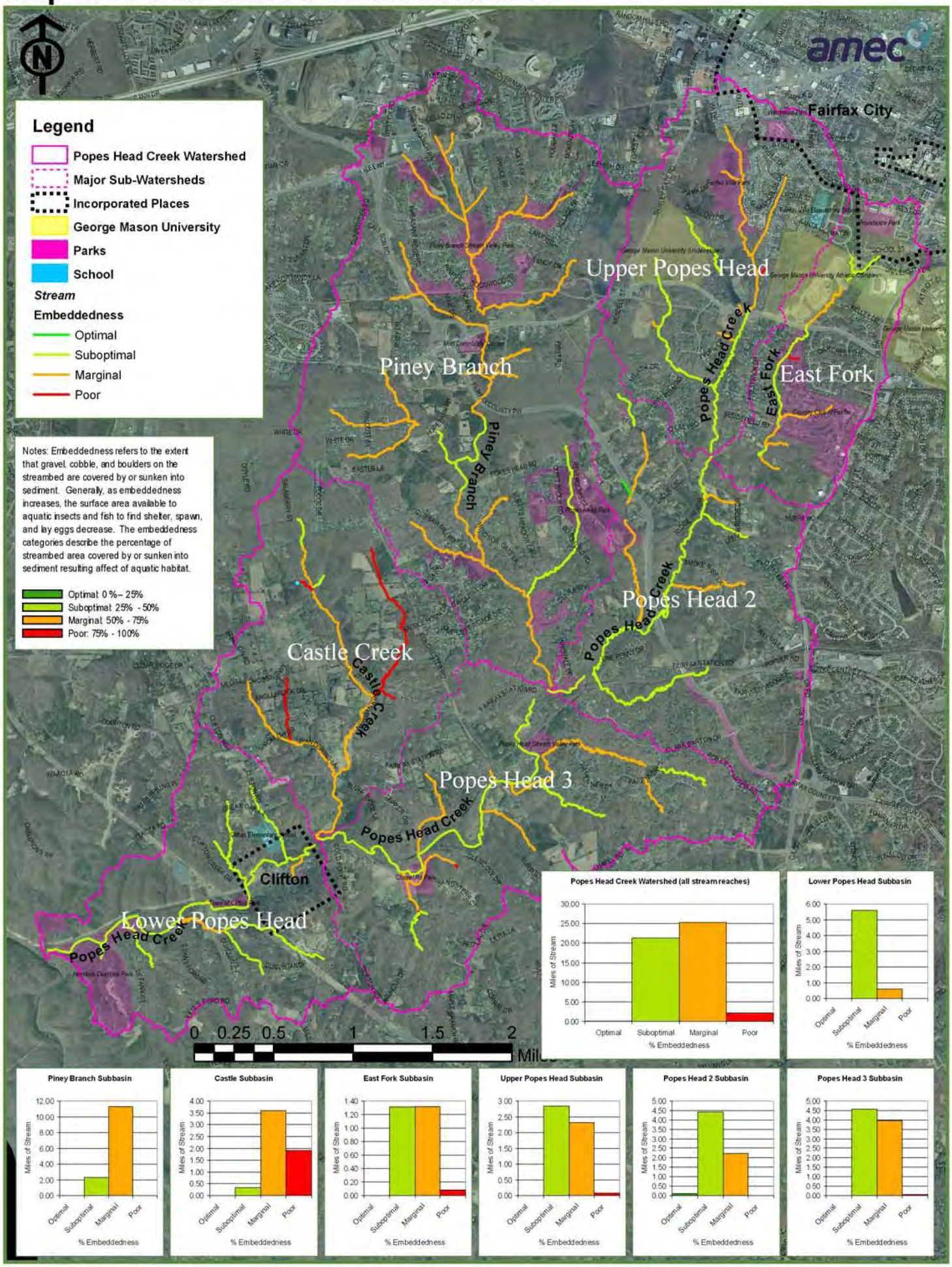
Impact	Description
Pipes and Ditch Outfalls	
Severe to Extreme	Stormwater runoff from a ditch or pipe is causing a significant erosion problem to the stream bank or stream. Discharge that may not be stormwater is coming from the stormwater pipe.
Moderate	Stormwater runoff from a ditch or pipe is causing a moderate erosion problem and should be fixed; it may get worse if left unattended. Discharge is coming from the pipe. It is probably stormwater, but it will be uncertain without further investigation.
Minor	Stormwater runoff from a ditch or pipe is causing a minor erosion problem and some discharge is occurring.
Public Utility Lines	
Extreme	A utility line is leaking.
Severe	An exposed utility line is causing a significant erosion problem and/or obstruction (blockage). The potential for the sanitary line to burst or leak appears high.
Moderate	A partially exposed utility line is causing a moderate erosion problem. The line is partially visible (mostly buried in a stream bed with little if any erosion).
Minor	A utility line is exposed but stabilized with concrete lining and stable anchoring into the bank.
Road and other Crossings	
Extreme	The condition of debris, sediment, or erosion poses an immediate threat to the structural stability of the road crossing or other structure. Major repairs will be needed if the problem is not addressed.
Severe	The condition probably poses a threat to a road crossing or other structure. The problem should be addressed to avoid larger problems in the future
Moderate	The condition does not appear to pose a threat to a road crossing or other structure but should be addressed to enhance stream integrity and the future stability of the structures.
Minor	The condition is noticeable but may not warrant repair.

Source: *Fairfax County Stream Physical Assessment Protocols*, December 2002

Trash and Dumpsites

The stream physical assessment identified eight dumpsites in the Popes Head Creek watershed. The dumpsites consisted of lawn waste such as leaves and grass, an abandoned car, tires, pallets, tree limbs and a leaking 55 gallon drum. The dumpsites were located in the stream, on the bank, or in the floodplain. The volume of trash found in the stream was not measured.

Map 2.14 Streambed Embeddedness



Stream Geomorphologic Assessment

The geomorphologic assessment of the stream channels in the Popes Head Creek Watershed was based on the conceptual incised channel evolution model (CEM) developed by Schumm et al. (1984). Based on visual observation of the channel cross section and other morphological observations of the channel segment, the CEM type was assigned for the channel segment. The CEM types are summarized in Table 2.8 The CEM type for the stream segments is shown on the stream geomorphology maps provided for each of the subwatersheds.

Table 2.8 Summary of CEM Types

CEM Type	Description
1	Stable stream banks and developed channel
2	Deep incised channel
3	Unstable stream banks and actively widening channel
4	Stream bank stabilizing and channel developing
5	Stable stream banks and widened channel

2.5.12 Fish and Benthic Macroinvertebrate Studies

To evaluate changes in the water quality in the Popes Head Creek Watershed over time, a comparison of fish and benthic macroinvertebrate data from two different studies was conducted. The intent of the data comparison is to assess whether aquatic life conditions have improved or worsened from 1976 to 2002. The first study took place in the mid-1970s and was conducted by Dr. Donald Kelso of George Mason University, as part of the Occoquan Environmental Baseline study. The second study was conducted by Fairfax County from 1999 to 2002, as part of the Stream Protection Strategy Baseline Study.

Fish and benthic data were compared from five stations in Popes Head Creek. The data used were verified to have been collected from roughly the same locations using comparable methods. Benthic data were collected at different times, primarily during spring and winter in the early study and during spring in the later study. Fish were collected primarily during spring in the earlier study and during summer in the later study. Despite the differences in collection season, the data were thought to be comparable.

The difference in fish abundance was tested using ordinal data from the two collection periods. A nonparametric test showed that fish were more abundant in the later collections at PHCC01, but not at two other stations (PHPH01 and PHPI02). However, fish diversity appears to have improved dramatically from the mid-1970s to the late 1990s/early 2000s at all four stations were there was comparable data. It is possible that this is an artifact of a different sampling technique, as electroshocking was used by the County in the later study and is possibly more efficient than the seining used in the earlier study. It is also possible that the greater apparent species diversity is an artifact of bias introduced by sampling in different seasons.

Because there were so few overlapping benthic species between the two studies, it was not possible to compare abundance between the two periods. While there does not appear to have been an overall increase in species diversity, as was observed in the fish data, there does appear to have been a subtle shift in the species assemblage. There were fewer EPT (*Ephemeroptera, Plecoptera, Trichoptera)* species present; EPT species consist of mayflies, stoneflies, and caddisflies, which are pollution intolerant and are therefore indicators of good water quality. The

data comparison also showed that there are more pollution tolerant species, including aquatic worms (*Oligocheata),* true flies (*Diptera)* and mollusks (*Mollusca)* now than in the previous study. Please see Appendix D for the full report on the comparison between fish and benthic collections.

2.5.13 Summary of Previous Studies

The previous studies conducted by Fairfax County and others agree that the Popes Head Creek Watershed is in fair to good condition. The watershed suffers from several erosion and sedimentation problems, which has impaired the benthic community. The studies recommended the use of innovative BMPs and new Low Impact Development (LID) techniques, the preservation of trees and open space, and identified the need to update the Public Facilities Manual (PFM). They also identified opportunities to educate and involve the public, as well as promote regional cooperation between agencies, citizens, and nongovernmental organizations.

2.6 Hydrologic and Hydraulic Modeling

A Stormwater Management Model (SWMM) was developed for the Popes Head Creek Watershed. Its purpose is to represent current and future watershed conditions, including flow, imperviousness, and pollutant load. For the full SWMM report, please see Appendix E.

The Popes Head Creek Watershed was divided into four basins and 58 subbasins. Impervious area for the watershed was delineated from Fairfax County's GIS coverages of buildings, roads, and parking lots; it also used Fairfax County's GIS land use coverages to evaluate future conditions within the watershed. It modeled existing and future stormwater management (SWM) facilities. The storage and outflow relationship for each SWM facility was defined as peak flows under current conditions and future land use were equal to the peak flows for the two-year and 10-year design storms under undeveloped conditions.

The fully calibrated model was used to evaluate the impact of future development within the watershed on flow rates, velocity, and water quality. Increased flows, velocity, and pollutant loadings were assessed for the three main tributaries (East Fork, Piney Branch, and Castle Creek) as well as the entire watershed. For the tributaries, reported values were taken from the mouth of the tributary before they merge with Popes Head Creek. For the entire watershed, reported values were taken from the main channel as it flows out of basin PH30. Values for peak flow, peak velocity, and pollutant loading rates under current and future conditions for these four main areas are given in Table 2.9 including the percent increase for each value.

Table 2.9 Increase in Flow, Velocity, and Pollutant Loading Rates that Result in Moving from Current to Future Land Use Conditions

	Current Conditions	Future Conditions	Percent Difference
Mouth of East Fork (EFOUT)			
Peak Flow over simulation period (cfs)	257	257	0%
Peak Velocity over simulation period (ft/s)	4.13	4.13	0%
Total Loads (tons/year)			
Biological Oxygen Demand (BOD)	12.6	13.6	8%
Chemical Oxygen Demand (COD)	76.3	82.0	7%
Total Suspended Solids (TSS)	58.6	61.7	5%
Total Dissolved Solids (TDS)	124	129	4%

	Current Conditions	Future Conditions	Percent Difference
Dissolved Phosphorus (DP)	0.117	0.125	7%
Total Phosphorus (TP)	0.346	0.365	5%
Total Kjeldahl Nitrogen (TKN)	1.756	1.888	8%
Total Nitrogen (TN)	2.937	3.113	6%
Total Cadmium (TCd)	0.001	0.001	0%
Total Copper (TCu)	0.024	0.026	8%
Total Lead (TPb)	0.004	0.004	0%
Total Zinc (TZn)	0.118	0.127	7%
Mouth of Piney Branch (PIOUT)			
Peak Flow over simulation period (cfs)	402	414	3%
Peak Velocity over simulation period (ft/s)	3.63	3.67	1%
Total Loads (tons/year)			
BOD	28.0	29.5	5%
COD	165.5	173.4	5%
TSS	88.5	93.8	6%
TDS	468	473	1%
DP	0.286	0.300	5%
TP	0.852	0.896	5%
TKN	3.989	4.163	4%
TN	6.586	6.833	4%
TCd	0.004	0.005	1%
TCu	0.042	0.044	4%
TPb	0.018	0.019	2%
TZn	0.182	0.190	4%
Mouth of Castle Creek (CCOUT)			
Peak Flow over simulation period (cfs)	271	271	0%
Peak Velocity over simulation period (ft/s)	4.26	4.26	0%
Total Loads (tons/year)			
BOD	8.2	8.7	6%
COD	49.8	52.4	5%
TSS	21.7	23.1	7%
TDS	183	185	1%
DP	0.093	0.099	6%
TP	0.270	0.287	6%
TKN	1.243	1.300	5%
TN	2.105	2.177	3%

	Current Conditions	Future Conditions	Percent Difference
TCd	0.002	0.002	2%
TCu	0.014	0.014	3%
TPb	0.008	0.008	3%
TZn	0.055	0.057	4%
Mouth of Popes Head Creek (OUT)			
Peak Flow over simulation period (cfs)	871	906	4%
Peak Velocity over simulation period (ft/s)	5.84	5.90	1%
Total Loads (tons/year)			
BOD	88.4	96.5	9%
COD	529.0	570.7	8%
TSS	281.4	313.4	11%
TDS	1,687	1,721	2%
DP	0.891	0.958	7%
TP	2.632	2.821	7%
TKN	12.988	13.961	7%
TN	22.238	23.730	7%
TCd	0.016	0.016	1%
TCu	0.151	0.163	8%
TPb	0.064	0.066	4%
TZn	0.652	0.717	10%