Cameron Run

Watershed Management Plan

Final

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Fairfax County
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Department of Public Works and Environmental Services

Prepared by

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Executive Summary

The *Cameron Run Watershed Plan* is a strategic plan that will protect and improve the condition of water resources in the watershed over the next 25 years. The watershed planning process, initiated by Fairfax County, included characterizing existing stream conditions, modeling conditions in the base year (2001) and for future years, and soliciting the participation of a watershed advisory committee and the public. The Cameron Run Watershed Advisory Committee created the following vision to guide development of the watershed plan:

> *A fishable, swimmable, and biologically diverse Cameron Run watershed that supports a safe and enjoyable environment for people and property.*

The Cameron Run Watershed Plan includes recommended policies and specific projects for mitigating adverse effects on the watershed and its streams, particularly those resulting from impervious surfaces and stormwater runoff.

BACKGROUND

The Cameron Run Watershed Plan is part of a series of planning projects initiated by Fairfax County beginning in 2002. The Cameron Run watershed encompasses 44 square miles, 33 of which are located in Fairfax County, and has a long history of urbanization. Most land within the watershed was developed by the early 1970s, and only an estimated 5 percent remains vacant today. The watershed's large proportion of impervious surface causes substantial physical consequences for streams, such as erosion, flooding, and channel alteration due to the increased volume and rate of flow of stormwater runoff. Several reaches within the watershed fail to meet water quality standards specified in Section 303d of the Clean Water Act (CWA) and, therefore, are included in the Virginia Department of Environmental Quality's list of impaired streams. Two reaches are listed because of the presence of fecal coliform bacteria and require determinations of total maximum daily loads. Two other reaches are listed because they have impaired benthic communities, and a fifth reach is listed because of the presence of both fecal coliform in the water and PCBs in fish tissue. The county's 2001 Stream Protection Strategy (SPS) Baseline Study classified Cameron Run as Watershed Restoration Level II. Primary goals in Watershed Restoration Level II areas are to prevent further degradation and to take active measures for improving water quality to support Chesapeake Bay initiatives and comply with existing water quality standards. In order to support the Chesapeake 2000 Agreement, Fairfax County is committed to developing watershed management plans for all of its watersheds.

PURPOSE

The objectives for developing the Cameron Run Watershed Plan were:

1. To apply a comprehensive approach in addressing multiple regulations, commitments, and community needs.

2. To replace the previous, out-dated watershed management plan.

3. To support Virginia's commitment to the Chesapeake 2000 Agreement.

4. To meet state and federal water quality standards.

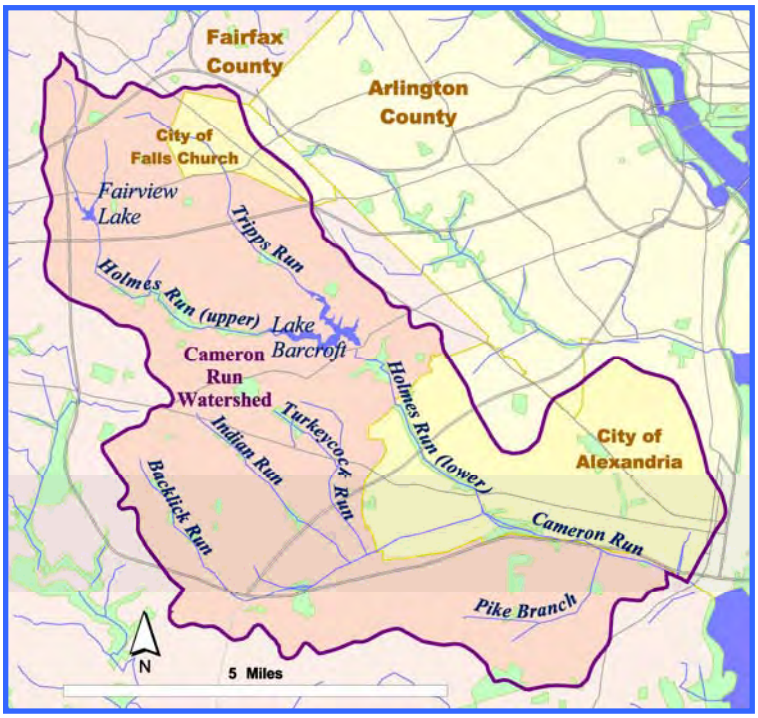
This watershed plan addresses these objectives with a strategy for restoring and protecting the watershed.

The plan was developed with input from the Cameron Run Watershed Advisory Committee and other members of the community. The Advisory Committee comprised members of the local community who represented the views and concerns of various interest groups, including environmental organizations, businesses, and homeowners. The Committee met with the Project Team regularly over 18 months to provide valuable local input and feedback. This public involvement process helped to ensure that the watershed plan will meet the specific needs and desires of residents of Cameron Run watershed.

The developers of this plan recognized that many parcels in older neighborhoods across the county are undergoing "mansionization," as smaller dwellings are replaced with substantially larger structures. Although mansionization is likely to affect stormwater runoff and water quality, this plan does not address that issue directly because the county intends to examine the issue comprehensively in the future.

WATERSHED CONDITION

Today, the mainstem Cameron Run is a flood-control channel whose surrounding area is characterized by medium- to high-density urban development. The Cameron Run watershed encompasses some of the oldest and most highly developed areas in Fairfax County. Nearly 95% of the watershed is developed with homes, strip malls, commercial enterprises, and extensive roadway systems that were built before the advent of modern stormwater management facilities for controlling the quantity and quality of runoff. The effects of this development are evident throughout the watershed. The historic floodplain of lower Cameron Run is primarily a



Map of Cameron Run watershed

transportation corridor throughout which the Capitol Beltway parallels the stream channel. Industrial, commercial, and residential areas have replaced the wetlands and forests that once attenuated floodwaters. Only small remnants of wetlands remain in the watershed. Sections of the Cameron Run mainstem and Holmes Run were channelized to remove floodwaters quickly from developed areas. The poor quality of water within the channels illustrates the effects of these alterations.

Non-point source pollution and urban stormwater runoff greatly affect the health of this watershed. According to the 2001 SPS Baseline Study, the Cameron Run mainstem and its tributaries "have substantially degraded biological and habitat integrity." The SPS study listed Cameron Run as a Watershed Restoration Level II watershed, characterized by dense development, significantly degraded in-stream habitat conditions, and substantially degraded biological communities. Based on the Stream Physical Assessment (SPA) study, the Cameron Run watershed has few adequate riparian buffers. In addition, the watershed has more than five discharge pipes and ditches per mile and a large number of points at which public utility lines and roadways cross over streams. Erosion and instability of stream banks is widespread throughout the watershed, and illegal trash dump sites are common.

PLAN GOALS AND OBJECTIVES

Drawing on knowledge of the ultimate causes and proximate stresses affecting the watershed, the Project Team and Advisory Committee developed the following goals and objectives that are consistent with the vision defined for Cameron Run:

Goal A: Reduce the effects of stormwater runoff from impervious areas to help restore and protect streams within the Cameron Run watershed

Objective A1: Increase the effectiveness of existing Best Management Practices (BMPs) by improving maintenance or "retrofitting" them to further reduce the effects of impervious areas (altered flows and poor water quality).

Objective A2: Install new BMP and Low Impact Development (LID) facilities in areas that do not have existing stormwater management controls.

Objective A3: Require (1) reduction of the rate and volume of runoff following the development of new commercial and residential sites to the minimum possible levels and (2) reduction of post-development runoff at redevelopment sites by targeted percentages from the pre-development rate and volume.

Objective A4: Increase the participation of residents in decreasing the amount of stormwater runoff from impervious surfaces in residential areas.

Objective A5: Reduce the effects of stormwater runoff from existing and proposed roadways by instituting new countywide watershed management requirements.

Goal B: Preserve, maintain, and improve watershed habitats to support appropriate native flora and fauna

Objective B1: Preserve, restore, and manage riparian buffers to benefit appropriate native flora and fauna (and reduce the effects of stormwater runoff).

Objective B2: Preserve, restore, and manage habitat in streams and on stream banks to benefit appropriate native flora and fauna (and water quality).

Objective B3: Preserve, restore, and manage wetlands to benefit appropriate native flora and fauna.

Goal C: Preserve, maintain, and improve water quality within streams to benefit humans and aquatic life

Objective C1: Reduce and mitigate the effects of bank erosion and sedimentation.

Objective C2: Reduce the amount of pollutants such as fecal coliform, phosphorous, and nitrogen in stormwater runoff.

Objective C3: Reduce the amount of trash and number of dumping sites in the watershed to help protect and improve the streams.

Goal D: Improve stream-based quality of life and environmentally friendly recreational opportunities for residents of and visitors to Cameron Run watershed

Objective D1: Create additional access and trails for stream-based recreational opportunities in the watershed.

Objective D2: Increase public awareness and appreciation of streams in the watershed.

POLICY RECOMMENDATIONS

Policy recommendations address the goals and objectives stated above and include proposals that typically would involve amending the County Code and other supporting documents, such as the Public Facilities Manual. These recommendations are part of a series being developed during the first round of watershed planning, and several are in various stages of implementation. The county will undertake a separate effort to combine and refine policy recommendations stemming from the plans. Recommendations developed as part of the Cameron Run Watershed Plan are as follows:

Goal A

- Change the inspection and assessment protocols for stormwater controls.
- Amend inspection and maintenance ordinances for privately owned controls.
- Update the county's list of recommended BMPs.
- Retrofit existing facilities.
- Enact new policy to require on-site water retention for all land-disturbance projects.
- Avoid granting water quality waivers for non-bonded lots that exceed 18% imperviousness.
- Install new BMP and LID facilities for properties without stormwater controls.
- Increase fines for noncompliance with BMP or LID requirements.
- Coordinate stormwater management activities with neighboring jurisdictions, including annual reviews.
- Require 10% net decrease in runoff on commercial and residential redevelopment.
- Amend zoning regulations to promote smarter development and better design.
- Provide incentives for developers to use conservation design and LID to reduce runoff.
- Limit removal of mature trees and native vegetation in any development or renovation.
- Conduct frequent inspections to ensure compliance with permit conditions regarding landscaping and stormwater runoff requirements.
- Allocate sufficient funding for inspection and enforcement
- Facilitate technical assistance and financial incentives for residential LID practices in headwater areas.
- Involve the public in watershed planning from initial conception through implementation.
- Require road-widening projects to control runoff from all paved areas and reduce existing peak runoff by 5%.
- Replace grasses on medians and sides of roadway with native trees and vegetation where possible.

Goal B

- Plant buffers using native vegetation and trees, and monitor those buffers for 5 years.
- Provide additional personnel and resources for protecting buffers in Resource Protection Areas (RPAs), and ensure adequate training.
- Require restoration of buffers at developments within RPAs and mandate the use of native vegetation mixes for restoration.

- Provide educational assistance regarding buffers to owners of properties with tidal shorelines or streams.
- Amend ordinance to expand woodlands and survey existing trees, and amend requirements for builders to protect existing trees.
- Determine current level of mature tree canopy, and establish a reforestation goal.
- Monitor and report on stream condition by performing stream physical assessments.
- Facilitate acquisition/donation of easements to community groups for buffer/stream protection.
- Install natural and water-conserving landscaping at county facilities.
- Educate property owners about steps for improving water quality in their streams.
- Perform wetlands functions-and-values survey to identify characteristics of existing wetlands.
- Construct and restore wetlands at suitable locations as identified in wetlands survey.
- Purchase, designate, and acquire land for conservation of critical wetland habitat areas.
- Provide outreach materials describing the value and benefit of wetlands and identifying which permits are required for wetland activities.
- Discourage further development within native wetlands, and require mitigation when adverse effects are unavoidable.

Goal C

- Increase personnel and resources to inspect development projects regarding erosion and sediment controls.
- Encourage the development community to use bioengineering to stabilize streambanks and improve habitat.
- Reduce the amount of de-icing chemicals and sand entering surface waters of the watershed.
- Identify sources of fecal coliform in the watershed and prepare an action plan to reduce it.
- Perform additional water quality monitoring including surveys of macroinvertebrates and aquatic plants.
- Identify, investigate, and prosecute illicit discharges from commercial and residential activities.
- Educate the public about ways to reduce pollutants in stormwater runoff.
- Create a "green label" program for lawn-care and landscaping companies that use environmentally sound techniques.

- Strengthen enforcement of "pooper scooper" regulation and institute $100 fine for violators.
- Partner to clean up trash, woody debris, and dumpsites throughout watershed.
- Conduct a vigorous public information campaign to deter littering and dumping.
- Place containers at public facilities for recycling along with signs requesting sorting of recyclables and stating the fines for littering.
- Enforce solid waste and erosion and sediment control ordinances against illegal dumping; impose fines, and require restoration of dumping sites.

Goal D

- Identify stream corridors that could be purchased to increase public access to streams and environmentally friendly recreation.
- Develop a master plan for environmentally friendly recreation opportunities in Cameron Run.
- Post signage publicizing the existence and importance of RPAs for stream protection and recreation.
- Install signage explaining benefits of LID and identify sources for further information.
- Conduct a study to determine the most effective program of public education for watershed stewardship.

RECOMMENDED PROJECTS

The proposed projects for the Cameron Run Watershed Plan are based on analyses performed by the Project Team with contributions from the Advisory Committee and the public. The projects were selected to help meet the goals and objectives stated above. The projects recommended in the plan fall into the following four categories:

- **Low Impact Development (LID)** – LID approaches are innovative practices designed to mimic natural flows by reducing the volume of stormwater runoff at the source, not merely by managing flows as they leave a site. Distributed LID involves a series of small landscape features that function as detention areas within a developed area. These features are designed and constructed to detain and treat stormwater through natural processes such as infiltration, soil storage, and uptake by vegetation. In addition to being incorporated into planning for new development, these solutions are being used increasingly to reduce the effects of stormwater runoff and other adverse influences on the environment in previously developed areas.
- **New Storm Water Management (SWM) ponds** – Placing new stormwater management ponds, including small, extended-detention dry ponds, in locations that currently have no mechanisms for controlling the quantity and quality of stormwater runoff.

- **SWM pond retrofits** – Modifying existing SWM ponds to provide additional quantity or quality controls.
- **Stream restoration** – Modifying stream channels, banks, and instream habitat to improve degraded and unstable conditions.

Projects were separated into the following three groups to help define priorities among the approximately 650 opportunities for watershed improvements identified during this study:

- **Tier 1** – Projects that represent the best opportunities for the county's efforts because they are located on public lands and were selected using SWMD's prioritization framework in rough proportion to the amount of uncontrolled impervious surface within the subwatershed.
- **Tier 2** – Sites representing lower-priority projects on public land, or sites on private lands that present good opportunities and have received various levels of support from Advisory Committee members or the general public.
- **Tier 3** – The rest of the sites identified during the initial map review and public involvement process.

The plan focuses on the Tier 1 projects because they represent the best opportunities for the county to implement watershed improvements. The Tier 2 and Tier 3 sites also present good opportunities, particularly if they can be implemented through the development-review process or other means. Information on individual projects is included in Appendix A, including site-specific factsheets for each Tier 1 project, and tables containing descriptive information for Tier 2 and Tier 3 projects.

In a supplemental effort, drainage complaints filed with the Fairfax County's Maintenance and Stormwater Management Division were used to help identify areas with problems related to stormwater drainage, flooding, and streambank erosion. These records provided an initial list of 70 candidate drainage projects. The best opportunities to address drainage problems were selected from the candidates using a ranking process. The 25 drainage projects selected by the ranking process include 21 projects that address localized flooding issues and four projects that address localized streambank erosion in residential backyards. Recommended actions to help alleviate problems at the 25 selected drainage projects are described in project fact sheets found in Appendix A-4.

The breakdown of all projects by project type and tier is shown below.

Project Type	Tier 1	Tier 2	Tier 3	Total
New SWM Pond	1	1	-	2
SWM Pond Retrofit	15	5	78	98
LID	77	54	306	437
Stream Restoration	4	32	2	38
Non-structural Projects & Special Studies	3	-	21	24
Drainage Complaint Projects	25	-	-	-
Total	125	92	407	624

BENEFITS OF THE PLAN

The Cameron Run Watershed Plan provides a set of tools for communities to go beyond minimum regulatory requirements. These tools can be used to help communities ensure the protection of water resources, the reduction of streambank erosion, and the restoration of fish and wildlife habitat. They will also help to meet commitments under the Chesapeake 2000 Agreement, which include the following:

- State signatories will work with local governments, community groups, and watershed organizations to develop and implement locally supported watershed management plans in two-thirds of the bay's watershed.
- Local watershed management plans will address the protection, conservation, and restoration of stream corridors, riparian buffers, and wetlands for the purpose of improving habitat and water quality.

Implementing the recommended policy amendments and projects will provide a range of benefits for the Cameron Run watershed. Policies that are implemented countywide in conjunction with other watershed management plans will be more efficient and should result in improved environmental conditions throughout Fairfax County and the surrounding region. Because these policy recommendations are non-structural, it will be difficult to measure their benefits quantitatively. Generally, the policy recommendations will help to improve the enforcement of existing regulations and laws and to provide additional protection for areas that are environmentally valuable but not necessarily located within an RPA. Instituting programmatic solutions is one of the best ways to deal with the cumulative adverse effects of distributed influences, such as stormwater.

Cameron Run is the most heavily urbanized watershed in the county: impervious surface in every subwatershed exceeds the 10% to 15% threshold considered the minimum for good stream conditions. Most of the development in the watershed occurred before stormwater controls were required; therefore, reducing the effects of stormwater runoff created by uncontrolled impervious surface is the most important benefit that can be achieved through this plan. Each project included in the plan will provide a degree of control for the effects of stormwater runoff. Both the quantity (i.e., reduction in average peak flows) and the quality (i.e., reduction in pollutant loading) of the runoff will be improved .

Model-based estimates of the benefits of the projects indicate that the proposed actions in the Cameron Run Watershed Management Plan will reduce pollutant loadings throughout the Fairfax County portion of the watershed. The model of future conditions with proposed projects shows a 4.9% decrease in total suspended solids, a 3.8% decrease in total phosphorus, and a 3.6% decrease in total nitrogen loads for the entire Cameron Run watershed. The modeled decreases in pollutant loading seem small because the watershed is highly developed, and opportunities for BMPs are limited in many areas. These model-based estimates can be used to evaluate the Plan's contributions to meeting water quality standards (e.g., TMDL implementation) and Chesapeake Bay Tributary goals.

The selected restoration projects will improve habitat and water quality within streams. To quantify the benefits of the proposed stream restoration projects, the U.S. Army Corps of Engineers stream condition index (SCI) rating was applied to determine the increase in stream habitat quality and reduction in erosion and sediment loss. Restoration is anticipated to improve SCI ratings for each project site, resulting in an 11% to 17 % increase in SCI rating among the sites. The stream restoration projects in the plan will improve a number of stream miles from one condition class to another (e.g., very poor habitat to fair habitat); therefore, increases can be expected in the abundance and diversity of stream life in those areas.

PLAN TOTAL COST

The 25-year estimated funding requirements for all the structural and non-structural recommended actions is $47.4 million. The breakdown of funding requirements for each 5-year period of the plan is shown below. Estimated costs included in this plan represent actual costs that, in some cases, may be off-set through the use of existing staff resources, in-kind services, cost-share programs, donated materials, volunteer labor, and other means.

The policy recommendations of this plan will require further evaluation in light of greater countywide implications. The current approach for processing policy recommendations is to consolidate them with similar recommendations included in management plans for other watersheds in the county.

Funding Requirements	
Implementation Period	**Estimated Funding Requirements**
Group A: Fiscal Year 2007 – 2011	$11,468,000
Group B: Fiscal Year 2012 – 2016	$9,174,000
Group C: Fiscal Year 2017 – 2021	$8,840,000
Group D: Fiscal Year 2022 – 2026	$10,028,000
Group E: Fiscal Year 2027 – 2031	$6,833,000
Drainage Complaint Projects: Fiscal Year 2007 – 2011	$1,059,000
Total	$47,402,000

Although this plan proposes a schedule for implementing recommended actions, additional factors may affect the individual projects and the implementation schedule:

1. Members of the county's staff and the Fairfax County Board of Supervisors (Board) will review the projects, programs (both structural and non-structural), and policy recommendations in this plan prior to implementation. The Board's adoption of the Watershed Management Plan will not ensure automatic implementation of projects, programs, initiatives, or policy recommendations that have not first been subjected to sufficient scrutiny to determine if they will provide the greatest environmental benefit for the cost.

2. The Watershed Management Plan provides a conceptual master-list of structural capital projects and a list of potential non-structural projects for the watershed. Each fiscal year, the county's staff will prepare and submit to the Board a detailed spending plan that includes a description of proposed projects and an explanation of their ranking, based on specific criteria that have yet to be established. Criteria used to assemble this list will include, but are not limited to, cost-effectiveness as compared to alternative projects, a clear public benefit, a need to protect public or private lands from erosion or flooding, a need to meet a specific goal for the watershed or for water quality, and the project's ability to be implemented within the same fiscal year that funding is provided. The staff also intends to track the progress of implementation and report back to the Board periodically.
3. Each project on the annual list of structural projects will be evaluated before implementation using basic value-engineering, cost-effectiveness principles and considering alternative structural and non-structural means for accomplishing the purposes of the project.
4. Obstruction removal projects on private lands will be evaluated on a case-by-case basis for referral to the Zoning Administrator and/or County Attorney for action as public nuisances. These projects will also be evaluated to determine appropriate cost-sharing by any parties responsible for the obstructions.
5. Any stream-crossing improvements not related to protecting streambeds or banks or to preventing structure flooding will not be implemented using the county's stormwater improvement funds.
6. Stream restoration projects on private lands will be evaluated to determine means for cost-sharing by landowners who are directly responsible for degradation resulting from their land uses.

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Chapter 1
Introduction

1.1 BACKGROUND

In 2001, a baseline evaluation found that 77 percent of Fairfax County's streams were in fair, poor, or very poor condition. The county is currently developing watershed management plans to restore and protect these streams. Watershed planning helps the county look at the whole "water system" in order to better manage these resources. A watershed management plan serves as a tool to identify pollution sources and develop strategies to address them. It also provides goals and objectives for achieving management actions (e.g., restore water quality, reduce flood frequency, improve fish and wildlife habitats) and recommends actions to mitigate or prevent watershed problems.

Fairfax County's watersheds (Figure 1-1) drain into the Potomac River and eventually into the Chesapeake Bay; currently the bay does not meet federal water quality standards. Virginia has signed agreements with other states and federal agencies to work toward restoring the Chesapeake Bay. The latest agreement, Chesapeake 2000, includes the goal of developing watershed plans for two thirds of the bay's watershed by 2010. In order to meet this goal, Virginia has encouraged Fairfax County and other jurisdictions to develop plans for cleaning up their watersheds.

The federal Clean Water Act and Virginia laws require Fairfax County to meet water quality standards for surface streams and groundwater. The county's stormwater permit, called a Virginia Pollution Discharge Elimination System (VPDES) permit, requires the county to develop watershed management plans to address water quality problems. In order to meet state and federal water quality standards, the county's watershed plans will identify strategies to prevent and remove stream pollution. Typically, nutrients such as phosphorus and nitrogen are the most damaging pollutants found in stormwater runoff. Other common pollutants found in runoff include oil, dirt, and trash.

Watershed planning is a way to identify the causes of these problems and then to address them in an integrated fashion. Growth in the county over the last 50 years has resulted in eroded stream channels and, in some cases, impaired waters. As the 1970s-era watershed plans have aged, many newer drainage problems have been addressed on a piecemeal, reactive basis. The county's 25-year old watershed plans are out-of-date and need to be replaced to meet new water quality standards using innovative technologies. The watershed plans currently being developed will propose effective, state-of-the-art solutions for the next 25 years.

Multiple environmental regulations, commitments, and community needs can be addressed comprehensively through the watershed planning process. Because all land surfaces and all land uses are united within a watershed, the watershed planning process provides an opportunity to integrate planning, zoning, and other management strategies in a comprehensive approach to reducing and preventing pollution. Integrated solutions will achieve the broadest range of goals with the greatest efficiency and at the lowest cost. A stream that is clean provides abundant and healthful habitat for fish, wildlife, and people.

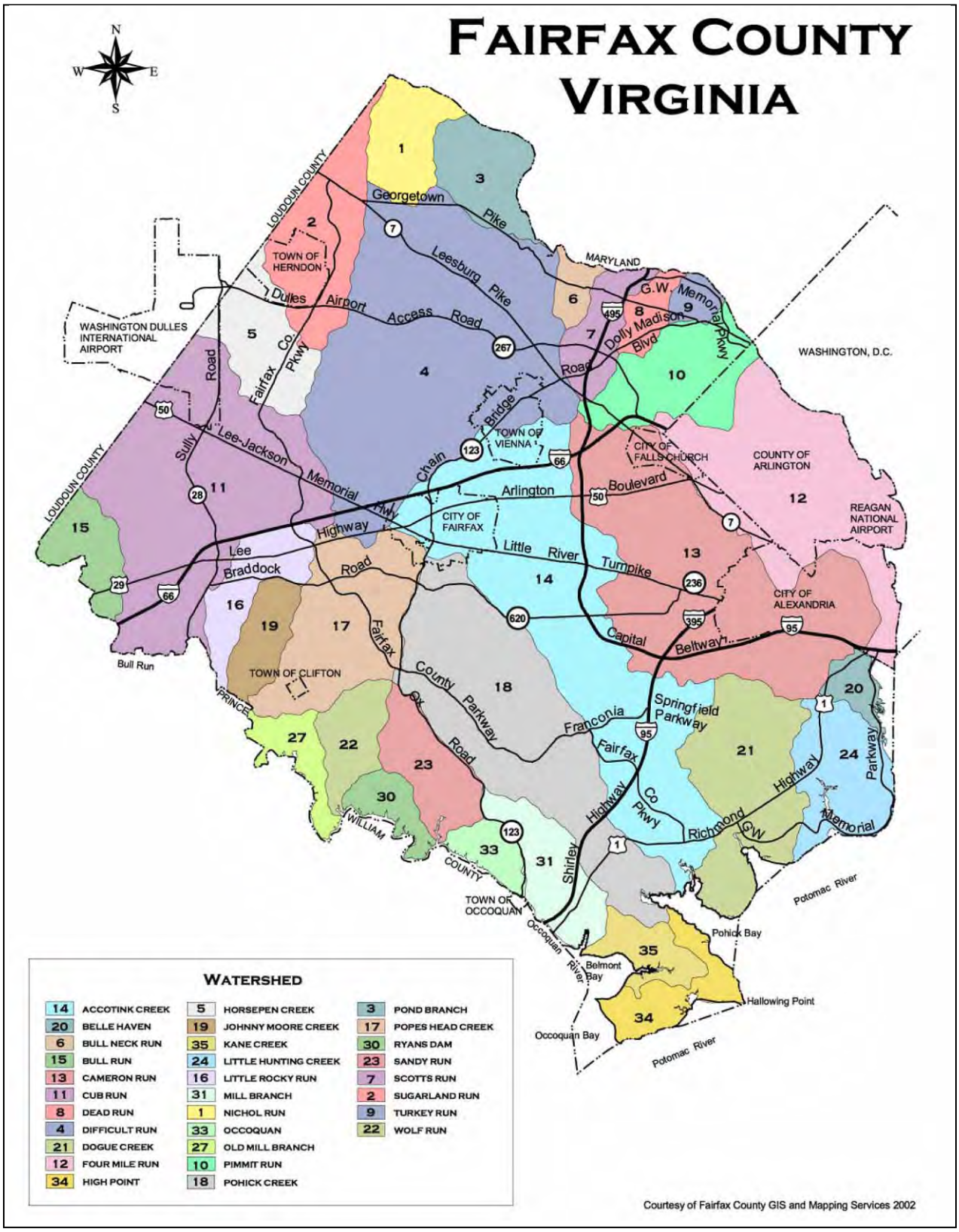


Figure 1-1. Watersheds within Fairfax County, VA

The Cameron Run watershed encompasses 44 square miles, 33 of which are located in Fairfax County. The watershed has a long history of urbanization; most of the land within it was developed by the early 1970s, and only 5 percent remains vacant today. The watershed has a large proportion of impervious surface that has contributed to substantial physical effects, such as erosion, flooding, and channel alteration. Several reaches within the watershed fail to meet water quality standards specified in Section 303d of the Clean Water Act (CWA) and, therefore, are included in the Virginia Department of Environmental Quality's list of impaired streams. Two reaches are listed because of the presence of fecal coliform bacteria and require determinations of total maximum daily loads. Two other reaches are listed because they have impaired benthic communities, and a fifth reach is listed because of the presence of both fecal coliform in the water and PCBs in fish tissue. The county's 2001 Stream Protection Strategy (SPS) Baseline Study classified Cameron Run as Watershed Restoration Level II. Primary goals in Watershed Restoration Level II areas are to prevent further degradation and to take active measures for improving water quality to support Chesapeake Bay initiatives and comply with existing water quality standards. In order to support the Chesapeake 2000 Agreement, Fairfax County is committed to developing watershed management plans for all of its watersheds.

1.2 PURPOSE OF PLAN

Cameron Run watershed has experienced environmental degradation, primarily as a result of urban and suburban development. The Fairfax County government initiated a planning process to improve the quality of Cameron Run, its tributaries, and its watershed. An Advisory Committee and the Cameron Run Watershed Plan Project Team, which consists of members of Fairfax County's staff, its contractor, Versar, Inc., and members of the community, worked together to produce the Cameron Run Watershed Plan. It accomplishes the following:

- acts as a tool for evaluating, assessing, and managing the watershed
- provides goals and objectives for improving the watershed (e.g., to restore water quality, reduce flood frequency, improve fish and wildlife habitats)
- recommends actions to achieve these goals and prevent or mitigate watershed problems
- provides a benchmark for measuring the plan's success

This planning effort is one of five concurrent watershed planning projects undertaken by Fairfax County that used similar data and standardized methods to facilitate consistent planning across the county. Together the Advisory Committee and Project Team reviewed existing reports and studies to describe the current status of the watershed and to highlight key issues of concern. They relied heavily upon readily available data about land use (2003) and imperviousness (1997), and other electronic data available at the outset of the project, which served as the study's base year. Although the Advisory Committee and Project Team recognize that many parcels in older neighborhoods across the county are undergoing "mansionization" (i.e., the replacement of smaller dwellings with substantially larger structures), this plan does not address the effects of mansionization on stormwater runoff and water quality in the Cameron Run

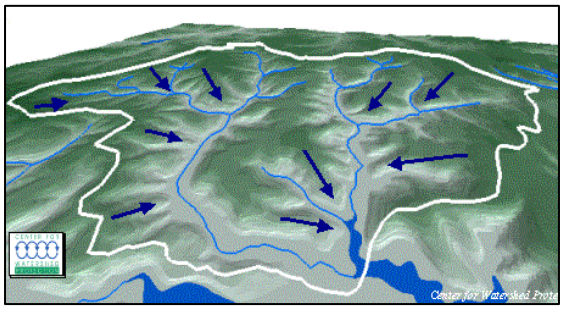
watershed. The county intends to examine that issue comprehensively in the future. Computer modeling was used to identify flooding, channel erosion, water quality problems, and other factors affecting the quality of the ecosystem of Cameron Run watershed. Modeling also was used to assess present conditions and predict conditions after the addition of Best Management Practices (BMPs) to assist in identifying and selecting cost-effective BMPs that could provide the greatest improvement in stream water quality. The Project Team used these results to develop recommendations for capital improvement projects and non-structural management strategies. The Cameron Run Watershed Plan is the result of this holistic planning process.

Although this plan proposes a schedule for implementing recommended actions, additional factors may affect the individual projects and the implementation schedule:

1. Members of the county's staff and the Fairfax County Board of Supervisors (Board) will review the projects, programs (both structural and non-structural), and policy recommendations in this plan prior to implementation. The Board's adoption of the Watershed Management Plan will not ensure automatic implementation of projects, programs, initiatives, or policy recommendations that have not first been subjected to sufficient scrutiny to determine if they will provide the greatest environmental benefit for the cost.
2. The Watershed Management Plan provides a conceptual master-list of structural capital projects and a list of potential non-structural projects for the watershed. Each fiscal year, the county's staff will prepare and submit to the Board a detailed spending plan that includes a description of proposed projects and an explanation of their ranking, based on specific criteria that have yet to be established. Criteria used to assemble this list will include, but are not limited to, cost-effectiveness as compared to alternative projects, a clear public benefit, a need to protect public or private lands from erosion or flooding, a need to meet a specific goal for the watershed or for water quality, and the project's ability to be implemented within the same fiscal year that funding is provided. The staff also intends to track the progress of implementation and report back to the Board periodically.
3. Each project on the annual list of structural projects will be evaluated before implementation using basic value-engineering, cost-effectiveness principles and considering alternative structural and non-structural means for accomplishing the purposes of the project.
4. Obstruction removal projects on private lands will be evaluated on a case-by-case basis for referral to the Zoning Administrator and/or County Attorney for action as public nuisances. These projects will also be evaluated to determine appropriate cost-sharing by any parties responsible for the obstructions.
5. Any stream-crossing improvements not related to protecting streambeds or banks or to preventing structure flooding will not be implemented using the county's stormwater improvement funds.
6. Stream restoration projects on private lands will be evaluated to determine means for cost-sharing by landowners who are directly responsible for degradation resulting from their land uses.

1.2.1 Watershed Planning

A watershed can be defined as the land that drains to a particular point along a stream; therefore, each stream has its own watershed. The boundary of a watershed is defined by the highest elevations surrounding the stream, such as mountains. Everyone lives in a watershed, as all land drains to a stream or other waterbody. Watersheds encompassing more than one stream can be broken down into smaller geographic units called subwatersheds. A watershed plan tracks the planning and management within these individual subwatersheds. The Cameron Run watershed has 8 subwatersheds that encompass approximately 44 square miles.



Land draining to a stream forms a watershed

A watershed plan is the best way to protect watersheds. Watershed plans assess current stream conditions and outline strategies to maintain or restore desired conditions. They can be used to direct proposed development to the least sensitive areas or to attempt to control the impervious cover in a watershed as a means of achieving the watershed quality desired by a community. The land and tributaries within a watershed should be considered as a unit for environmental planning. The health of the aquatic communities in the watershed's rivers, lakes, and wetlands can be used to monitor progress in watershed planning.

Protecting and restoring watersheds can provide a variety of benefits depending on the community's goals. A local planning process should be used to develop the plan's unique goals and objectives. For example, a plan may define goals to restore water quality, reduce the frequency of flooding, and improve habitat for fish and wildlife. A watershed plan provides an opportunity to develop targeted strategies and land planning efforts to achieve these goals.

1.2.2 Benefits of Watershed Plans

Effective local planning for watershed management provides a set of tools for communities to go beyond minimum regulatory requirements. Plans can help communities to protect their supplies of surfacewater and groundwater, maintain the quality of their of drinking water , reduce stream-bank erosion, and restore habitat for fish and wildlife habitat. Plans will also help local governments to meet commitments under the Chesapeake 2000 Agreement, which include the following:

- State signatories will work with local governments, community groups, and watershed organizations to develop and implement locally supported watershed management plans in two-thirds of the bay's watershed.
- Local watershed management plans will address the protection, conservation, and restoration of stream corridors, riparian buffers, and wetlands for the purpose of improving habitat and water quality.

Watershed plans can incorporate a community's other goals and related outcomes, such as providing access to rivers or lakes at appropriate locations, protecting current or future water

supplies, protecting cultural and historic resources, protecting threatened or endangered species, or providing greenway parks along rivers. Ultimately, an effective watershed plan should lead to healthy streams with diverse aquatic life, stable streambanks, vibrant native vegetation, adequate floodplains, and vegetated buffer areas that reduce flooding and provide recreational opportunities.

1.2.3 Components of an Effective Planning Process

Several key components are shared by all effective watershed plans. A watershed planning process should

- establish the watershed as the management framework;
- identify key stakeholders within the watershed community, define stakeholder roles and responsibilities, and provide a clear participation process;
- assess the current state of the watershed and identify critical issues of concern;
- establish a collective vision for the watershed based on community input;
- set a clear strategy that addresses goals, objectives, action plans, funding, timeframes, and evaluation; and
- provide a process for using and applying the watershed plan and for adapting it as needed over time.

Including these components in the watershed planning process will ensure that the plan results in a comprehensive approach to watershed management that meets the community's needs.

From the outset, effective watershed planning must also account for future trends in land use. Watersheds are dynamic systems and exist within a changing landscape. Unless the watershed lies within a stable land-use pattern, changes in land use, such as new residential and commercial developments, will affect a watershed's hydrology, habitat, wildlife, and water quality. As a result, planning efforts should consider the potential effects of future development scenarios. For example, if every land parcel were developed to its maximum allowed density, would the amount of impervious cover increase to the extent that watershed protection goals for the next decade could not be met?

Based on assessments of future land-use trends, it may be necessary to modify the comprehensive plan goals and zoning regulations. For instance, stream valley wetlands may need to be set aside for protection, or sensitive headwater areas may need to be rezoned to permit less intensive land development. Already developed parcels may be redesignated to provide pollution prevention and mitigation measures, such as planting vegetation to trap and break down pollutants.

A watershed plan is not a static document, but rather a living process that sets goals and steps for better management of the watershed on a daily basis. To ensure that the plan's goals are

achieved, the watershed plan should include a method for evaluating the plan's overall implementation and for changing the plan as needed.

1.3 PLAN ORGANIZATION

The Cameron Run Watershed Management Plan integrates environmental management, natural resource protection, and community goals to improve the watershed. The watershed plan chapters contain the following information:

Chapter 1	Background, purpose, and plan organization
Chapter 2	General overview of the watershed, including the history of Cameron Run, a summary of existing reports and data sources, and issues in the watershed
Chapter 3	Summary of how Cameron Run watershed was assessed through stream characterization methods, modeling, and public involvement
Chapter 4	Current state of Cameron Run and its subwatersheds: Tripps Run, Upper Holmes Run, Lower Holmes Run, Turkeycock Run, Indian Run, Backlick Run, Pike Branch, and Cameron Run mainstem and direct tributaries
Chapter 5	Summary of the watershed management plan development process, including methods used to integrate and consolidate information, potential solutions, public involvement, and steps to identify and present solutions
Chapter 6	Cameron Run Watershed Plan: vision, goals and objectives, policy actions, land use actions, programmatic actions, project actions, actions summary, implementation tracks, and benefits summary
References	
Glossary	
Appendix A	Project fact sheets for Tier I projects (organized by stormwater management ponds, low impact development, and stream restoration), tables and maps of Tier II and Tier III projects, and project fact sheets for Group I Drainage Complaint Projects
Appendix B	Modeling Report
Appendix C	Public Involvement Minutes (including the minutes of Advisory Committee meetings and public meetings)

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Chapter 2
Overview of the Cameron Run Watershed

2.1 WHAT IS THE CAMERON RUN WATERSHED?

The Cameron Run watershed drains a 44-square-mile section of Northern Virginia. Thirty-three square miles of this area lie within the jurisdiction of Fairfax County; the remaining area lies within the cities of Falls Church and Alexandria (Figure 2-1). The western part of the watershed is within the Piedmont physiographic province (i.e., just west of the fall line); the eastern part is in the Coastal Plain. The Piedmont is an area of very old crystalline rocks underlying rolling hills. The Coastal Plain is characterized by a recent series of unconsolidated sedimentary strata (sands) typified by flat lands. Holmes Run is the primary headwater stream of the Cameron Run watershed. The headwaters of Holmes Run lie near the junction of the Capital Beltway (I-495) and I-66, approximately 1.5 miles west of the city of Falls Church. Flowing south and east, Holmes Run drains a portion of the area between Tyson's Corner and the cities of Vienna and Falls Church. The stream crosses beneath four major highways before flowing into Lake Barcroft. Lake Barcroft is located at the confluence of Holmes Run and Tripps Run. Tripps Run drains the southeastern half of the city of Falls Church. Other major tributaries of Cameron Run are Backlick Run, Indian Run, and Pike Branch. Lake Barcroft (137 acres), Fairview Lake (15 acres), and four regional ponds are major waterbodies within the watershed.

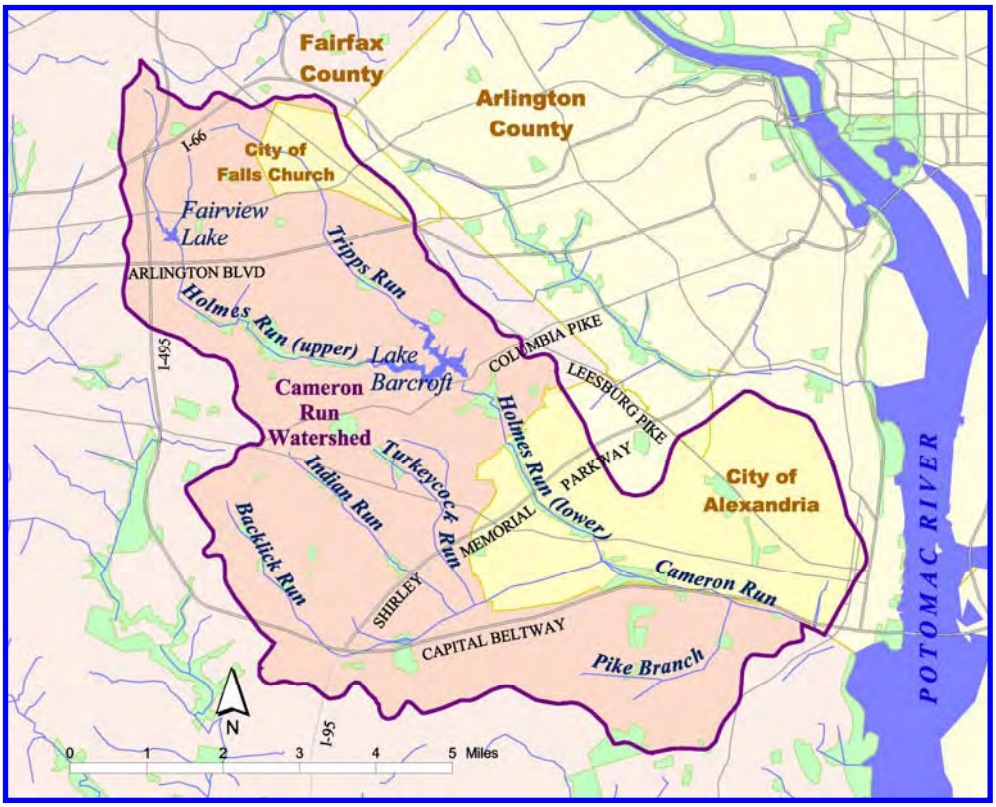


Figure 2-1. Cameron Run watershed

Approximately four miles southeast of Lake Barcroft, Holmes Run meets Backlick Run. Backlick Run and its two major tributaries, Turkeycock Run and Indian Run, drain the south-western portion of the watershed. This area makes up approximately one-third of the watershed and is characterized as a high-density residential area. The headwaters of Backlick Run are located in Annandale and flow in a northeasterly direction to the city of Alexandria, where Backlick Run meets Holmes Run. At the confluence of Backlick Run and Holmes Run the name of the mainstem changes to Cameron Run. In Alexandria, Cameron Run drains the southern and western portions of the city, except areas of Old Town that drain directly to the Potomac River. Cameron Run continues to flow in a southeasterly direction past the point at which Pikes Branch connects with the mainstem. The name of the mainstem changes to Hunting Creek before it reaches the Potomac River.

2.2 HISTORY OF CAMERON RUN WATERSHED

The Cameron Run watershed, like all of eastern North America, was nearly completely forested before the period of human settlement. Until the mid 1600s, the high density of beaver dams and ponds provided a chain of wetlands and ponds that controlled the surfacewater and groundwater in the stream valleys and provided habitat for a wide variety of flora and fauna. Three major plant associations were present in this area. In the northwestern Piedmont part of the watershed, the forest was composed of oaks and hickories. Tripps Run, Lake Barcroft, and much of the Holmes Run and Backlick Run stream corridors are located in the Piedmont. In the southeastern Coastal Plain part, the forest was composed of oaks and pines; in between these areas (i.e., near the fall line) grew American beech forests. Most of the city of Alexandria lies within the Coastal Plain. The Native Americans that lived in this watershed cleared forests and planted crops along the Potomac River. They also hunted game animals in the inland regions, trapped fish, and collected freshwater mussels. When the European settlers arrived, they purchased meat, hides, and crops from the Native Americans. From 1630 to 1650, Europeans hired local Native Americans to trap beaver for pelts. The killings essentially exterminated all beaver, causing the dams to deteriorate and changing the hydrology and ecosystem of the stream valley. As the forest was converted to agriculture, habitats were altered, and many animals disappeared. Around 1723, farms were established that cultivated tobacco, wheat, and corn. In 1850, railroad construction began in the watershed. The first settlement in the watershed was Falls Church in 1699, which became a township in 1875. Fairfax County was formally created in 1742; Alexandria was incorporated in 1779 and became a city in 1852 (Parsons Brinckerhoff 1974).

At the turn of the 20th century, the growth of the federal government in Washington, D.C., expanded into the watershed. Falls Church, Alexandria, and Arlington developed first, and the first subdivision was built by 1891 (Gernand and Netherton 2000). With the development of the watershed came necessary infrastructure such as reservoirs and sewers. Lake Barcroft was created in 1915. The city of Alexandria's increasing need for water led the Alexandria Water Company to build the dam and establish a reservoir to store water from the branches of Holmes Run. In the late 1940s, the reservoir became too small to serve the growing population of Alexandria, and other water sources replaced it. The first sewer lines ran from Falls Church to the Potomac, along Tripps Run, Holmes Run, and Cameron Run. These sewer lines dumped raw sewage into the Potomac until 1954.

By the end of the 1950s, residential subdivisions covered the northern half of the watershed, and by 1965, most land suitable for development had been built upon. By the 1970s, growth around the watershed was directly attributable to the expansion of federal employment and the growth of service industries that assisted that expansion. Private economic interests also contributed to unprecedented commercial growth in Fairfax County.

As the watershed was developed, the floodplains along the perennial streams were altered. Many of the natural stream channels were piped, resulting in a network of storm sewers and culverts. The effects of urbanization (e.g., impervious surfaces, channelization, and storm sewers) led to frequent flash flooding in the lower portion of the watershed. Highly erodible soils and frequent, intense rainstorms also contributed to the flooding. The county addressed this problem by constructing flood-control channels in lower Holmes Run, lower Backlick Run, and Cameron Run.

Marshes were once extensive in both the Piedmont and Coastal Plain parts of the watershed, but today only a few wetlands remain. Sedges, rushes, cattails, grasses, and aquatic shrubs (e.g., tag alder and buttonbush) can be found along the borders of manmade lakes and where normal drainage is blocked. A natural tidal marsh occurs where the lower Cameron Run mainstem flows into the Potomac River. This marsh consists mainly of the yellow water lily, as well as aquatic species such as pickerel weed, cattail, tuckahoe, tearthumb, and knotweed.

The Virginia Department of Forestry reports a 32% decrease in forest resources in the Cameron Run watershed from 1957 to 1992 (Woodrow Wilson Bridge Project 2001). Remaining forest resources are typically small, fragmented, and associated with riparian corridors. No large forested areas remain in the watershed. Prior to development, the forests provided habitat for a variety of wildlife, including black bear, mountain lion, bison, chipmunks, mice, eagles, wild turkey, and the passenger pigeon (Parsons Brinckerhoff 1974). Since the 1970s, the remaining small areas of undeveloped land, combined with suitable forms of development, have provided only limited wildlife habitat for animals such as deer, foxes, raccoons, muskrat, Canada geese, and ducks. Remnant alluvial forest areas sometimes produce spring wildflowers such as dogtooth violets, spring beauties, yellow violets, and toothworts (Parsons Brinckerhoff 1974).

Today, Fairfax County is nearly fully built out; nevertheless, existing residential and commercial buildings are being expanded regularly, and associated paved surfaces are increasing within those building lots. Poor water quality and flooding became a countywide problem during the 1970s as development increased throughout the county. Through the 1930s, the headwater streams were fishable and swimmable. As the population grew, the streams became degraded and were no longer fishable or swimmable. In Fairfax County, protection of stream corridors began in the 1980s. To improve water quality, Fairfax County implemented BMPs that consisted of low-density residential zoning and the creation or maintenance of vegetated stream buffers for its most threatened watersheds. By 1993, the BMPs were implemented countywide with the designation of stream corridors as Resource Protection Areas (RPAs). In the late 1980s, Fairfax County adopted the Regional Stormwater Management Plan for managing stormwater countywide. The original plan identified 134 sites for building regional ponds that would control stormwater runoff to reduce peak flow rates, prevent erosion and flooding, and improve water quality (Bryant et al. 2003).

Recognizing the need to protect the living environment while planning for the orderly development and redevelopment of the county, Fairfax County has increased its watershed planning efforts. The county initiated the SPS and Stream Physical Assessment (SPA) programs were to assess the health of the streams within the county. Fairfax County developed the SPS program to focus recommendations for protecting and restoring subwatersheds, identify priorities for allocating limited resources, establish a framework for long-term stream quality monitoring, and support overall watershed management (Fairfax County 2001). Currently, Fairfax County is developing comprehensive watershed management plans for each of the county's 30 watersheds.

2.3 SUMMARY OF EXISTING REPORTS AND DATA SOURCES

The following sections summarize information available from 16 watershed assessments and planning efforts in Cameron Run watershed. Where available, the web site for the entire report is provided.

- Environmental Baseline Report
- Immediate Action Plan Report
- Future Basin Plan Report
- Lake Barcroft History
- "UrBIN" Urban Biodiversity Study in the Holmes Run/Cameron Run watershed
- UrBIN Gap Analysis of the Holmes Run/Cameron Run watershed
- UrBIN Stream Flow in the Holmes Run/Cameron Run watershed
- Infill and Residential Development Study
- Low Impact Development (LID) As a Watershed Management Tool
- The Role of Regional Ponds in Fairfax County's Watershed Management
- Perennial Stream Mapping Project
- Stream Water Quality Report
- Annual Report on the Environment 2003
- Fairfax County Park Authority Natural Resource Management Plan, 2004-2008
- Fairfax County Stream Protection Strategy Baseline Study
- Fairfax County Stream Physical Assessment

2.3.1 Environmental Baseline Report

The *Cameron Run Environmental Baseline Report* was written by Parsons, Brinkerhoff, Quade, and Douglas in April 1974. The report presented a comprehensive view of the environmental baseline conditions for the watershed. Development dominated the watershed when this report was written and still does today. The report predicted an increase in stream flow as development density increased and, therefore, the need for on-site stormwater detention. These predictions accurately reflect the condition of the Cameron Run watershed today.

2.3.2 Immediate Action Plan Report

The *Immediate Action Plan Report for the Cameron Run Watershed* was written by Parsons Brinckerhoff, Quade, and Douglas in December 1977. The report identified 40 projects for the Cameron Run watershed at an estimated cost of $7,537,000. The various projects included the replacement of culverts, installation of riprap and gabions along streambanks, and construction of earthen berms. The purposes of these projects included both controlling erosion and protecting houses and roads from flooding. To date, approximately 10% of these projects have been implemented.

2.3.3 Future Basin Plan Report

The *Future Basin Plan Report for the Cameron Run Watershed* was written by Parsons Brinckerhoff, Quade, and Douglas in December 1977. This report, in conjunction with the Immediate Action Plan, specified the watershed's projected needs up to the year 2000. Recommended programs included installation of sanitary sewer lines, channelization, bank protection, stormwater detention, and flood proofing. These programs were estimated to cost $3,831,000.

2.3.4 Lake Barcroft History

This document provided a detailed history of Lake Barcroft and its community. The Barcroft community was named in memory of Dr. John W. Barcroft, who built his home there and operated a mill. Lake Barcroft was created in 1915 in response to the city of Alexandria's increasing demand for water. Construction of the dam began in 1913 and resulted in a 135-acre reservoir. The community surrounding Lake Barcroft was one of the first major real-estate developments in Fairfax County. On February 23, 1954, the residents of Lake Barcroft approved the bylaws of their homeowners association, officially launching the Lake Barcroft Community Association (LABARCA). This association brought the homeowners together to protect their community and the lake. In June of 1972, hurricane Agnes caused a breach in the Lake Barcroft dam, causing the lake to empty. A Watershed Improvement District (WID), a Virginia government agency, was then created in 1973 in an effort to gather funding and staff resources needed to repair the dam and preserve the surrounding land. The WID was able to levy taxes and issue bonds needed to restore the lake. Today, WID taxes are still being used to maintain Lake Barcroft. Recent activities include WID's six-year EPA 319 Grant, which committed $800,000 to identifying and demonstrating stormwater management BMPs. WID has published a 72-page book about BMPs for watersheds and lakes.

2.3.5 Urban Biodiversity Study in the Holmes Run/Cameron Run Watershed

This study was developed for the Urban Biodiversity Information Node Pilot (UrBIN), part of the National Biological Information Infrastructure (NBII) coordinated by the U.S. Geological Survey's Biological Resource Division. UrBIN aims to provide communities with the information and decision-support tools needed to manage urban natural resources proactively. The purpose of the Holmes Run/Cameron Run pilot study was to develop and test a framework for facilitating access to existing data about biodiversity, conservation, and natural resources,

but the study also highlighted gaps in knowledge about the watershed. The report was divided into four parts. Part 1 discussed urban biodiversity and contained a description of the watershed and its history and a summary of Virginia's Chesapeake Bay regulations. These regulations were the impetus for much of the natural resource planning in the region. Part 2 contained an inventory of physical and biological resources and analyses of land use and land cover. Part 3 addressed considerations for planning to enhance biodiversity. Part 4 contained reflections on this phase of the UrBIN pilot project.

The study concluded with several findings regarding biodiversity in the Cameron Run watershed:

1. Riparian areas and stream corridors associated with floodplains, parks, and Chesapeake Bay RPAs serve as the main habitats and corridors.
2. Upland habitats are very limited; consequently, those that remain are important.
3. Local jurisdictions have sophisticated planning staffs with a strong interest in environmental protection.
4. Local stakeholders (members of nonprofit organizations and residents) also have a strong interest in environmental protection and apply this interest in advocacy and volunteer activities.
5. A unique set of integrated tools and programs exist that have helped protect the remaining habitats and corridors. These include Chesapeake Bay programs, flood plain management, environmental quality corridors, parks and recreation, the Lake Barcroft WID, land conservation by land trusts and local governments, and citizen volunteer programs.
6. In this highly urbanized watershed, most opportunities for enhancing biodiversity must come from ecological restoration and redevelopment. These activities should focus on remaining habitats and corridors, mainly stream channels, streambanks, riparian areas, and BMP retrofits. De-armoring selected sections of stream and connecting fragmented riparian corridors should be considered.

2.3.6 UrBIN Gap Analysis of the Holmes Run/Cameron Run Watershed

This project was initiated to compile information about biodiversity within the Holmes Run/Cameron Run watershed in Northern Virginia. The UrBIN Gap Analysis Project (GAP) was funded by the National Gap Analysis Program (NGAP) to provide additional biodiversity information to supplement the information compiled in UrBIN. The UrBIN GAP was a cooperative effort between the NGAP and the NBII UrBIN.

The major objective of this project was to apply gap analysis to the Holmes Run/Cameron Run watershed. Sub-objectives of this project were (1) to produce GIS-databases describing the actual kinds of land cover, predicted distributions of terrestrial vertebrates, and land-management status at a target scale of 1:24,000; (2) to identify kinds of land cover and terrestrial vertebrate species that are not represented or are underrepresented in areas managed for biodiversity (i.e., "gaps"); and (3) to facilitate cooperative development and use of information to help institutions, agencies, and private landowners become more effective stewards of natural resources. This

project was a preliminary step toward the more detailed efforts and studies needed for long-term planning for biodiversity within Virginia's increasingly urban landscape.

The results emphasized the importance of parks for conserving species within the watershed. Without these refuges, some species may be lost from the watershed. Most parks within the watershed are managed for recreation rather than biodiversity; therefore, the potential for increasing biodiversity protection within the watershed is great.

2.3.7 UrBIN Stream Flow in the Holmes Run/Cameron Run Watershed

This report was prepared by Virginia Tech to support the UrBIN pilot biodiversity study in the Holmes Run/Cameron Run watershed (Estes 2003). The drainage area extending to the dam at Lake Barcroft and the area extending to the USGS gauge station on Cameron Run were analyzed to characterize streamflow and runoff in the watershed. The Lake Barcroft watershed is approximately 15 square miles, or 36 percent of the Fairfax County portion of the Holmes Run/Cameron Run watershed. This area is not as highly urbanized as the southern areas of the watershed. Flow data for Cameron Run are recorded at USGS gauge station 01653000, Cameron Run, at Alexandria, VA. The drainage area to the gauge is 33.7 miles, or 80 percent of the total Holmes Run/Cameron Run watershed. The period of record for flow data at this gauge is June 1, 1955, to the present, with occasional missing dates.

The water level at Lake Barcroft dam is controlled by a bascule gate, a hinged device that is counterbalanced so that when one end is lowered, the other is raised. The gate is operated by a digital controller that receives signals from a lake-level instrument and a gate-position detector. The controller also records the lake level and gate position at constant time increments, thus providing data for calculating the discharge from the dam. A Fortran program was created to convert the data from the controller into usable discharge data (Estes undated). The period of record for the raw data was October 1, 1991, to the present.

Analysis of the period of record indicated an increase in flow over time that was independent of precipitation. The study concluded that the increase in flow probably was due to a significant increase in development within the watershed since 1970. The increase in impervious area in the urban watershed resulted in increased runoff and increased stream flow. The researchers tested for a correlation between recorded flow at the Lake Barcroft Dam and at the USGS gauge on Cameron Run. The correlation was not as high as expected, but the relationship can be used to obtain a reasonable prediction of flow at either location.

2.3.8 Infill and Residential Development Study

The combination of the development patterns in Fairfax County and a growing concern over water quality issues led the Board of Supervisors to request the *Infill and Residential Development Study* in May of 1999. The Board accepted the final recommendations of that study at a public hearing on January 22, 2001. The study included the following recommendations related to stormwater management:

- Improve, in the erosion and sedimentation control process, the awareness, planning, and financial resolution capability of the County for land disturbing projects upstream of sensitive sites in order to reduce impacts.

- Enhance, during the erosion and sedimentation control inspection and enforcement process, the enforcement of violations including, in certain egregious instances, revoking of land disturbing permits.

- Enhance, through education programs, the knowledge and awareness of staff, the development industry, and citizens regarding the importance and capabilities of an erosion and sedimentation (E&S) control program, as well as create an E&S Hotline to improve program responsiveness.

- Improve the design and installation of erosion and sedimentation control silt fences and super silt fences by improving the design standards of the County's regulations.

- Improve the effectiveness of temporary erosion and sedimentation inlet controls on construction sites by reducing the allowable area that may be drained to them, therefore increasing the number of these control devices and improving sediment control.

- Allow the use of an optional Faircloth Floating Skimmer as a dewatering device in temporary sediment traps to increase sediment removal efficiency.

- 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 mulched and when the grass is fully established.

- 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 mulched and when the grass is fully established.

- Where storm water detention/water quality waivers are deemed appropriate for development projects with proposed land disturbing activities, require conditions as necessary to avoid adverse impacts to downstream properties.

- Require reports to demonstrate adequacy of E&S measures to protect downstream properties.

- Enhance water quality controls and best management practices to maintain good ecological health in the County's streams by enhancing current practice in a variety of ways detailed in this recommendation.

- Amend the current language of the Public Facilities Manual regarding definitions of terms and requirements for adequate outfall analysis; to give the Director of DPWES

discretion regarding additional measures where there will be discharge into an inadequate channel; to better define the design procedure for pipe outlets; and to allow consideration of the recent Virginia Dept. of Conservation and Recreation proposal pertaining to hydrologic stormwater design.

- Modify requirements and procedures as they relate to the consideration of stormwater management during the zoning process to include amending submission requirements for residential zoning applications regarding adequate outfall; to provide for more direct DPWES involvement in the zoning process for residential applications; to seek commitments for SWM facility sizes.

Most of these recommendations have been implemented or addressed. The Land Development Services, Department of Public Works and Environmental Services, is tracking the status and disposition of specific recommendations.

2.3.9 Low Impact Development (LID) As a Watershed Management Tool

Two letters on the use of BMPs were sent to all architects, builders, developers, engineers, and surveyors practicing in the county, one in 2001, the other in 2002. These letters were an initial step in adopting and encouraging the use of LID techniques for improving water quality in the county. Procedures for requests to use innovative BMPs in Fairfax County were defined in a letter dated October 2, 2001. This letter detailed the application procedure, discussed the general design standards and application conditions, provided a list of innovative BMPs, and included an Innovative BMP Tracking Form. The second letter, *Innovative BMPs – 3.07 Enhanced Extended Detention Dry Ponds Now Acceptable for Public Maintenance in Residential Areas and on Governmental Sites*, was sent on May 14, 2002. This document provides a comprehensive overview of the application of LID in Fairfax County (see http://www.fairfaxcounty.gov/dpwes/watersheds/rpr/rpr_k-n.pdf).

2.3.10 The Role of Regional Ponds in Fairfax County's Watershed Management

On January 28, 2002, the Board of Supervisors directed county staff to form a multi-agency committee to develop a unified position on the use of regional ponds and other kinds of storm-water controls as watershed management tools. During 2003, the Regional Pond Subcommittee provided recommendations regarding the use of regional ponds and other innovative and nonstructural techniques as part of watershed management. The focus of the effort was to evaluate, deliberately and comprehensively, the potential benefits of modifying watershed management practices, policies, and regulations. A comprehensive list of issues was organized into the following ten categories: ecology; economics; local, state, and federal permits; regulations and policies; hydrology and design; land use and watershed management; parks and recreation; health and safety; aesthetics; construction planning and phasing; and public participation, outreach, and support. Representatives of business, industry, and the public were asked to review and comment on this process.

After much deliberation, research, and consultation with the public and stakeholders, the Subcommittee identified 61 recommendations to improve Fairfax County's stormwater manage-

ment program and to clarify the role of regional ponds in that program. The general consensus was that regional ponds play a role in the county's stormwater management program, but that they should be designed to address several ecological, economic, and social concerns and should work in concert with better site designs and LID practices. The Subcommittee is coordinating the development of an implementation plan for all recommendations, including a time line and assignments. Several of the recommendations address the need to modify the county's Public Facilities Manual (PFM), stormwater policies, codes, and ordinances (see http://www.fairfaxcounty.gov/dpwes/stormwater/).

2.3.11 Perennial Stream Mapping Project

A project to identify perennial streams was initiated in September of 2001 in response to the Fairfax County Board of Supervisors' direction implementing an Environmental Quality Advisory Council (EQAC) resolution concerning mapping and protecting additional stream segments within the county under the Chesapeake Bay Preservation Ordinance (BPO). A perennial stream is a flowing system that is continuously recharged by groundwater or surface runoff, regardless of weather conditions. Under the Virginia Chesapeake Bay Preservation Act (CBPA), areas designated as RPAs include tidal wetlands, non-tidal wetlands connected by surface flow to tidal wetlands or tributary streams, tidal shores, tributary streambeds (not owned by the Commonwealth of Virginia), and stream buffer areas 100 feet in width. Resource Management Areas (RMAs) include land that has a potential for causing degradation of water quality or of an RPA if it is not used properly. RPAs are defined by the regulation; RMAs are determined by local discretion. Amendments to Chapter 118 of the county's BPO changed the definition of an RPA from "tributary streams" to "water bodies with perennial flow." These amendments included a requirement to identify water bodies with perennial flow by using a scientifically valid method to conduct site-specific surveys. Perennial stream protocols were developed by the county and approved by the state; the county then embarked on a survey of the headwater reaches of streams to designate perennial streams upstream of existing RPAs. The Board of Supervisors adopted the results of the survey as amendments to the county's BPO in November 2003. This extensive perennial stream survey identified an additional 330 miles of perennial streams, a 52% increase (from 638 to 968 miles). This increase in stream miles established 17.06 square miles (or 10,921.57 acres) of new RPAs in the county, an increase of 31% (from 55.3 to 72.3 square miles, http://www.fairfaxcounty.gov/dpwes/stormwater/).

2.3.12 Stream Water Quality Report

The Fairfax County Health Department monitors stream water quality at 84 sampling sites throughout the county (http://www.fairfaxcounty.gov/hd/strannualrpt.htm). The program was introduced at the Fairfax Fair in June 1989 in response to EQAC's recommendations to promote citizens' awareness of the potential hazards of recreational usage of streams and to provide the Health Department with citizen surveillance and reporting of possible pollution problems. The program was awarded the National Association of Counties 1991 Achievement Award and the Virginia Municipal League's 1991 award for Environmental Quality. Seven monitoring sites are shown in Figure 2-2. Site 12-04 is located on Tripps Run. Sites 12-15 and 12-05 are located on Upper Holmes Run. Site 12-07 is located on Lower Holmes Run. Site 12-12 is located on Turkeycock Run, and sites 12-14 and 12-13 are located at the confluence on the Cameron Run

mainstem. No samples were taken at site 12-15 in 2002. In 2002, these sites were sampled for fecal coliform, dissolved oxygen, nitrate nitrogen, pH, total phosphorous, and temperature. These parameters indicate the amount of pollution contributed from manmade sources and help to evaluate the quality of the aquatic environment.

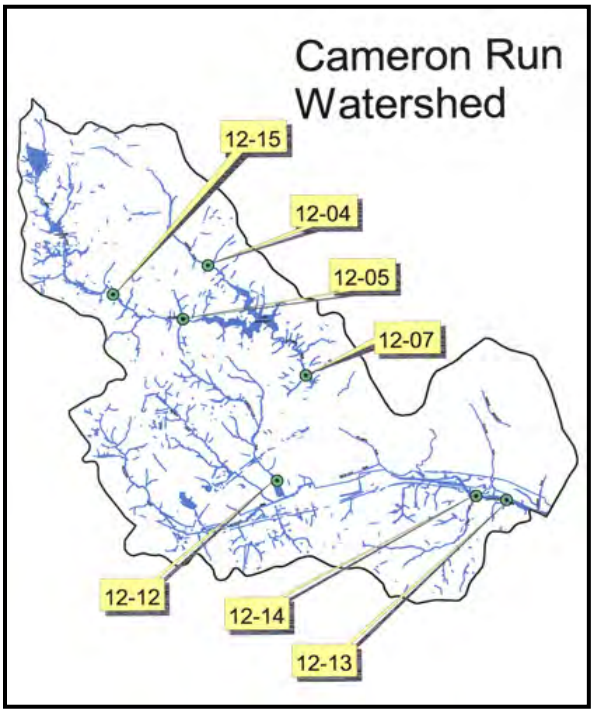


Figure 2-2. Water quality sampling sites located in the Cameron Run watershed

Water quality standards include standards for concentrations of fecal coliform bacteria. These "indicator organisms," although not necessarily harmful themselves, are found in the intestinal tracts of warm-blooded animals, including humans, and can indicate fecal contamination and the possible presence of pathogenic organisms. In surface waters, fecal coliform bacteria should not exceed a geometric mean of 200 fecal coliform bacteria per 100 ml of water. Table 2-1 shows the results of fecal coliform sampling. For each sampling site, more than 70% of the samples had fecal coliform counts greater than 200/100ml.

Table 2-1. Fecal coliform (F.C./100ml)			
Sample Station	**Total Samples Collected**	**Number of Samples with <200/100ml**	**Number of Samples with >200/100ml**
12-04	12	3	9
12-05	12	1	11
12-07	13	2	11
12-12	18	3	15
12-13	16	2	14
12-14	18	3	15

The presence of dissolved oxygen (DO) in water is essential for aquatic life, and the structure of the aquatic community depends to a large extent on the concentration of dissolved oxygen available in the water. Dissolved oxygen standards are established to ensure the growth and propagation of aquatic ecosystems. The minimum standard for dissolved oxygen is 4.0 mg/l. The average dissolved oxygen for each site in the Cameron Run watershed was above the minimum standard. Sampling sites 12-04 and 12-13 exhibited 14.3 and 23.8 percent of samples with less than 4.0 mg/l respectively (Table 2-2).

Table 2-2. Dissolved oxygen (mg/l)			
Sample Station	**Total Samples Collected**	**Average Dissolved Oxygen**	**Percentage of Samples less than 4.0 mg/l**
12-04	14	7.5	14.3
12-05	14	7.7	0
12-07	15	8.2	0
12-12	21	9.1	0
12-13	21	6.9	23.8
12-14	21	8.4	0

Nitrate nitrogen is usually the most prevalent form of nitrogen in water because it is the end product of the aerobic decomposition of organic nitrogen. Nitrate from natural sources is attributed to the oxidation of nitrogen in the air by bacteria and to the decomposition of organic material in the soil. Nitrate concentrations can range from a few tenths of a milligram to several hundred milligrams per liter. In unpolluted water, nitrate seldom exceeds 10 mg/l. Nitrate is a major component of human and animal wastes, and abnormally high concentrations suggest pollution from these sources. Table 2-3 shows the average nitrate nitrogen values at the sampling sites.

Table 2-3. Average nitrate nitrogen (mg/l), pH, and total phosphorus (mg/l)			
Sample Station	**Average Nitrate Nitrogen (mg/l)**	**Average pH**	**Average Total Phosphorus (mg/l)**
12-04	1.0	7.0	0.1
12-05	0.5	7.2	0.1
12-07	0.6	7.0	0.1
12-12	0.5	6.8	0.1
12-13	0.4	6.8	0.1
12-14	0.6	7.1	0.1

Stream pH is an important factor in aquatic systems. Biological productivity, stream diversity, metal solubility, the toxicity of certain chemicals, and important chemical and biological activity are strongly related to pH. The pH range of 6.0 to 8.5 generally provides adequate protection for aquatic life and for recreational use of streams. Average pH values for all of the sampling sites were within the range for aquatic life (Table 2-3).

Phosphorus is found naturally in water in the form of various types of phosphates. Phosphorus is essential to the growth of organisms and can be the nutrient that limits the growth that a body of water can support. There is no established limit for total phosphorus content in stream water. Significant increases in total phosphorus may indicate increasing amounts of contaminants entering the stream. The average total phosphorus values for each site are shown in Table 2-3.

2.3.13 Annual Report on the Environment

The *Annual Report on the Environment*, which is an update on the condition of the county's environment, serves a threefold purpose. First, it is intended to assist the Board of Supervisors in evaluating ongoing environmental programs and to provide the basis for proposing new programs. The document also aids public agencies in coordinating programs to jointly address environmental issues. In addition, the report is directed to citizens who are concerned with environmental issues. The report contains chapters on major environmental topics including water resources; air quality; ecological resources; wildlife management; solid waste; hazardous materials; noise, light, and visual pollution; and land use and transportation. Each chapter discusses environmental issues, summarizes relevant data, and identifies applicable government programs. Discussions of legislative issues are provided, where relevant. Most of the chapters conclude with recommendations that identify additional actions that EQAC believes are necessary to address environmental issues. Annual reports from 2001 through 2006 are available on the county's website (see http://www.fairfaxcounty.gov/dpz/eqac/report/).

2.3.14 Fairfax County Park Authority Natural Resource Management Plan, 2004 – 2008

The purpose of this document is to coordinate efforts to achieve the Fairfax County Park Authority's (FCPA) vision for preserving resources. The plan creates a systemwide approach

necessary to achieve the Park Authority's goals (http://www.fairfaxcounty.gov/parks/ nrmp.htm). The plan contains seven elements: Natural Resource Management Planning, Vegetation, Wildlife, Water Resources, Air Quality, Human Impact on Parklands, and Education. Each of these elements includes a background section to introduce the topic, as well as the plan's issues and strategies.

FCPA is the county's largest landowner. FCPA's lands represent 8.6% of Fairfax County's total land area of 262,400 acres. Combined with other public parks in Fairfax County, FCPA's holdings represent more than 15% of the county's landmass. Key recommendations of this plan include the following:

- Conduct an inventory of existing vegetative communities, including plants that are designated as threatened, endangered, or of special concern at the federal, state, or local level.
- Develop an FCPA policy to address the planting and cultivation of native plants, and the removal of invasive plants on parkland.
- Assess stream valleys within parks at stormwater outflows to identify sites where corrective actions are needed most urgently.

2.3.15 Fairfax County 2001 Stream Protection Strategy Baseline Study

This study rated four components of stream/watershed condition including benthic macro-invertebrate community integrity, vegetation and instream features, fish taxonomy richness, and percent impervious cover. The 2001 SPS Baseline Study established three broad management categories, Watershed Protection, Watershed Restoration Level I, and Watershed Restoration Level II, for future watershed protection and restoration efforts, based primarily on overall stream rankings of biological quality and projected development. Subwatersheds that fall into the Watershed Protection category tend to be areas of low-density development with biological communities that are relatively healthy. The primary goal of this category is to preserve 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 primary goal of the Watershed Restoration Level I category is to re-establish healthy biological communities by taking active measures to identify and remedy causes of stream degradation, both broad-scale and site-specific. These watersheds generally have fair biological conditions and are in areas of substantial and continuing development, but still hold potential for significant enhancement of stream quality. High development density, significantly degraded instream habitat conditions, and substantially impacted biological communities generally characterize subwatersheds in the Watershed Restoration Level II category. The primary goal for this category is to maintain areas to prevent further degradation and to take active measures to improve water quality.

The study showed that the Cameron Run watershed has substantially degraded biological and habitat integrity (Fairfax County 2001). The Cameron Run watershed was classified as a Watershed Restoration II Area. A summary of 2001 SPS Baseline Study data for Cameron Run watershed is shown in Table 2-4.

Table 2-4. Summary of 2001 SPS Baseline Study data for Cameron Run watershed							
	Tripps Run	**Holmes Run Upper**	**Holmes Run Lower**	**Turkeycock Run**	**Indian Run**	**Backlick Run**	**Pike Branch**
Condition Rating	Very Poor	Very Poor	Very Poor	Poor	Very Poor	Very Poor	Very Poor
Index of Biotic Integrity Score	Very Poor	Very Poor	Fair	Very Poor	Fair	Poor	Fair
Habitat Score	Very Poor	Poor	Very Poor	Fair	Poor	Very Poor	Very Poor
Fish Taxa Richness	Very Low	Variable	Low	Low	Very Low	Low	Very Low

2.3.16 Fairfax County Stream Physical Assessment

The SPA study provided information about the condition of habitats, specific infrastructure and problem areas, and general characteristics of streams throughout the watershed and a geomorphic classification of stream type (CH2M Hill 2004). Based on a length-weighted habitat score of 92, Cameron Run watershed is one of the poorest watersheds in the county. Approximately 6 miles of stream were categorized as having very poor habitat conditions, 23 miles as poor, 17 miles as fair, and 2 miles as good. A summary of SPA data for Cameron Run watershed is shown in Table 2-5. Analysis of the results indicates that the Cameron Run watershed has few adequate riparian buffers, with more than 40 acres of deficient buffer per 10 miles.

Table 2-5. Summary of SPA data for Cameron Run watershed							
	Tripps Run	**Holmes Run Upper**	**Holmes Run Lower**	**Turkeycock Run**	**Indian Run**	**Backlick Run**	**Pike Branch**
Inadequate Buffers (ft.)	37,850	93,950	10,300	51,615	42,850	70,485	27,450
Eroded Streambanks (ft.)	0	4,590	0	4,295	4,840	3,725	75
Stormdrain Pipes	18	124	10	36	25	2	29
Dumping Sites	0	6	0	1	0	1	1
Headcuts	0	0	0	2	0	2	0
Exposed Utilities	2	11	1	4	6	4	2
Obstructions	0	26	1	11	9	7	5
Road Crossings	25	68	3	38	29	59	13

2.4 ISSUES IN THE CAMERON RUN WATERSHED

The Advisory Committee initially identified 16 issues of concern (i.e., watershed problems) in the Cameron Run watershed. For simplicity, the 16 issues were combined into 10 broader issues (Table 2-6). These issues were the starting point for the Cameron Run Watershed Plan and were refined within the Committee and through public involvement. The sources and environmental effects associated with each issue are described in the sections below.

Table 2-6. Cameron Run watershed issues	
10 Primary Issues	**16 Component Issues**
Bank Erosion and Sedimentation	• Bank erosion including infrastructure impacts and channel instability • Sediment loading to watershed and accumulation in streams
Impervious Surfaces	• Impervious surfaces and loss of tree cover • Decreased infiltration and increased runoff
Loss of Riparian Buffer and Wetlands	• Loss or degradation of riparian buffers along streams and shorelines • Loss of wetlands in watershed
Irregular Stream Flows	• Higher peak flows • Lower low flows • Direct inflow from stormwater systems into streams
Loss of Stream Habitat and Stream Life	• Loss or degradation of habitats and biological communities
Pollution	• Discharge or runoff of toxic pollution into streams and lakes • Nutrients loading into watershed
Bacteria	• Bacteria and pathogens in streams and lakes
Flooding	• Flooding of property
Stream Channel Alteration	• Channel alteration of streams • Obstructions to flow and fish passage in streams
Trash	• Dumping and accumulation of trash in streams and lakes

2.4.1 Bank Erosion and Sedimentation

Streambank erosion at Lower Holmes Run

Streambank erosion and the transport of sediment results from the force of water flowing through a stream channel. In undeveloped landscapes, natural streams still erode and alter their course, but this process generally occurs over very long time periods or only during very heavy storms. Urbanization has magnified this erosion and channel alteration process to occur even during light storms as impervious surfaces increase the volume and frequency of stormwater flows. Excessive erosion and the transport of eroded sediment downstream affect streams in a number of ways. Physical effects include degradation of the streambank (e.g., bank erosion, slumping) and changes in the stream channel (e.g., incision or downcutting). As stormwater flows tear away the soil, excess sediment is mobilized, and the natural ability of the stream to transport and store the sediment is overwhelmed. Consequently, sediment is deposited on the bottom, filling in critical habitats for aquatic fish and invertebrates. Large gravel and sediment bars may be formed that deflect stream flow against the streambank, resulting in more erosion. This cycle of erosion degrades the streambank structure until it collapses, introducing additional sediment into the stream. This process can threaten the structural integrity of bridges, buildings, roads, sewer and water pipelines, or other human structures located nearby.

Stream channels and stream life are adapted to natural levels of sediment. Excessive amounts of sediment and particles of certain kinds and sizes (commonly fine silt and clay) disrupt the stream ecosystem. In particular, fine sediment settles into the spaces between the gravel and rock substrate. Insects and small fish need those spaces to graze algae, hide from predators, hunt prey, and shelter themselves from the faster currents above. Sediment accumulating in these spaces may bury plants and animals alive or reduce the amount of living space available for these organisms. As the native species disappear, other more tolerant species that prefer the altered habitat move in.

In addition to affecting the amount and quality of stream habitat, excess sediment can also directly impact the health of aquatic insects and fish. Many fish and insects rely on their vision to detect prey and help avoid predators. As increasing levels of suspended sediment reduce visibility through the water, organisms become less able to find food and avoid being eaten. Fish and many kinds of insects breathe underwater by using gills to gather dissolved oxygen from the water. Gills are sensitive organs, and suspended sediment can clog them, making it harder for the organism to breathe. These organisms are also subject to abrasion from sediment particles. Just as sand can abrade your car's windshield, it can pound and grind down the scales of fish and the shells of insects, as well as their softer, less protected body parts. These physical effects are likely to make it harder for organisms to find food, eat, and grow normally. Organisms that are not growing normally may not have the energy to fight off disease or to reproduce; thus, populations of native species dwindle or disappear from their historical numbers and ranges.

2.4.2 Impervious Surfaces

The primary effect of urbanization (the development of natural or agricultural landscapes) is to convert forests, wetlands, meadows, and farm fields into buildings and other impervious surfaces. Water cannot infiltrate these surfaces as it can natural soils. Common examples of impervious surfaces in urban areas are rooftops, driveways, roads, parking lots, and sidewalks. Compacted soils and lawns also are generally impervious.

Highly developed Seven Corners area

This shift from natural soils and vegetation to impervious surfaces drastically changes the hydrology of an area. In a natural area, only a small amount of rainfall runs off; most is absorbed into the soil. In urbanized areas, the increase in impervious area produces large amounts of stormwater runoff because infiltration is limited. As a result, runoff from the urban landscape conveys a large volume of water to streams in a short time period. The increase in the frequency and magnitude of runoff adversely affects the stability of streams, and ultimately their health.

Natural soil infiltration contributes to recharging groundwater, which helps sustain stream flow between periods of rain. Streams are especially dependant on the influx of groundwater to

maintain surface flow and health during summer months. Because urban areas are largely impervious, there is little recharge of the groundwater upon which the streams depend for summer flow. Without an adequate groundwater supply, stream flows in summer may become very low or nonexistent. Such low flows reduce stream habitat available to aquatic communities and may lower water quality (e.g., the amount of dissolved oxygen in the water).

Impervious surfaces also affect stream ecology by increasing water temperature. As rainfall hits asphalt on a hot summer day, the temperature of the rainwater rises before it reaches the stream. Even small temperature changes can affect the activity and life cycles of stream organisms.

2.4.3 Loss of Riparian Buffer and Wetlands

The riparian buffer is the vegetated area along a stream where development is restricted or prohibited. The buffer's primary use is to physically protect and separate the stream from future disturbance or human encroachment. If properly designed, buffers can provide stormwater management benefits, such as reducing property damage from flooding. Additional benefits of riparian buffers include:

- separating the stream from impervious cover
- protecting the streambank from erosion
- shading and reducing stream warming
- reducing the inflow of nutrients and other pollutants to the stream
- providing habitat and migration corridors for fish and wildlife

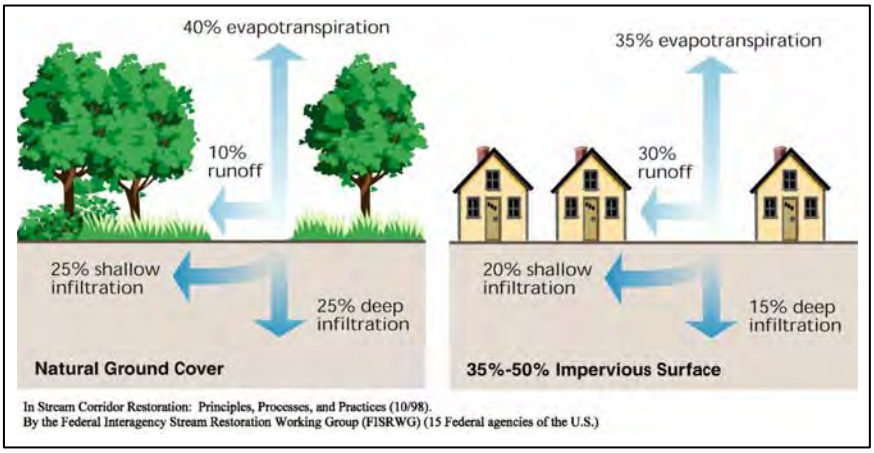
Riparian buffers may be vegetated with grass, shrubs, or forest. The more completely and densely vegetated the buffer is, the more benefits it will provide. Wetlands also act as buffers along streams. Wetlands include marshes, swamps, and bogs, and may be either forested or open. The root systems of wetland plants can hold streambanks and shorelines, while their stems and trunks can reduce erosion by absorbing the energy of the water currents. This energy would otherwise carry soil particles away from the streambank or shoreline.

Riparian buffers are critical to healthy stream ecosystems because they provide space for natural stream dynamics that is physically separated from humans and their structures. Specifically, buffers help contain floodwaters, thereby reducing risks to property and providing storage of flow that would otherwise cause erosion. Wetlands are particularly good at providing temporary storage of floodwaters. Because wetlands typically form in low-lying areas, they often are the first areas to receive water when flooding occurs. Wetland vegetation slows the movement of the floodwaters and acts as a natural sediment trap, as suspended sediment is deposited in the calm water.

Riparian buffers and wetlands can be conserved or restored to protect stream corridors, lakes, and coastal areas. Creating buffers is typically a low-cost means for meeting many stormwater management goals, improving water quality, and providing wildlife habitat. Riparian buffers and wetlands can fit into many different kinds of physical and political landscapes.

2.4.4 Irregular Stream Flows

The change in landscape from a natural area to an urban area drastically changes the hydrology of a watershed, resulting in flashy streams: ones that have higher maximum and lower minimum flows. The fast flow of the stormwater downstream may result in too little water upstream to sustain aquatic habitats, while the increased amount of water downstream stresses the habitats and aquatic organisms there.



In Stream Corridor Restoration: Principles, Processes, and Practices (10/98).
By the Federal Interagency Stream Restoration Working Group (FISRWG) (15 Federal agencies of the U.S.)

In natural landscapes such as forests and wetlands, rainwater and snowmelt slowly filter into the ground. The infiltration, or absorption of water into the soil, recharges the groundwater supply. In the summer, streams depend on groundwater to prevent them from running dry. In urban areas much of the natural landscape is converted to impervious surfaces such as rooftops and roads. These impervious surfaces prevent rain and snowmelt from infiltrating the ground. Most of the rainfall and snowmelt remains above the surface, where it runs off rapidly. This runoff enters the storm drain system and eventually empties into a stream. The loss of infiltration in urban areas may reduce the amount of groundwater and cause low or nonexistent flows in the stream during the dry summer months. In addition to lower permanent or "base" flows, the large amount of impervious surface in urban areas directs large volumes of water to streams in a short period of time. The increase in the frequency and magnitude of runoff adversely affects the stability of streams, and ultimately their health.

2.4.5 Loss of Stream Habitat and Stream Life

Stream ecosystems and the plant and animal communities they sustain depend upon a wide range of physical and biological factors. Because streams collect water from their watersheds, activities that take place in the watershed can negatively affect the quality of the water entering the stream. If the stream receives poor quality water, then the organisms that live in or use the stream will be adversely affected. Stream organisms, such as fish, salamanders, and invertebrates, have adapted to natural stream conditions and depend upon these conditions for

their survival. Natural stream habitats involve clean water, steady and adequate flows, and diverse structures on the bottom and banks. If one or more factors are missing, then stream organisms either will have difficulty surviving, or will not be able to survive at all.

Degradation of stream habitats and ultimately of biological communities results from the well-known list of stresses common in urban areas: bank erosion and sedimentation, irregular stream flows, loss of riparian buffer and wetlands, pollution, and stream alteration. Each of these watershed problems acts to change the natural conditions and degrade or eliminate stream habitats. In the urban setting, stream channelization that replaces natural habitat with concrete channels is the most extreme form of habitat loss. More pervasive, and probably more important, are the bank erosion, sedimentation, and irregular stream flows that result from increases in impervious throughout the watershed. By increasing the volume and frequency of stormwater runoff, impervious surfaces cause erosion and scouring in the stream. Stormwater runoff also picks up pollutants and increases in temperature as it runs across asphalt and concrete before entering the stream or lake. Because the rapid runoff of storm flows depletes groundwater, stream flows in summer may be very small or nonexistent. Obviously, without water, aquatic organisms cannot live.

2.4.6 Pollution

Streams and lakes collect the water that falls as precipitation and flows over and through the land surfaces of the watershed. In urban watersheds, the quality of the water in streams is determined by the pollutants carried in stormwater as it runs off the land and its impervious surfaces. The amounts and kinds of pollutants carried in stormwater reflect the activities occurring within the watershed. Common household activities that affect water quality include automobile maintenance (washing your car and changing the oil), lawn care, and walking your pet. Pollutants generated by these activities wash off the surface into the stormdrain system and end up, untreated, in our streams and lakes.

Outdoor car washing has the potential to contribute a high load of nutrients, metals, and hydrocarbons to the water body. The detergent-rich water used to wash dirty cars flows down the street and into the storm drain to be discharged into the stream. More than 50% of households wash their own cars.

Automobile maintenance generates significant amounts of hydrocarbons, trace metals, and other pollutants that can reach stormwater. Kinds of waste include solvents (paints and paint thinners), antifreeze, brake fluid, batteries, motor oils, fuels, and lubricating grease. Dumping automotive fluids down storm drains is the same as dumping them into the stream.

Lawn care often includes the application of fertilizers and pesticides. Excess fertilizers and pesticides applied to lawns and gardens wash off and pollute streams. Fertilizers contribute a significant amount of phosphorus and nitrogen to water bodies. Even very low levels of insecticides and certain herbicides can be harmful to aquatic life. The major source of pesticides in urban streams is home applications used to kill insects and weeds in the lawn and garden.

Pet waste can be a major source of bacteria and excess nutrients in water bodies. Failure to clean up after your dog can cause water quality problems. A single gram of dog feces can contain 23 million fecal coliform bacteria.

The runoff of nutrients into a waterbody can cause eutrophication (i.e., the proliferation of algae and aquatic weeds that ultimately die and consume dissolved oxygen from the water). The result can be oxygen shortages that cause fish kills. Eutrophication can significantly reduce aquatic biodiversity and interfere with use of the water for fisheries, recreation, industry, agriculture, and drinking. The runoff of toxic chemicals, such as pesticides, can kill small aquatic organisms (such as worms, crustaceans, and insect larvae) or build up in the bodies of larger animals that eat them. When toxic chemicals "bioaccumulate" in fish, ducks, and other food sources, they pose a threat to human health.

2.4.7 Bacteria

Bacteria are single-celled organisms that can cause diseases. High bacteria counts often lead to beach closures during the summer. Bacteria can pollute streams and lakes, making them unsafe for contact and recreation. Fecal coliform, a kind of bacteria, are typically found within the digestive systems of warm-blooded animals. Fecal coliform in water is an indicator that disease-carrying bacteria may be present; therefore, streams are regularly monitored for the presence of bacteria to avoid risks to public health. During storms, fecal coliform are washed off the land into rivers, streams, lakes, or groundwater. Sources of fecal coliform include leaking sewer lines, failing septic systems, coliform-laden sediment in stormdrain pipes, livestock, wildlife, waterfowl, and pets.

2.4.8 Flooding

Floods are natural events that occur when rainfall exceeds the capacity of the streambanks at a given location. In a natural area, rainfall is absorbed by the surrounding vegetation and soil. During the heaviest rains, the floodplain adjacent to the stream stores the excess flow. In urban areas, much of the natural soil and vegetation has been replaced with impervious surfaces in the forms of structures and compacted soils. When rainfall hits an impervious surface, it cannot be absorbed, so it flows downhill toward a waterbody. Curbs and gutters, stormwater

drainage pipes, ditches, catch basins, and other drainage systems are designed to convey stormwater directly into receiving waters.

If the amount of rain and flow from upstream exceeds the capacity of the stormwater conveyance system, it overflows, leading to flooding in streets, basements, and backyards. During such flooding, streams may overtop their banks, drainage systems may back up (especially if they are blocked by trash or debris), and sewers may overflow. Human alterations of the landscape in urban areas result in increased frequency and severity of floods. Urban areas typically have few natural floodplains, high-density development, and more paved areas such as roads and rooftops.

Channelized streams generally are wider and straighter than natural stream channels, and they are disconnected from the floodplain. Floodwaters that normally soak into floodplain soils and recharge groundwater are rapidly exported downstream in channelized streams. Because there is less groundwater, stream flows in the summer may be low or nonexistent. Such low flows not only limit habitat for aquatic communities but may also stress or deplete the vegetation that grows alongside the stream.

Natural streams are adapted to the frequency and severity of flooding in undeveloped landscapes. Floods naturally rearrange streambed habitats, uproot aquatic or riparian plants, and increase the drift of aquatic insects. Adaptations of stream inhabitants include sheltering behind rocks or snags, burrowing into the streambed and banks, moving to slower water along the stream's edges and in backwaters, or by having life cycles that are terrestrial or aerial during flood-prone seasons. The more frequent and severe flooding that occurs in developed areas often exceeds the ability of aquatic organisms to survive. Floods also act as a cue for spawning or migration in some fish. When floods occur during the wrong season, spawning may fail, and fish populations can crash.

2.4.9 Stream Channel Alteration

Historically, the reasons for channelizing river systems have included flood control, wetland drainage, erosion prevention, and navigation improvement. In urban environments, channels are usually altered to drain wetland areas and move water away from buildings and infrastructure. These alterations generally produce wide, straight channels with steep streambanks that are disconnected from the floodplain.

Several methods are used to channelize rivers and streams. One method, called re-sectioning, makes rivers wider or deeper to contain water that naturally would spread onto the floodplain. In addition, the slope of the streambank may be altered to increase the volume of water the channel can hold, which helps to accommodate the increased stormwater runoff from urban developments. Another method, realignment, involves straightening a river's channel. Straightening shortens the channel and results in a faster flow downstream. This faster flow removes potentially flood-level flows from one area, but transmits them downstream, where the frequency of flooding may increase.

The banks of altered channels often need to be stabilized to enable them to withstand the erosive forces of the large volumes of water and strong flow in the new channel. Bank stabilization

involves protecting streambanks with various materials. Riprap, consisting of large broken rocks piled against the bank, is commonly used reduce the erosive force of water in drainage channels and on steep banks. Gabion baskets, another method of bank stabilization, are wire mesh containers filled with tightly packed rocks. In addition, concrete, vegetation, wood, or other structural materials can be used to protect against erosion.

Channelized section of Tripps Run

Streams that have been channelized offer many fewer habitats for communities of aquatic plants and animal. Habitat diversity is important because organisms use the distinct resources in different habitats to meet their complex life-cycle needs. For example, alternating riffle-pool habitats are important to fish species, because they provide areas for feeding, breeding, and shelter.

2.4.10 Trash

Improper disposal of trash is evident across the landscape. Single littering events accumulate into large "trash areas" when litter is washed into streams and lakes. Trash enters the stream environment from a number of sources, including inadequately treated wastewater, recreation activities, littering, and dumping. During a storm, trash from all sources is carried through the stormwater conveyance system to the local stream.

Trash skimmer on Tripps Run before it enters Lake Barcroft

Illegal dumping to avoid disposal fees at landfills or recycling facilities often occurs in or near streams. Illegal dumping occurs in all settings in all geographic regions but is especially common near abandoned industrial, commercial, or residential buildings; vacant lots; and poorly lit areas such as rural roads and railway lines. The effects of illegal dumping may be more pronounced in areas with heavy rainfall (i.e., where there is a greater volume of runoff). In urban areas, illegal dumping may result from the inaccessibility of recycling centers or solid-waste disposal facilities, which often are located on the suburban-rural fringe.

Dumping sites may contain a wide variety of kinds of trash, depending on how long the site has been used. Manmade materials that float or are suspended in water are especially apparent. These include plastic bags, six-pack rings, bottles, yard waste, and cigarette butts. Once in the stream, the trash can choke, suffocate, or disable aquatic animals such as ducks, fish, turtles, and birds. It also degrades the aesthetic quality of a stream valley or lake, and limits the enjoyment and recreational experience of the community. Collection and disposal of the trash is a burden on the community.

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Chapter 3
Assessing the Condition of Cameron Run Watershed

Developing a successful watershed plan requires accurately assessing the condition of the watershed at scales appropriate for management; therefore, the Project Team undertook a detailed assessment of the condition of the Cameron Run watershed, its subwatersheds, and constituent streams. We applied the following three approaches: (1) characterization of stream condition from field sampling of chemical, physical, and biological parameters; (2) estimation of stream processes by modeling of flow and water quality parameters; and (3) identification of specific problems through local knowledge (i.e., public involvement). This chapter describes the methods employed to assess the condition of the Cameron Run watershed.

3.1 STREAM CHARACTERIZATION

Prior to developing this watershed plan, Fairfax County completed countywide biological and physical habitat sampling.. Data collected from the SPS and the SPA were the primary sources of information used in this plan for characterizing streams throughout the watershed.

3.1.1 Stream Protection Strategy (SPS)

Specifically, the purposes of the SPS program are to

- understand the degree of stream degradation and formulate measures to effectively reverse negative trends,
- identify and rank areas with the greatest needs,
- recommend streams for preservation and restoration efforts where appropriate,
- support detailed comprehensive watershed planning or stormwater master plans from which specific capital improvements may evolve,
- integrate applicable environmental policies, initiatives, and regulatory requirements,
- provide an additional information base to aid future planning efforts, and
- encourage environmental stewardship by supporting established and new citizens' programs for stream monitoring and public education (Fairfax County 2001).

In general, objectives of the program focused on defining recommendations for protecting and restoring subwatersheds by ranking areas according to priority for allocation of limited resources; establishing a framework for long-term, stream-quality monitoring; and supporting overall watershed management. Each of the SPS monitoring sites within the county was ranked according to overall quality based upon its numeric scores for the following four components of stream/watershed condition:

- the Index of Biotic Integrity (IBI), which incorporates 10 separate measures (each scored on a 0 to 10 scale) of the condition of the benthic macroinvertebrate community

- a general evaluation of the watershed features (including vegetation and instream features) and a more specific evaluation of 10 parameters of condition in streams and riparian zones, each scored on a scale of 0 (worst) to 20 (optimal)

- the richness of fish taxa (i.e., number of distinct species present)

- the overall percentage of impervious cover within the contributing drainage area of each site based upon available Fairfax County GIS data layers

The ultimate numeric score for each sampling location reflects the site's degree of departure from reference or "highest-quality" conditions. These composite values were then assigned to one of the following qualitative categories: excellent, good, fair, poor, and very poor.

The 2001 SPS Baseline Study established three broad management categories for future watershed protection and restoration efforts, based primarily on overall stream rankings of biological quality and projected development. The three management categories include Watershed Protection, Watershed Restoration Level I, and Watershed Restoration Level II. The results of this study show that the Cameron Run watershed has substantially degraded biological and habitat integrity. A summary of SPS data for Cameron Run watershed is shown in Table 2-4, and in tables and maps in Chapter 4 for each subwatershed. The Cameron Run watershed is classified as a Watershed Restoration II Area. The primary goal of this category is to maintain areas to prevent further degradation and to take active measures to improve water quality to comply with regulations.

3.1.2 Stream Physical Assessment (SPA)

The SPA study provides information about habitat conditions, specific infrastructure and problem areas, general stream characteristics, and a geomorphic classification of stream type throughout the watershed (CH2M Hill 2004). Stream assessments were performed in all county watersheds for approximately 800 stream miles.

The data were entered into a database and digitized for incorporation into a GIS-based Stream Assessment Tool. Data analysis placed stream reaches into one of five habitat assessment rating categories. Each stream reach was also placed in one of the five stages of geomorphic condition in the Channel Evolution Model (CEM), as shown in Figure 3-1.

The stream assessments comprised a habitat assessment and an inventory of physical stream features based on protocols developed specifically for this project. The habitat assessment (scoring of various habitat parameters) and the inventory (characterization of physical features such as pipelines, utilities, and buffers) together provide a baseline of overall stream conditions, from which watershed conditions can be inferred.

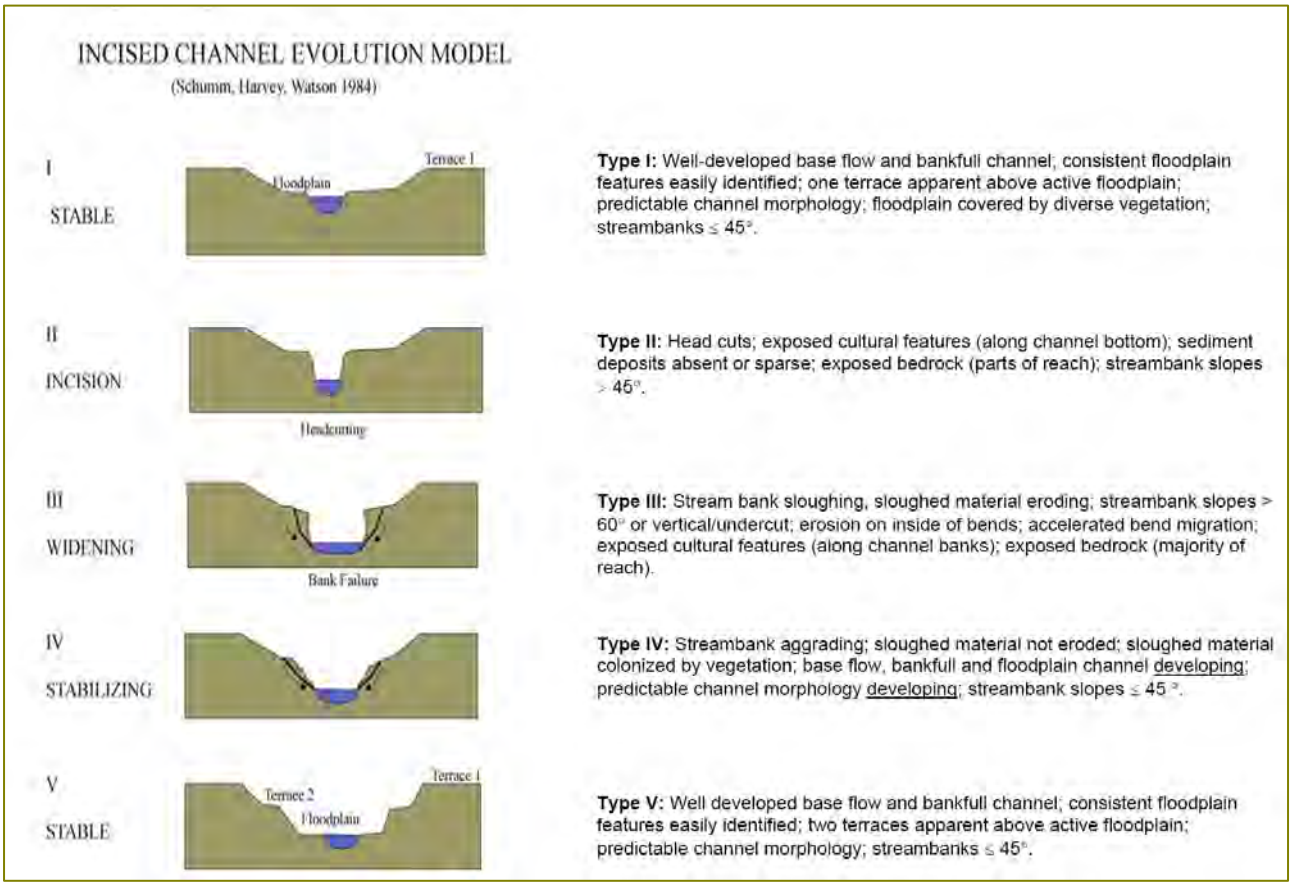

Figure 3-1. Stages in the Channel Evolution Model used in the Fairfax County SPA (CH2M Hill 2004)

Habitat assessments were performed in combination with inventory assessments for 1,523 stream reaches, totaling 720.5 miles. Inventory assessments alone were performed for an additional 304 reaches, totaling 85.7 miles. For 14 additional miles, habitat and inventory assessments could not be performed because of dangerous conditions, the presence of wetlands, and streams that were piped or channelized. The stream habitat data were used to place each stream into one of five habitat assessment rating categories: excellent, good, fair, poor, or very poor.

Based on a length-weighted habitat score of 92, Cameron Run watershed is one of the poorest in the county. Approximately 6 miles of stream were categorized as having very poor habitat conditions, 23 miles as poor, 17 miles as fair, and 2 miles as good. A summary of SPA data for Cameron Run watershed is shown in Table 2-5, and in tables and maps in Chapter 4 for each subwatershed. Analysis of the results indicates that the Cameron Run watershed has few adequate riparian buffers and more than 40 acres of deficient buffer per 10 miles.

3.2 MODELING FLOW AND WATER QUALITY

A Storm Water Management Model (SWMM) was developed for the Cameron Run watershed; the model included all of the watershed areas in Fairfax County, Falls Church, and Alexandria, upstream of the USGS gauge on Cameron Run. The purpose of the model is to represent base-

year and future conditions in the watershed, including imperviousness and land use, from which it simulates rainfall-runoff hydrology and water quality. The Hydrologic Engineering Center River Analysis System (HEC-RAS) hydraulic model was developed to simulate 1-, 2-, 10-, 25-, and 100-year design storms. HEC-RAS is used to evaluate road crossing overtopping, structure flooding, analysis of bankfull capacity, and erosion velocities for selected design storms. The full model report is included as Appendix B.

The Cameron Run watershed was divided into 8 subwatersheds and 155 subbasins. The total area in the delineated watershed equals 44.4 square miles, of which 33.9 square miles are upstream of the USGS gauge on Cameron Run in Alexandria. The subbasins range in size from 100 to 290 acres and average 183 acres. Impervious area for the watershed was delineated from Fairfax County's GIS coverages of buildings, roads, and parking lots; SWMM also used Fairfax County's GIS land use coverages to evaluate base-year and future conditions within the watershed. Existing and future stormwater management facilities were simulated with SWMM within the Fairfax County portion of the watershed. The storage and outflow relationships for the facilities in each subbasin were simulated so that peak flows under base year-conditions and future land use were equal to the peak flows for the 2-year and 10-year design storms for undeveloped conditions.

SWMM was used to evaluate the influence of base-year and future development within the watershed on flow rates, velocity, and water quality. Increased flows, velocity, and pollutant loadings were assessed for each of the subwatersheds as well as the entire watershed; summary results are provided in Chapter 4 by subwatershed. For each subwatershed, reported pollutant-loading values are the area-weighted averages of all the subbasins in each subwatershed. Values for peak flow and pollutant loading rates under base-year and future conditions for the eight subwatershed areas are provided in Chapter 4, including the percent increase for each value.

3.3 PUBLIC INVOLVEMENT

The third critical source of information about the condition of the Cameron Run watershed was local knowledge obtained through public involvement. The Project Team solicited information in two ways: (1) frequent meetings with an Advisory Committee representative of major stake-holders in the watershed, and (2) outreach through public meetings and information exchange via the Cameron Run watershed web site.

3.3.1 Advisory Committee

Advisory Committee (AC) meetings were held 13 times. Dates and locations of the meetings held to date are listed below.

- November 20, 2003 John Marshall Library, Alexandria, Virginia
- December 16, 2003 Woodrow Wilson Public Library, Falls Church, Virginia
- January 13, 2004 Woodrow Wilson Public Library, Falls Church, Virginia
- February 12, 2004 Ellen Coolidge Burke Branch Library, Alexandria, Virginia

- April 1, 2004 Richard Byrd Branch Library, Springfield, Virginia
- April 28, 2004 Mason District Government Center, Annandale, Virginia
- May 26, 2004 George Mason Regional Library, Annandale, Virginia
- August 25, 2004 Mason District Government Center, Annandale, Virginia
- September 20, 2004 Mason District Government Center, Annandale, Virginia
- November 10, 2004 Versar Headquarters, Springfield, Virginia
- January 12, 2005 Woodrow Wilson Public Library, Falls Church, Virginia
- April 7, 2005 Woodrow Wilson Public Library, Falls Church, Virginia
- June 8, 2006 Mason District Government Center, Annandale, Virginia

Minutes from these meetings are included as Appendix C. AC members and their affiliations are listed in the acknowledgments section of this plan. Problems identified by the AC are outlined in Chapter 4.

3.3.2 Public Outreach

Four public meetings were scheduled as part of the process of developing the watershed plan. Dates of public meetings and scopes of each are listed below.

- Public Issues Scoping Forum - June 17, 2004, Mason District Government Center, Annandale, VA

  This meeting provided a brief introduction to the watershed planning process, answered questions, and discussed specific issues of concern in break-out groups. Ways to increase public involvement were solicited.

- Community Watershed Forum - October 23, 2004, Holmes Middle School, Alexandria, VA

  This forum presented watershed analysis results and discussed alternative approaches to solving watershed problems.

- Draft Watershed Plan Forum - June 16, 2005, Mason District Government Center, Annandale, VA

  The forum briefly introduced the watershed planning process and summarized the Cameron Run watershed plan. Break-out groups reviewed and discussed the programmatic recommendations and projects selected for each subwatershed in the draft plan.

- Final Watershed Plan Forum - December 4, 2006, Mason District Government Center, Annandale, VA

The final forum reviewed the watershed planning process and the groups involved in developing the plan and summarized the Cameroun Run watershed plan, including the next steps involved in finalizing the plan. Break-out groups reviewed and discussed Tier 1 Projects, Group 1 Drainage Complaint Projects, and Policy Recommendations included in the Draft Final Cameron Run Watershed Plan.

The Project Team also provided comprehensive information about the Cameron Run watershed planning process to the public via the county's website at http://www.fairfaxcounty-watersheds.net/htmls/public/watershed.aspx?indx=11 (Figure 3-2). Information on the web site includes the following:

- Profile of Cameron Run
- Land Use Classification
- Current Announcements
- Current Event Calendar
- Watershed Documents
- Steering Committee
- Relevant Links

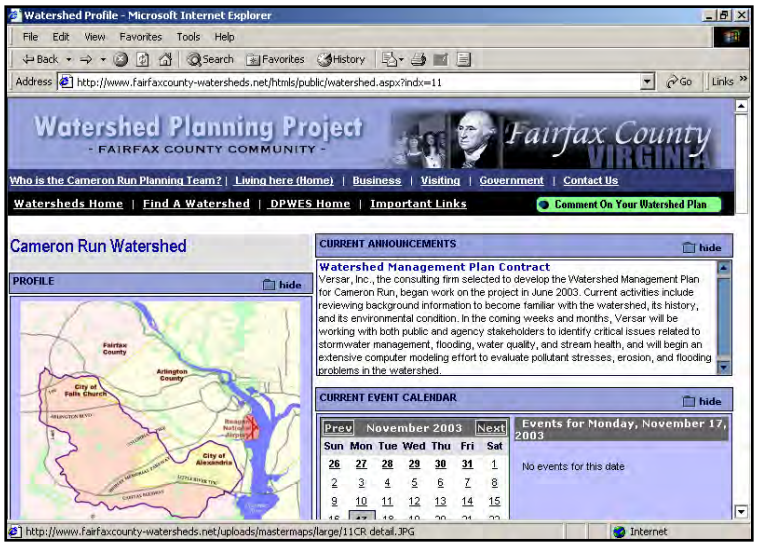

Figure 3-2. Cameron Run watershed web site

Chapter 4
State of Cameron Run and its Subwatersheds

4.1 STATE OF CAMERON RUN WATERSHED

Today, the Cameron Run mainstem is a flood-control channel whose surrounding area is characterized primarily by medium- to high-density urban development. The Cameron Run watershed (Figure 4-1) contains some of the oldest and most highly developed areas in Fairfax County. Nearly 95% of the watershed is developed with homes, strip malls, commercial enterprises, and extensive roadway systems. The major highways in Fairfax County that cross the watershed include the Capitol Beltway, Shirley Highway (I-395), Little River Turnpike (State Route 236), Arlington Boulevard (U.S. Route 50), and Lee Highway (U.S. Route 29). These major arteries contain the largest shopping areas as well as several commercial strip developments on streets throughout the watershed. These include Arlington Boulevard, the intersections of Little River Turnpike and Columbia Pike, and northwest of the Beltway interchange along Gallows Road.

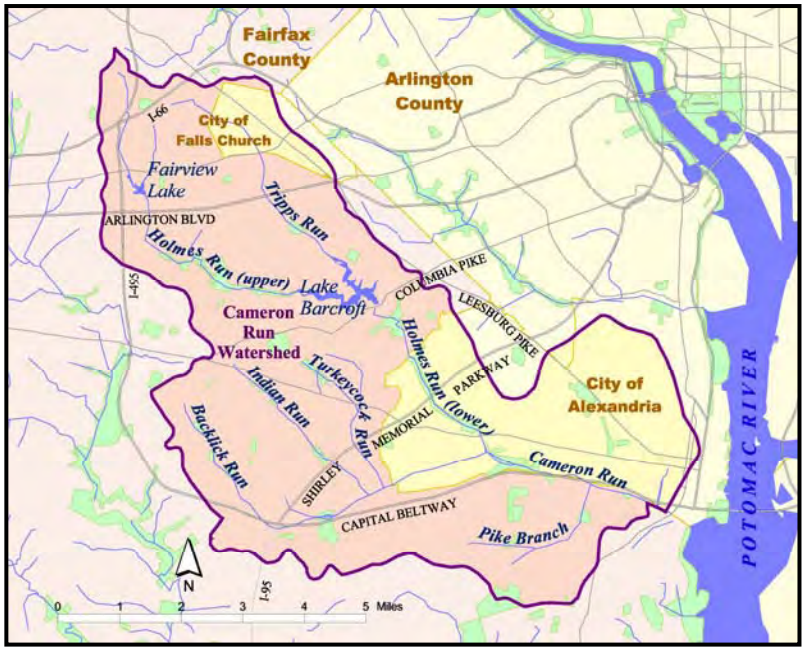

Figure 4-1. Map of Cameron Run watershed

The effects of development are apparent throughout the watershed. The historic floodplain of lower Cameron Run is now primarily a transportation corridor where the Capitol Beltway parallels the stream channel (Woodrow Wilson Bridge Project 2001). Industrial, commercial, and residential areas have replaced the wetlands and forests that once attenuated floodwaters. Small remnants of wetlands remain in the watershed. These include palustrine, lacustrine, and riverine wetlands (associated with tidal wetlands, open water bodies, and free-flowing tributaries, respectively). The channels of Cameron Run and Holmes Run were made into rocklined or

concrete channels to remove floodwaters from developed areas quickly. The effects of these alterations are apparent in the degraded water quality within the channels. The channels have experienced an increase in temperature and algal production (potentially leading to lower dissolved oxygen and higher pH), channel instability, and disconnection from the floodplain and wetland areas. Nonpoint-source pollution and urban stormwater runoff greatly affect the health of this watershed.

According to the 2001 SPS Baseline Study, the Cameron Run mainstem and its tributaries "have substantially degraded biological and habitat integrity." The SPS Baseline Study listed Cameron Run as a Watershed Restoration Level II watershed, which is characterized by high-density development, significantly degraded in-stream habitat conditions, and substantially degraded biological communities (Fairfax County SPS 2001). The number of different fish species was small, and stress-tolerant species dominated these communities. The macroinvertebrate community was dominated by highly stress-tolerant midges; sensitive species indicative of high-quality conditions were absent.

The imperviousness within each subwatershed exceeded 23%. Greater than 10% imperviousness has been shown to significantly diminish habitat quality and biological integrity in stream systems (CWP 1998). Streams have been altered extensively to accommodate the large volumes of stormwater runoff from the watershed. These changes reflect the historical view of streams as stormwater conveyance systems.

The SPA study provides watershed-wide information about the habitat conditions, specific infrastructure and problem areas, general stream characteristics, and a geomorphic classification of stream type (CH2M Hill 2004). Parameters analyzed include

- **Instream habitat** measures the amount of substrate that is available as refuge for aquatic organisms. A wide variety and abundance of submerged structures in the stream creates many niches for macroinvertebrates, increasing the potential for species diversity. As the composition and abundance of cover decrease, habitat structure becomes monotonous, species diversity decreases, and the potential for recovery following disturbance decreases.
- **Epifaunal substrate** measures the availability and quality of benthic habitat for macroinvertebrates (insects and snails) in riffle-prevalent streams. Riffle areas are critical for maintaining a healthy variety of insects..
- **Vegetated buffer zone** measures the width and overall condition of the vegetation or land use along a stream reach. This parameter is measured from the edge of the upper streambank out through, and in some cases, beyond the flood plain and riparian zone. The vegetated area serves as a buffer for pollutants entering a stream in runoff and minimizes erosion. Far fewer useful buffer zones occur when roads, parking lots, fields, heavily used paths, lawns, bare soil, rocks, or buildings are near the bank.
- **Inadequate buffer sites** are specific locations that have been identified as having little or no riparian buffer. Information on this parameter can be used to count the number of stream miles that are inadequate, as well as target future restoration efforts to areas that need better riparian buffer protection.

- **Erosion sites** are specific locations along the stream that have been identified as having erosion problems. A severity rating was also recorded to help evaluate the observed erosion problems.
- **Bank instability** measures the existence of or the potential for detachment of soil from the upper and lower streambanks and its movement into the stream. Steep banks are more likely to collapse and erode than are gently sloping banks and, therefore, are considered to be unstable.
- **Channel alteration** measures large-scale changes in or modification of instream habitat, which affects stream biotic integrity and causes erosion of the stream bottom. Channel alteration is present when artificial embankments, rip rap, and other forms of artificial bank stabilization or structures are present; when dredging has altered bank stability; when dams and bridges are present; when banks and channels have been disturbed by livestock, other agricultural practices, or hydrology; and when other changes have occurred.
- **Embeddedness** measures the degree to which cobble, boulders, and other rock substrate are surrounded by fine sediment and silt. Embeddedness relates directly to the suitability of the stream substrate as habitat for macroinvertebrates and for fish spawning and egg incubation.
- **Sediment deposition** measures the amount of soil, sand, and silt that have accumulated on the bottom of the stream and to how the shape of the stream bottom has changed as a result of deposition. Sediment deposition may create an unstable and continually changing environment that becomes unsuitable for many organisms.
- **Dump sites** counts places where trash has been left illegally in or near a stream.

Habitat conditions in the Cameron Run watershed are shown in Figure 4-2. Loss of instream habitat and epifaunal substrate are shown in Figure 4-3. Analysis of the results indicates that the Cameron Run watershed has few adequate riparian buffers, having more than 40 areas of deficient buffer per 10 miles (Figure 4-4). In addition, the watershed also has more than 50 discharge pipes and ditches per 10 miles, as well as a large number of public utility lines and roadway stream crossings compared with other watersheds in the county. Sites of erosion and instability of streambanks within the watershed are shown in Figure 4-5. Current impact ratings for channel alteration, and embeddedness and sedimentation are shown in Figures 4-6 and 4-7, respectively. Dump sites rated minor to moderate are found within the watershed (Figure 4-8). Threatened infrastructure (e.g. exposed sewer pipes and eroded bridges) and changes in the stability of the stream channel are noted (Figure 4-9).

Water quality problems within the watershed include PCBs in aquatic species, excessive levels of fecal coliform bacteria, and acute ammonia levels. Water quality standards are set by the Environmental Protection Agency (EPA) under the Clean Water Act and administered by the

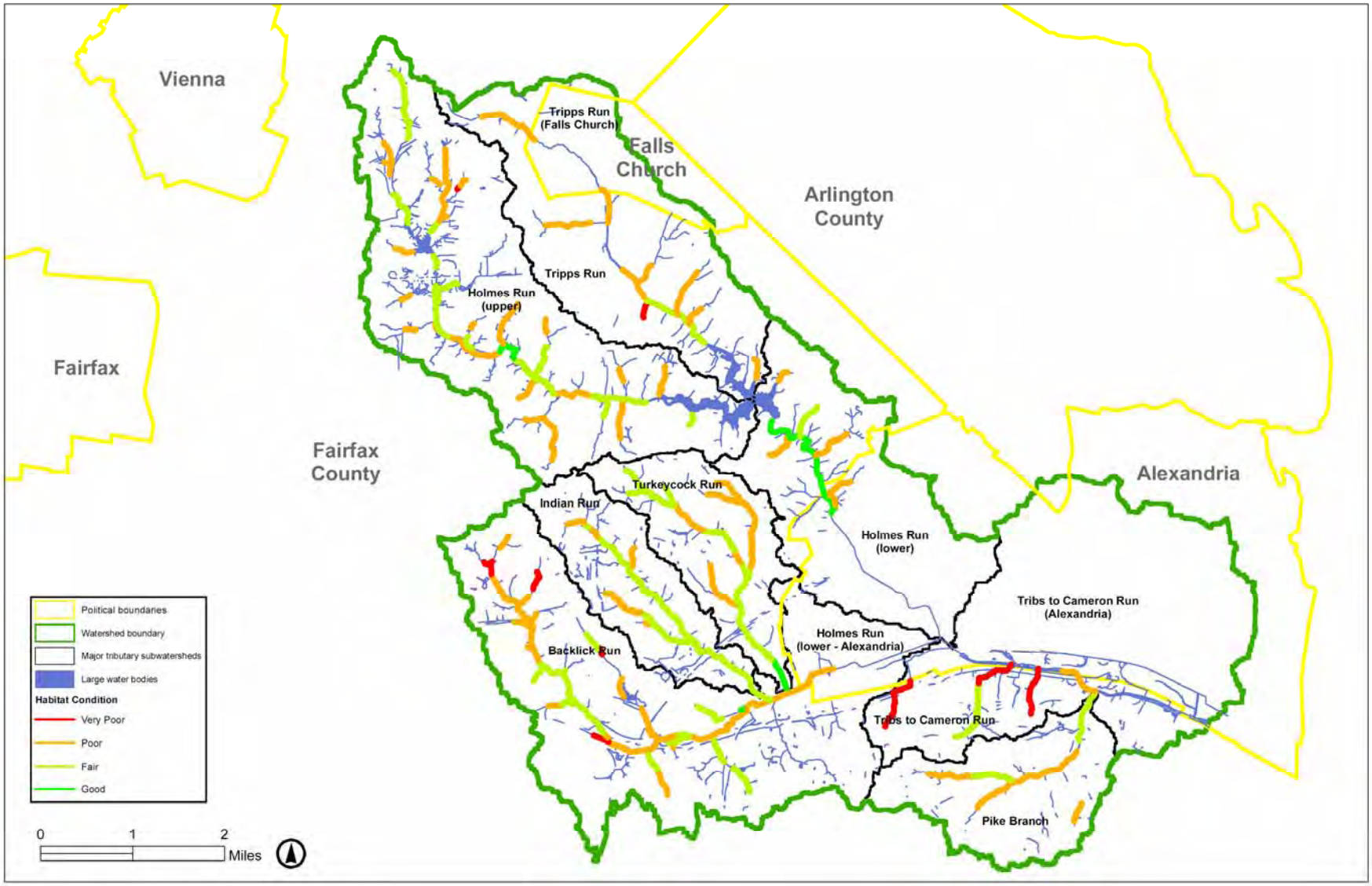

Figure 4-2. Habitat conditions in the Cameron Run watershed

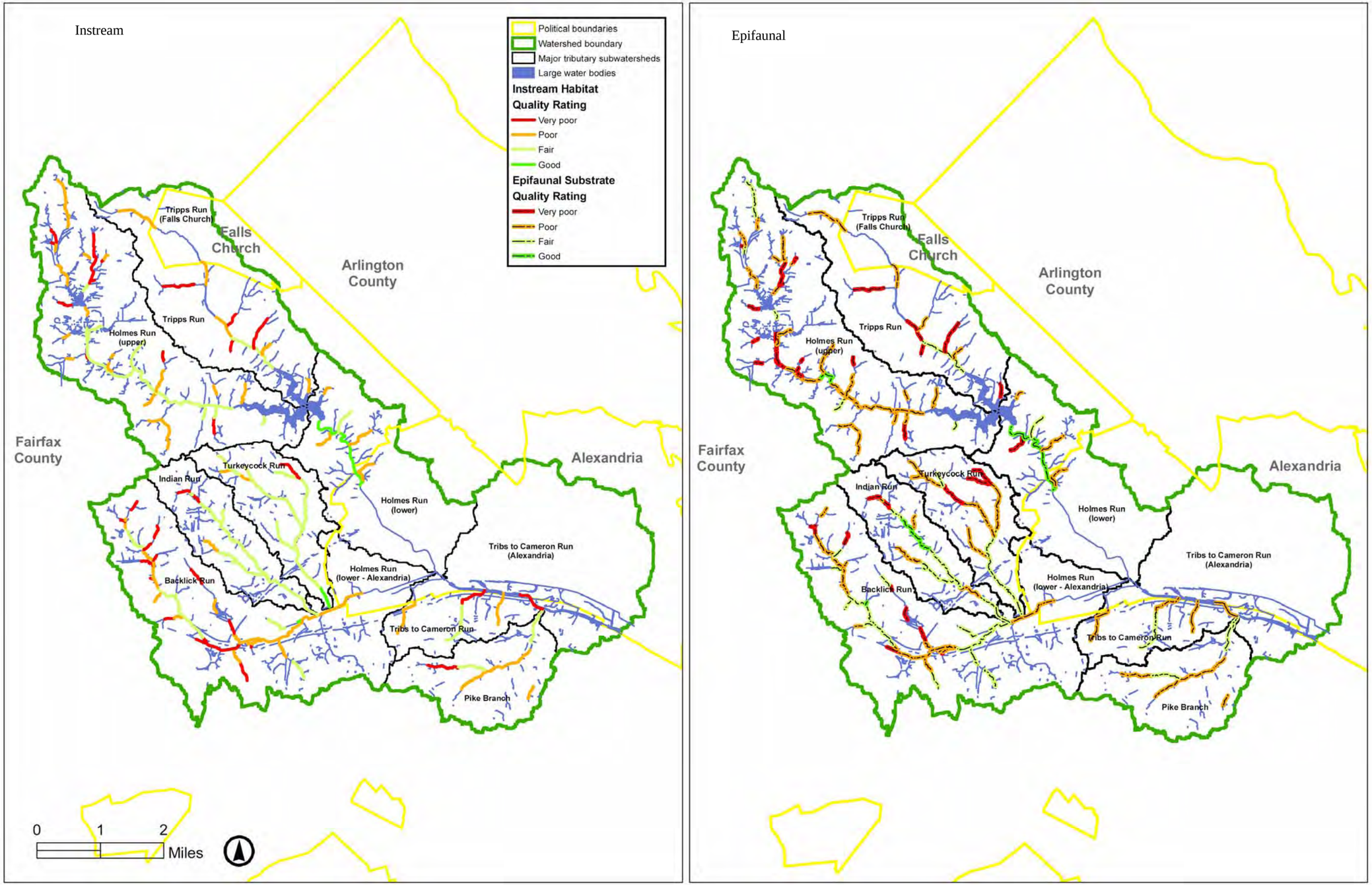

Figure 4-3. Loss of instream habitat and epifaunal substrate in Cameron Run watershed

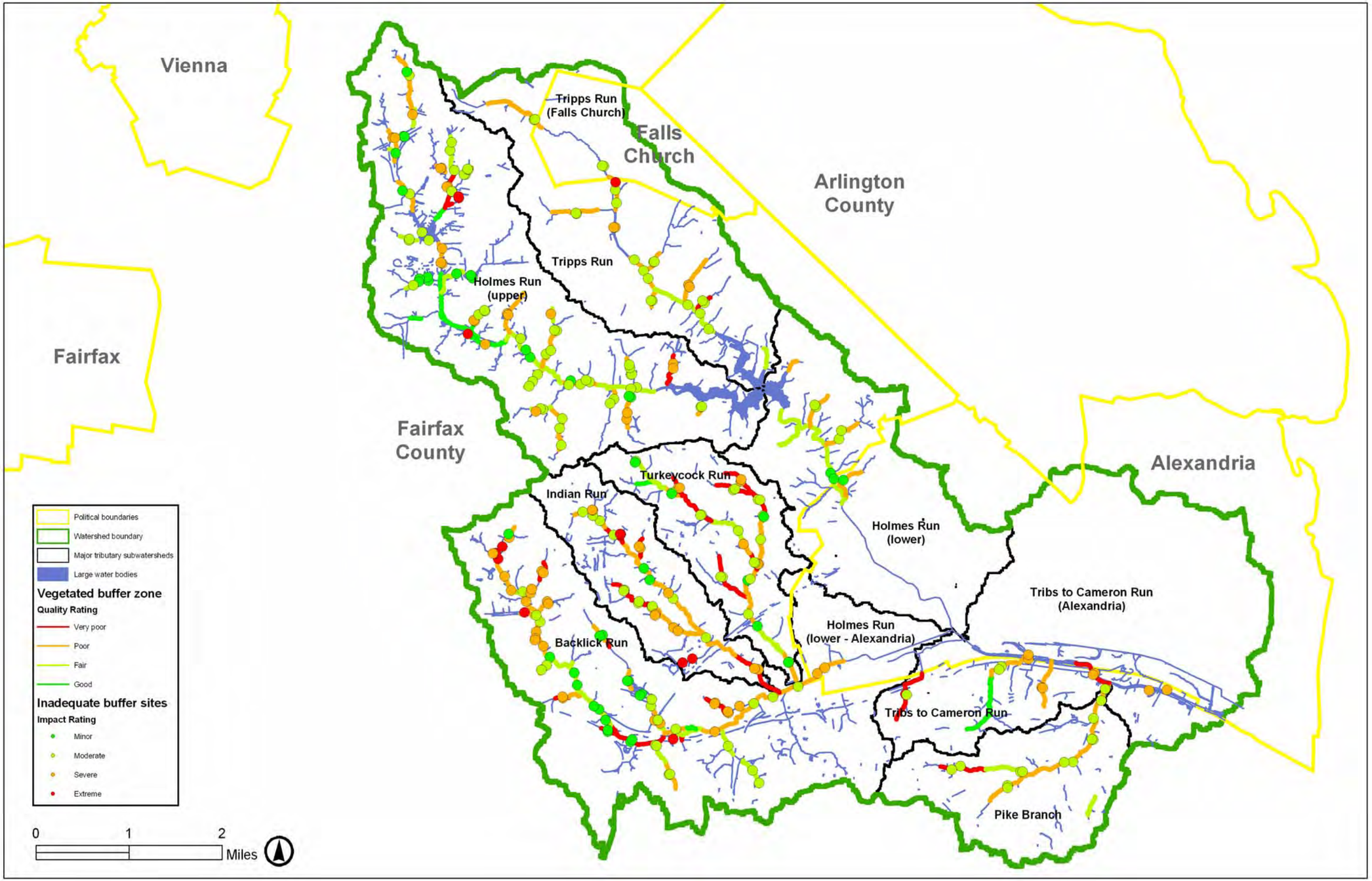

Figure 4-4. Vegetated buffer zone quality rating and inadequate buffer sites in Cameron Run watershed

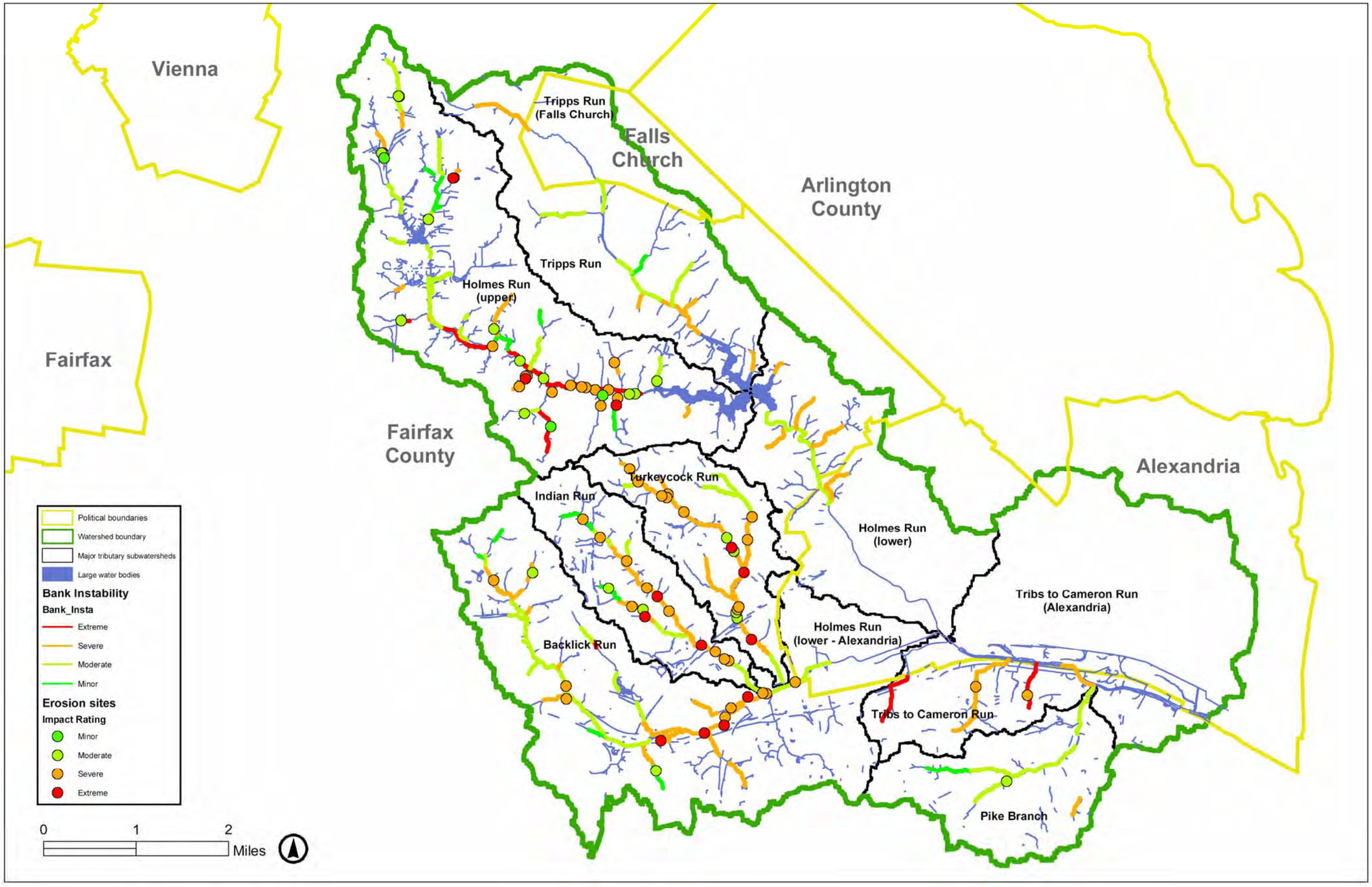

Figure 4-5. Bank instability and erosion sites in Cameron Run watershed

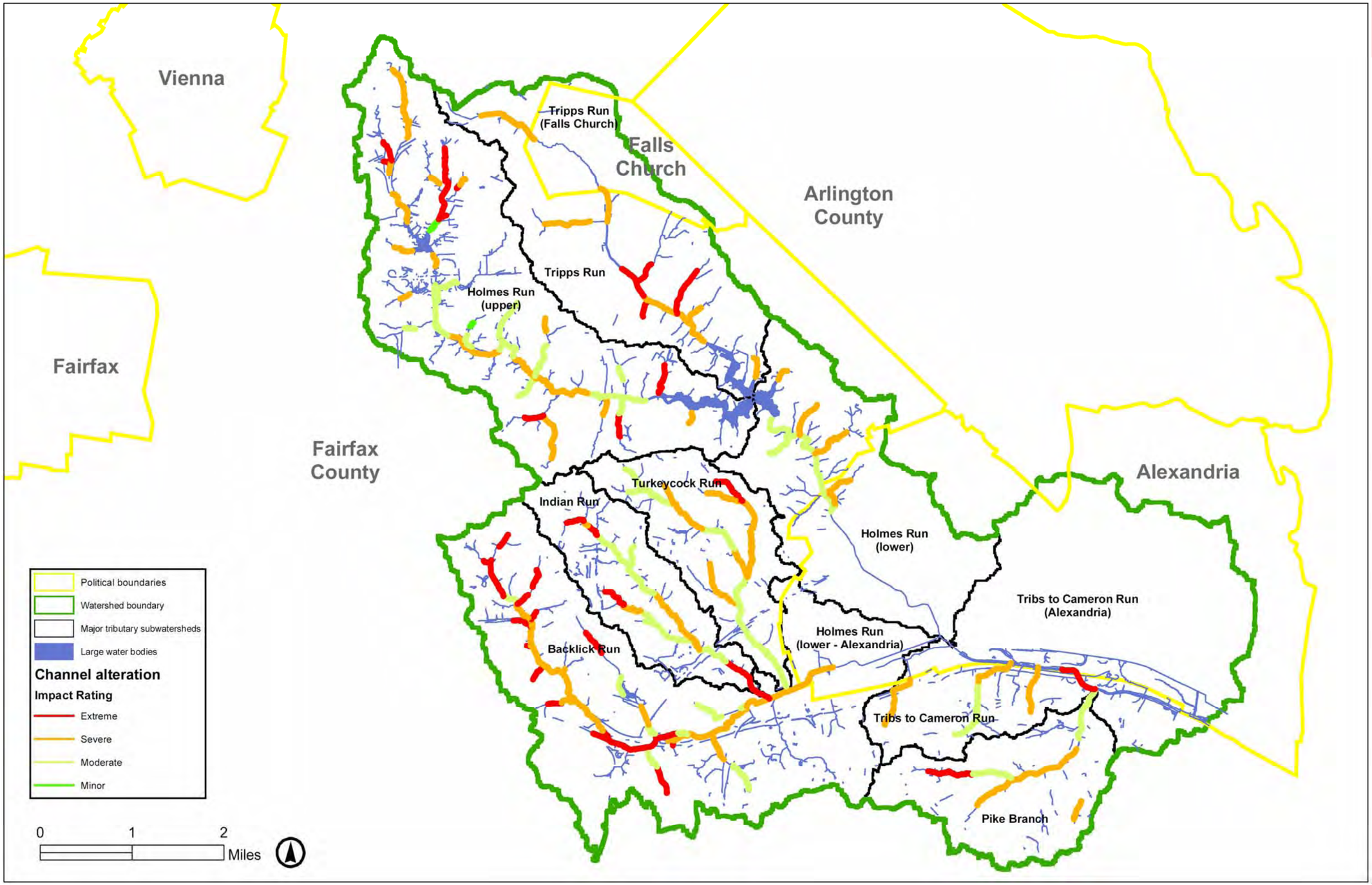

Figure 4-6. Current impact ratings for channel alteration in Cameron Run watershed

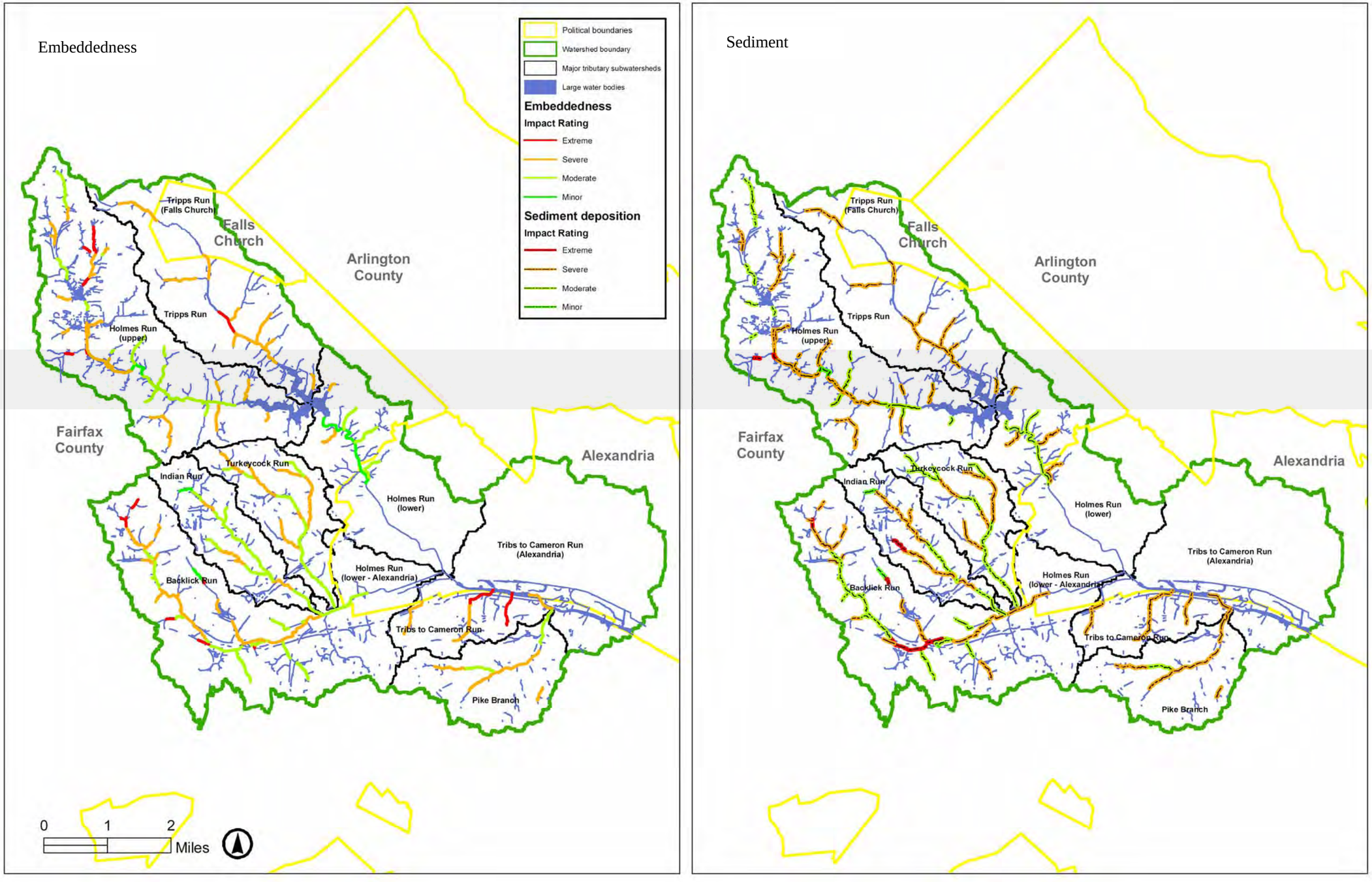

Figure 4-7. Current impact ratings for embeddedness and sediment deposition in Cameron Run watershed

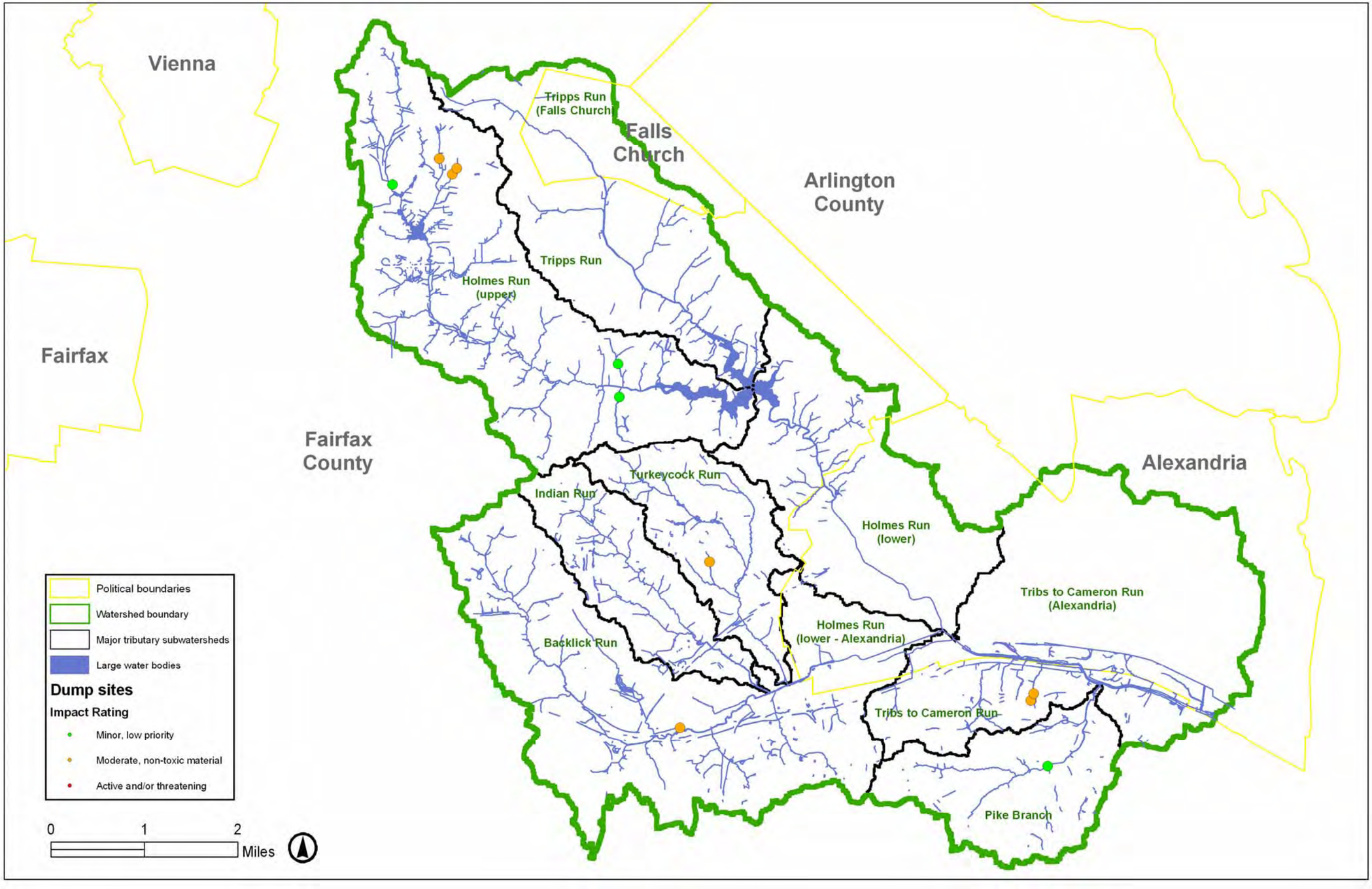

Figure 4-8. Trash dump sites in Cameron Run watershed

Figure 4-9. Threatened infrastructure and Channel Evolution Model (CEM) category in Cameron Run watershed

Virginia Department of Environmental Quality (VADEQ). PCBs were found in white perch, carp, channel cat fish, and American eel, resulting in a health advisory issued by the Virginia Department of Health. Fecal coliform levels were above Virginia's swimmable and fishable water quality standards.

Wildlife habitat conditions in the watershed are favorable for generalists or highly adaptable species. These species include deer, foxes, and raccoons. Large and area-sensitive species have limited habitat in this urban watershed. In 2001, the following wildlife were sighted in the city of Falls Church: raccoons, opossum, rabbits, southern flying squirrels, red and gray foxes, skunks, beavers, deer, muskrats, woodchucks, moles, voles, mice, rats, snapping turtles, and a variety of bats (Parsons Brinckerhoff 1974). This list is representative of wildlife found throughout the watershed.

Vegetation surveys of Cameron Run were conducted in 2001 in the floodplain section between the Metrorail bridge and the Capital Beltway crossing. This section of the stream is characterized by the removal of woody growth from the banks and floodplain, dredging of deposits along the floodplain, rip-rap along the streambanks, and large concrete weirs. There are also storm drains, trash and debris, and large colonies of invasive exotic plants. The sand-and-gravel bars and mudflats support a wide variety of native flora and provide high quality habitat for wildlife. Some of the plant species found growing on the sand-and-gravel bars include floating primrose-willow (*Ludwigia peploides*), marsh seedbox (*Ludwigia palustria*), wing-leaved primrose-willow (*Luswigia decurrens*), bearded flatsedge (*Cyperus squarrosus*), and arrow-leaved tearthumb (*Polygonum sagittatum*) (Bryant et al. 2003).

Land within the watershed is nearly all developed. Approximately 52% of the watershed is occupied by residential land uses (including 5% high-density residential) (Figure 4-10). The watershed has 14% commercial use, and only 1% open water. Open space accounts for 14% of

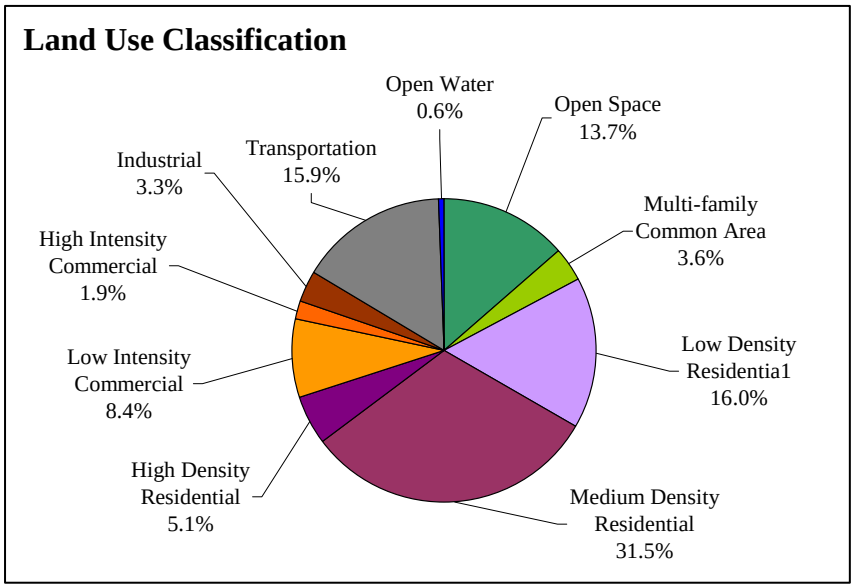

Figure 4-10. Land use in Cameron Run watershed

the watershed, although this land use is highly fragmented throughout the watershed. A few larger areas hold promise for biodiversity conservation (Figure 4-11). Because the watershed is predominantly developed, any new development opportunities involve redevelopment and limited infill. An example of redevelopment could involve converting warehouses into high-rise office buildings. Redevelopment has the potential to create green open space where none previously existed.

Example conditions in the Cameron Run watershed

Stream quality is closely related to the imperviousness of the surrounding landscape. Determining future (ultimate) imperviousness is critical for watershed planning. Fairfax County has developed a robust method for estimating future imperviousness by applying planned or zoned land-use values to underutilized residential/vacant parcels (as determined by the county's comprehensive plan and zoning district designations). Other land parcels are assumed to retain their base-year imperviousness. Figure 4-12 shows estimates of future imperviousness for small subwatersheds within the Cameron Run watershed and its eight large subwatersheds. Table 4-1 combines these values into average imperviousness by large subwatershed and calculates the projected change compared to base-year imperviousness.

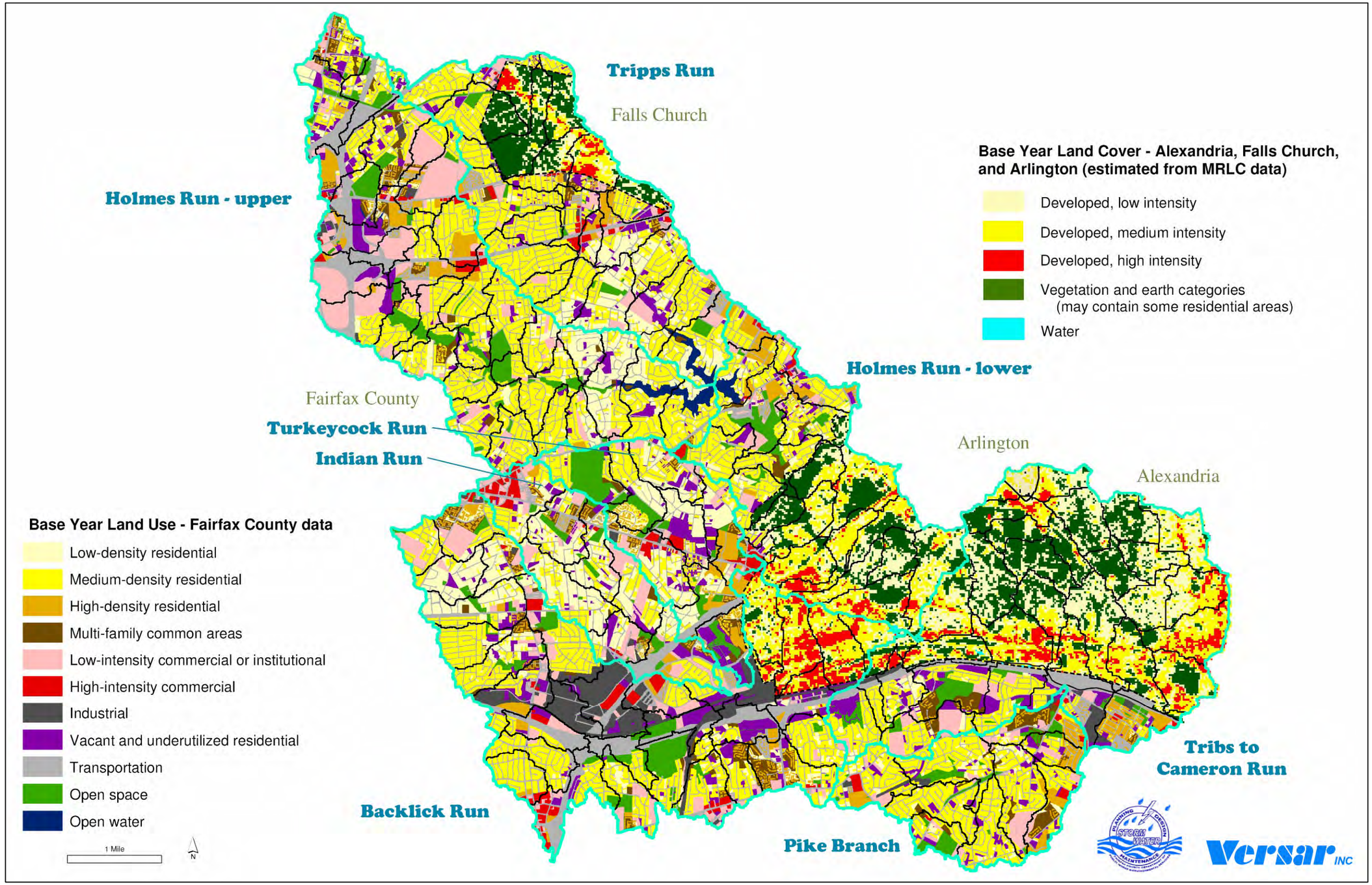

Figure 4-11. Map of land use in the Cameron Run watershed

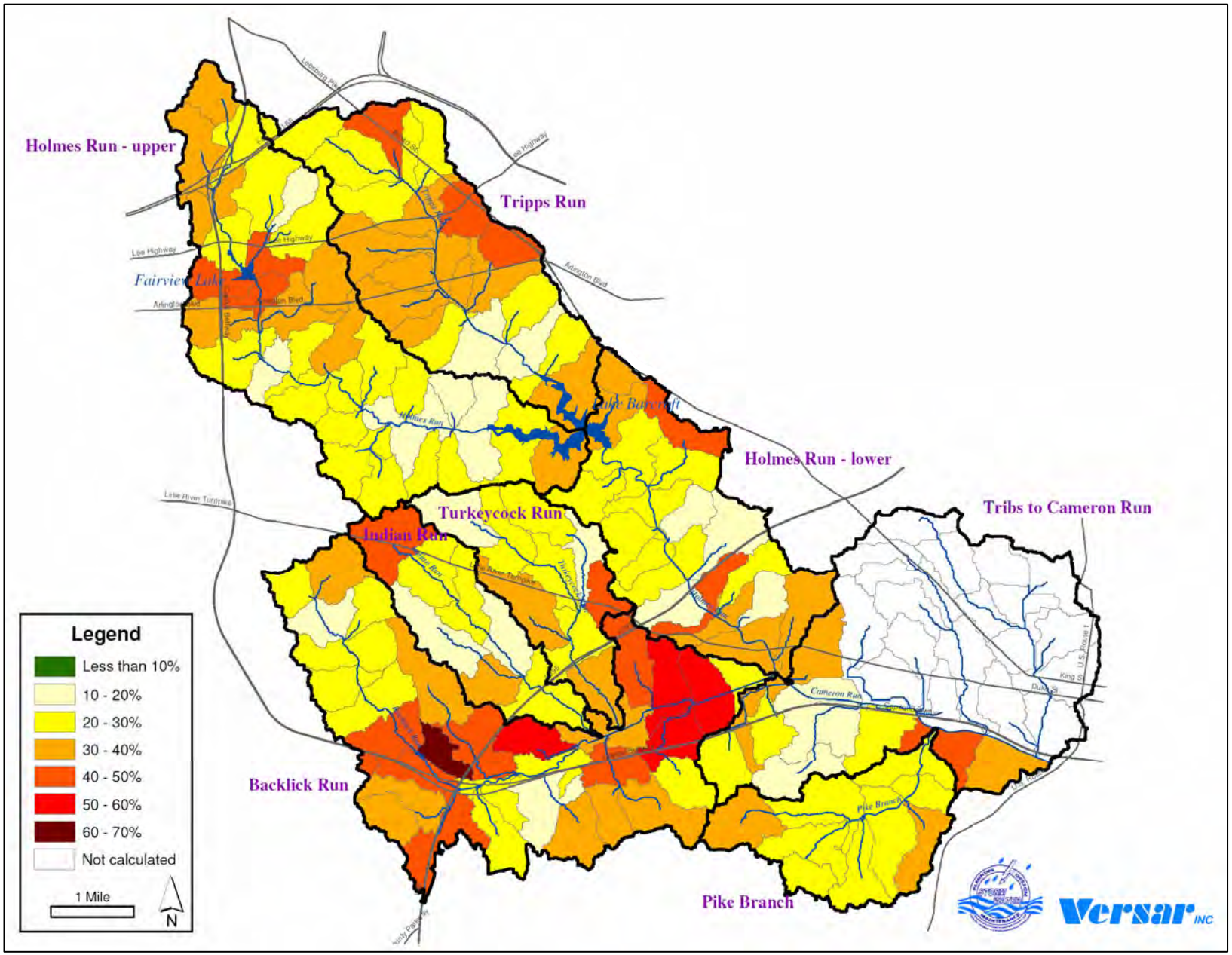

Figure 4-12. Estimates of future imperviousness for small subwatersheds within the Cameron Run watershed

Table 4-1. Cameron Run percent impervious area (Fairfax County area only)			
Subwatershed	**Base Year**	**Future**	**% Increase**
Tripps Run	25.0	29.8	19.1
Holmes Run - Upper	24.5	27.8	13.5
Holmes Run - Lower	25.2	27.5	9.4
Turkeycock Run	21.3	26.3	23.3
Indian Run	25.2	28.6	13.3
Backlick Run	30.7	35.9	16.9
Pike Branch	20.8	25.5	22.5
Tribs to Cameron Run	23.7	29.5	24.6
Weighted Average	25.6	29.8	16.5

As described in Chapter 3 and fully presented in Appendix B, hydrology and pollutant loadings were modeled for the watershed. These models were used to develop estimates of pollutant loads and peak flow for base-year and future conditions in the Cameron Run watershed (Tables 4-2 and 4-3). Peak flows were simulated for storms with estimated recurrence intervals of 1-, 2-, 10-, 25-, and 100-years, which are known as design storms.

Table 4-2. Pollutant loadings in Cameron Run watershed based on SWMM modeling for 1996-1998 hydrologic conditions, for base-year and projected future land use conditions			
	Base Year Land Use (pounds/acre/year)	**Projected Future Land Use** (pounds/acre/year)	**Percent Change**
Total nitrogen	9.8	10.7	9.6%
Total phosphorus	1.14	1.24	8.8%
Dissolved phosphorus	0.81	0.9	11.5%
Biological oxygen demand	64	70	10.5%
Chemical oxygen demand	321	354	10.2%
Total suspended sediment	227	243	6.9%
Lead	0.014	0.015	8.2%
Copper	0.066	0.071	8.1%
Zinc	0.341	0.371	8.8%
Cadmium	0.00056	0.00060	6.2%
Total dissolved solids	276	305	10.3%

Table 4-3. Design storm peak flows in Cameron Run for base year and projected future land use (Fairfax County only)			
Design Storm	**Base Year Land Use** (cfs)	**Projected Future Land Use** (cfs)	**Percent Change**
1-yr	217	229	5.5%
2-yr	287	298	3.8%
10-yr	669	676	1.0%
25-yr	763	779	2.1%
100-yr	1,054	1,089	3.2%

Members of the Advisory Committee and the general public identified the following additional areas of concern for specific locations within the Cameron Run watershed.

- **Sediment inputs and sedimentation**
  - Cameron Run mainstem along I-495
  - Stormwater settling within corrugated pipes located in Falls Church
  - Lake Barcroft dump sites
- **Impervious surfaces (paved land cover)**
  - Baileys Crossroads area, Eisenhower Avenue and Van Dorn Street in Alexandria
  - Cities of Falls Church, Alexandria, and Annandale
  - Seven Corners area, I-395, I-495, and mixing bowl
- **Biological and habitat degradation of good areas**
  - Lake Barcroft area past Columbia Pike (Holmes Run subwatershed)
  - Winkler Pond (Holmes Run subwatershed)
- **Bank erosion and channel instability (with infrastructure impacts)**
  - Tripps Run in Poplar Heights area
  - Inside Mason District Park
  - Backlick Run in the Brookhill area
- **Toxic polluted runoff**
  - Edsall Road Industrial Park
  - Falls Church cement plant
  - Eisenhower trash cogenerator in Culmore
- **High and flashy peak flows**
  - Backlick Run area
- **Riparian buffer loss**
  - Mason District Park
- **Bacteria and pathogens**
  - Dog parks on Eisenhower, Duke Street, and Cameron Station
  - Backlick Run area

- **Flooding**
  - Falls Church
  - Lower/Upper Tripps Run
  - Backlick Road
- **Direct storm inflow**
  - Specific example not given, but members indicated that the city of Falls Church demonstrates all problem issues
- **Trash/dump sites near streams**
  - Culmore area
  - East Telegraph Road
  - Lake Barcroft area
- **Channel alteration of streams**
  - Upper Tripps Run just before entering Falls Church
- **Obstructions in streams**
  - Lake Barcroft area
  - Mainstem obstructions via several dams eastward to Holmes Run
- **Wetlands loss and degradation**
  - Wetlands are virtually nonexistent in Cameron Run watershed
  - Could be loss of wetlands downstream of Alexandria in the Belle Haven watershed

4.2 STATE OF THE SUBWATERSHEDS

Cameron Run watershed comprises the following eight subwatersheds: Tripps Run, Upper Holmes Run, Lower Holmes Run, Turkeycock Run, Indian Run, Backlick Run, Pike Branch, and the Cameron Run mainstem and its direct tributaries. To gain a better understanding of overall conditions in Cameron Run, issues such as flow and contaminant contributions from each of these subwatersheds were evaluated. A detailed examination of these smaller subwatersheds enabled the identification of problem areas and opportunities for conservation, as well as the development of site-specific recommendations targeting such areas. The following sections describe the important characteristics of each subwatershed and summarize land use, stream condition, and problem areas.

4.2.1 State of Tripps Run

4.2.1.1 Subwatershed Characteristics

Tripps Run drains the northern portion of the watershed above Lake Barcroft (Figure 4-13). It covers 14.9 % of the Cameron Run watershed. Its course begins in Fairfax County just north of the Washington and Old Dominion Railroad. Flowing southeast, the stream passes through Falls Church for about one mile (3,000 feet partially underground), reenters Fairfax County adjacent to a commercial area on Lee Highway, and completes its four-mile journey by becoming the north fork of Lake Barcroft. (Before the impoundment was constructed, Tripps Run merged with Holmes Run).

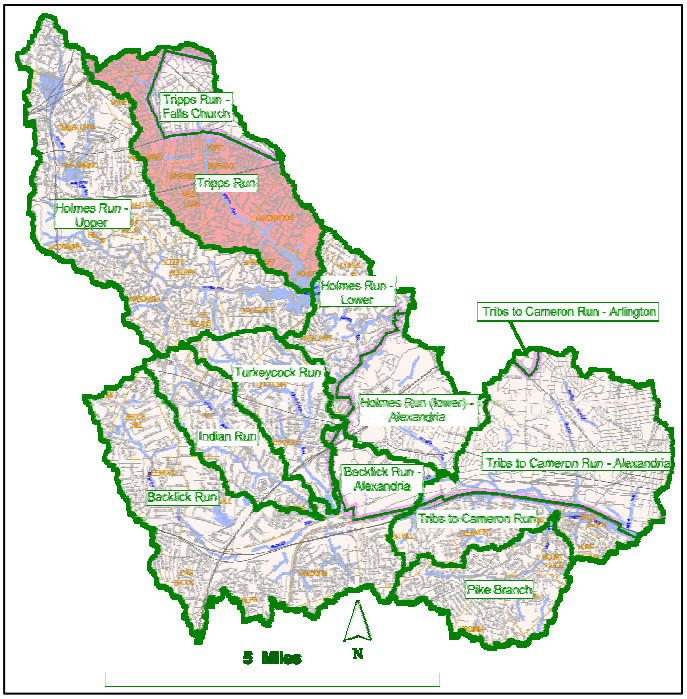

Figure 4-13. Tripps Run subwatershed

The natural stream channel is well defined. During normal, dry-weather flow, the water is about one foot deep. Stream banks rise vertically, averaging about three to four feet above the channel. The stream follows an essentially straight course with gentle curves. Meandering is restricted to the section just above Lake Barcroft. Bottom composition in the natural reaches is a mixture of sand, gravel, and cobble.

The Tripps Run drainage area is the oldest and most developed portion of the watershed, and the stream has suffered from this urbanization. Twenty-five percent (25%) of the subwatershed is impervious; this is estimated to increase to 30% in the future. Medium-density residential development dominates land use within the subwatershed (Figure 4-14). Table 4-4 shows land use, percentages of impervious area for base-year and future conditions, and percent change in land use for the subwatershed. Much of the natural vegetation of the stream valley was cleared during construction; the original woodlands that shaded the stream were replaced with lawns and low brush. The removal of vegetation exacerbated the erosion problems evident throughout the channel. Furthermore, the channel itself was modified. In addition to the 3,000 feet that are piped underground, several sections of Tripps Run in Falls Church are lined with concrete. In Fairfax County, a 4,500-foot section was straightened and lined with concrete from Annandale Rd. to about 3,000 feet upstream of Arlington Blvd. (Parsons Brinckerhoff 1974). In addition, the channel is badly littered with debris, particularly near the commercial area south of Falls Church.

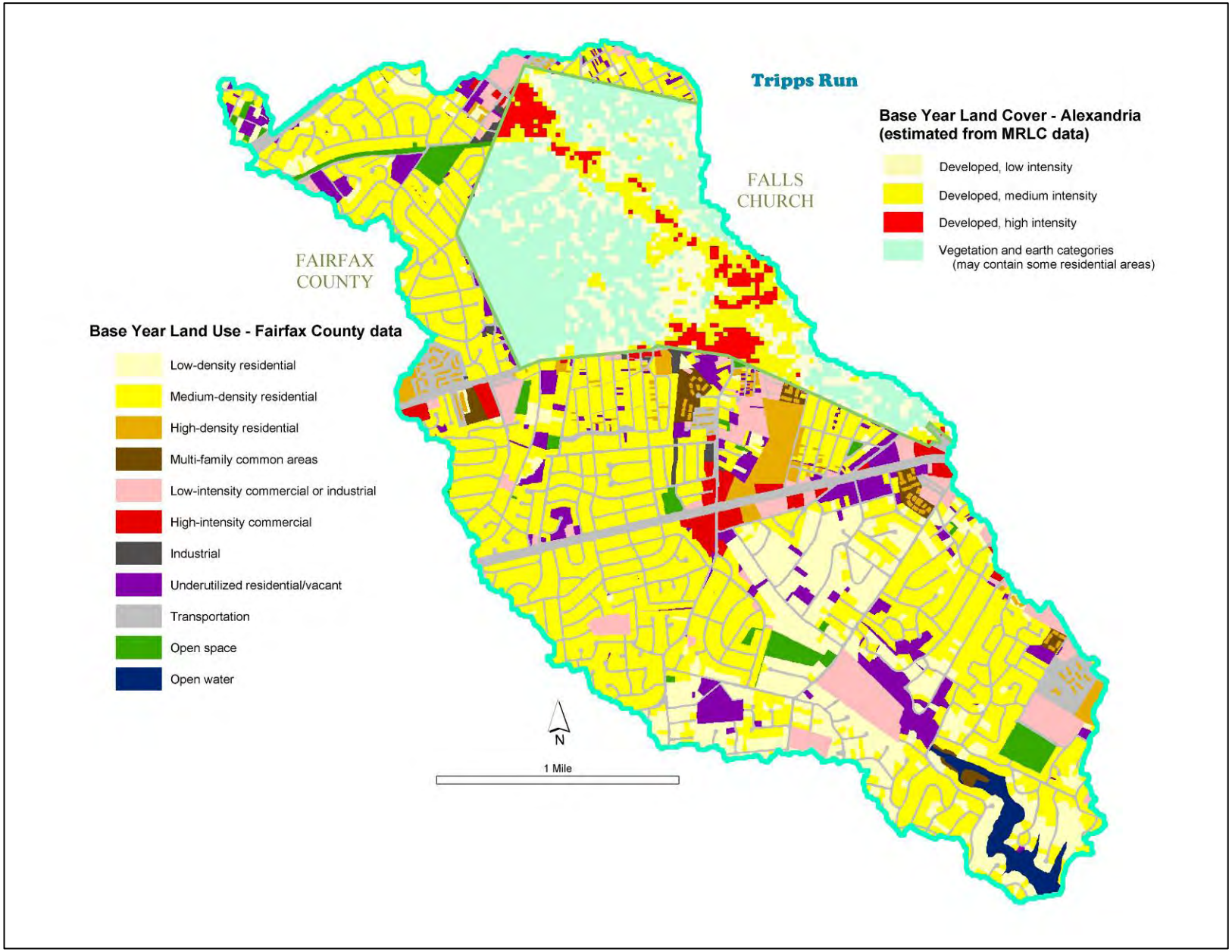

Figure 4-14. Land use map of Tripps Run subwatershed

Table 4-4. Estimates of future land use and percentage of impervious area in the Tripps Run subwatershed			
Subwatershed Area (acres)	3,704		
Land Use	**Base Year (% area)**	**Future (% area)**	**% Change**
Open space	16	13.2	-17.3
Multifamily common area	1.7	1.2	-28
Low-density residential	18.7	18	-3.6
Medium-density residential	37.9	41	8.2
High-density residential	2.8	2.9	3.8
Low-intensity commercial	5.55	5.57	0.4
High-intensity commercial	1.6	2.4	45.5
Industrial	0.45	0.37	-16.8
Transportation	14.3	14.3	0
Open water (Lake Barcroft only)	1.1	1.1	0
Impervious area	25	29.8	19.1

Previous watershed planning studies (e.g., *Cameron Run Environmental Baseline Report*, *Immediate Action Plan Report for the Cameron Run Watershed*, and *Future Basin Plan Report for the Cameron Run Watershed)* have identified several drainage projects that are included in the county's master plan. The county's list of drainage projects shows that 7 of the 12 projects in this subwatershed have been completed; 1 project is active with partial funding, and the remaining 4 projects are inactive. Table 4-5 summarizes the kind of drainage project, project name/location, and current status. No cost estimates were available for these projects.

In 2005, homeowners and other community stakeholders in the Poplar Heights and Falls Hill neighborhoods began working with Fairfax County to address problems with stormwater management and flooding in these neighborhoods bordering Tripps Run. A Stormwater Action Committee was formed to propose a feasible, comprehensive approach for resolving stormwater problems in the neighborhoods. Through an extensive series of meetings, work sessions, and other efforts, the committee developed a comprehensive plan in March 2007 that consisted of values ranked according to priority, overarching principles, and 11 recommended projects. These projects included encouraging LID on private property, planting trees, several focused studies to develop solutions for complex areas, and recommendations for immediate county action at specific sites.

Table 4-6 summarizes the condition of Tripps Run. This information is based on data from the 2001 SPS Baseline Study and the SPA. According to the SPS the overall condition of Tripps Run is very poor.

Table 4-5. Drainage projects in the Tripps Run subwatershed	
Type of Work	**Project Name/Location**
Active Project - Partially Funded	
Replace culvert/streambank stabilization	Falls Hill subdivision
Completed	
Streambank stabilization	Upstream of Sleepy Hollow
Riprap/stabilization	Juniper/Valley
Floodproof house	Juniper Lane
Floodproof houses	Poplar Drive, Falls Hill Subdivision
Gabion/stabilization	Bolling Way, Mason Terrace Subdivision
Streambank stabilization	Tripps Run
Streambank stabilization	Upstream of Annandale
Inactive	
Streambank stabilization	Tripps Run
Culvert addition/streambank stabilization	Tripps Run
Streambank stabilization	Juniper/Tripps
Streambank stabilization	Tripps Run

Table 4-6. Summary of 2001 SPS Baseline Study and SPA results for the Tripps Run subwatershed			
SPS Results		**SPA Results**	
Condition rating	V. Poor	Inadequate buffers (ft.)	37,850
Index of Biotic Integrity score	V. Poor	Eroded streambanks (ft.)	0
Fish taxa richness	V. Low	Habitat assessment	Poor
Base year % impervious	32	Stormdrain pipes	18
		Dumping sites	0
		Headcuts	0
		Exposed utilities	2
		Obstructions	0
		Road crossings	25

4.2.1.2 Problems Areas Identified from SPA Data

An analysis of the SPA data indicates that the major problems within the subwatershed are inadequate buffers, numerous stormdrain pipes, and exposed utilities (Figure 4-15).

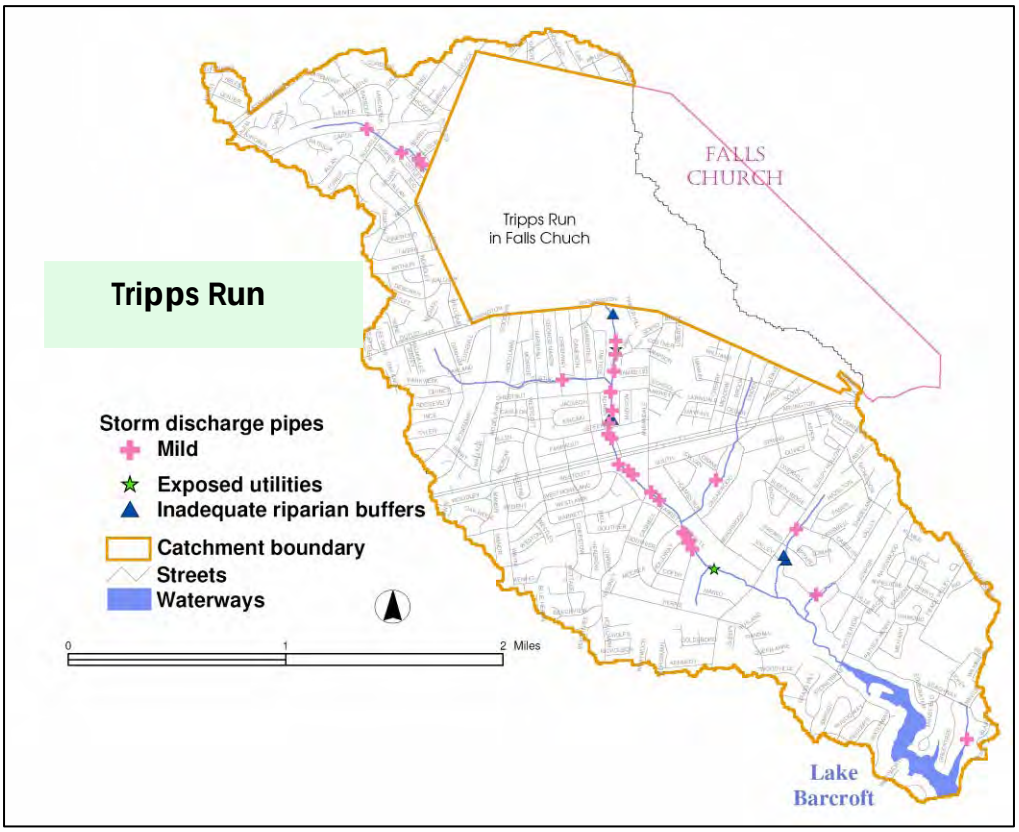

Figure 4-15. Locations of major problems in Tripps Run subwatershed as indicated by SPA data

4.2.1.3 Problem Areas Identified by the Public

Public input about problem areas within Tripps Run was obtained through forums and other avenues. Table 4-7 describes problem areas and potential solutions that were discussed during these meetings.

Channelized portion of Tripps Run

Table 4-7. Problem areas in the Tripps Run subwatershed identified by the public		
Location of Problem	**Description of Problem**	**Potential Solutions**
Between Great Oak Square and adjoining apartment complex	Erosion of stream bank at stormwater drainage and at the entry to Tripps Run.	Provide additional stormwater controls in upland areas to reduce the magnitude and frequency of flows; apply bioengineering and natural stream channel design approaches to stabilize streambanks and bed and improve habitat conditions.
Tripps Run	Channelization throughout the stream	Minimize or mitigate the effects of channelization, especially during maintenance and renovation work, by mimicking natural channel features and function.
Tripps Run (North of Rt. 50)	Channelization	Minimize or mitigate the effects of channelization, especially during maintenance and renovation work, by mimicking natural channel features and function.
Tributary perennial stream from Seven Corners to Tripps Run (Nicholson Lane past Valley Lane along Sleepy Hollow Road)	Spot flooding because the stream receives many storm sewer pipes	Provide additional stormwater controls in upland areas to reduce the magnitude and frequency of flows.
Tributary perennial stream from Seven Corners to Tripps Run (Nicholson Lane past Valley Lane along Sleepy Hollow Road)	Extensive open and closed concrete channels	Minimize or mitigate the effects of channelization, especially during maintenance and renovation work, by mimicking natural channel features and function.
Tripps Run in Poplar Heights area	Bank erosion and channel instability along Tripps Run	Provide additional stormwater controls in upland areas to reduce the magnitude and frequency of flows; apply bioengineering and natural stream channel design approaches to stabilize streambanks and bed, and improve habitat conditions.
Sleepy Hollow area near tributary to Tripps Run	Hazardous waste dumping in tributary to Tripps Run, severe high water flow, erosion, partial concrete channelization	Contact appropriate enforcement officials; provide community hazardous waste collections; install signage with information on collections and consequences of dumping. Provide owners/residents with (1) professional environmental advice, (2) riparian plantings, (3) stormwater controls, (4) retrofitting of concrete channels, (5) pollution monitoring equipment, and (6) neighborhood environmental watch groups.
Far side of Tripps Run behind Bill Page Honda and U.S. Post Office, Annandale Road, and Route 50.	Trash and chemicals in Tripps Run	Implement street sweeping and inlet trash collection program; organize community trash collection events (adopt-a-highway/ adopt-a-stream programs); provide trash receptacles and educational information. Identify chemical source.

Table 4-7. (Continued)		
Location of Problem	**Description of Problem**	**Potential Solutions**
Tributary perennial stream from Seven Corners to Tripps Run (Nicholson Lane past Valley Lane along Sleepy Hollow Road)	Chronic trash pollution in streams	Implement street sweeping and inlet trash collection program; organize community trash collection events (adopt-a-highway/ adopt-a-stream programs); provide trash receptacles and educational information.
Sleepy Hollow	Channelization Storm sewer runoff Pollution	Educate residents about: a) plantings b) stormwater controls c) pollution monitoring equipment d) neighborhood watch and environmental groups e) improving habitat conditions
Poplar Heights	Severe bank erosion Storm runoff	Provide additional stormwater controls in upland areas to reduce the magnitude and frequency of flows; apply bioengineering and natural stream channel design approaches to stabilize streambanks and bed, and improve habitat conditions; construct LID retrofits upstream.
Fairfax County portion of Tripps Run	Stream channelization	Investigate retrofit opportunities and stream restoration.
Custis Parkway	Stream erosion	Stabilize the streambank.
Trips Run south of Holmes Run Road between Annandale and Sleepy Hollow	Abandoned sewer line that occasionally leaches pollutants and other material	Clean up old sewer line.
Opposite side of Tripps Run behind Bill Page Honda and U.S. Post Office, Annandale Road and Route 50	Chemicals and trash in Tripps Run	Find chemical source and clean-up trash.
Potters Drive	Sedimentation	Stabilize streambank and dredge accumulated sediment.
Broad Street office building	Redevelopment of existing office building	Establish controls to minimize deduction of stream and habitat.

4.2.1.4 Modeling Results

Hydrologic modeling for Tripps Run indicates that stormwater runoff is about average within Cameron Run. Imperviousness is slightly below the average for Cameron Run as a whole, but this area has the lowest percentage of area with stormwater controls. The increase in discharges expected due to future development is the highest of the subwatersheds. Table 4-8 compares the existing and future 1-, 2- and 10-year peak discharges in the subwatershed.

The HEC-RAS stream hydraulic model was used to simulate peak water velocity and water levels in stream channels in Cameron Run for storms of various sizes. Peak stream velocities greater than 5 feet per second (fps) indicate the potential for channel erosion. The percentages of stream channels in Tripps Run with peak velocity greater than this value are 44% and 54% for the 1-year and 2-year design storms, respectively. The number of buildings estimated to be in or

touching the 100-year floodplain is 208 for the portion of Tripps Run within Fairfax County. Table 4-9 shows the number of roadway crossings in Fairfax County that will be overtopped by storms of various sizes under base-year and future conditions. Complete modeling details and results are provided in Appendix B.

Table 4-8. Peak runoff flows in the Tripps Run subwatershed

Drainage Area (acres)	3,704		
	1-Year Storm	**2-Year Storm**	**10-Year Storm**
Existing peak flow (cfs)	225	298	673
Future peak flow (cfs)	243	317	697
Percent increase in peak flow	8.0	6.3	3.6

Table 4-9. Number of roadway crossings (bridges) overtopped by design flows for Tripps Run subwatershed

	Present	**Future**
1-year	1	1
2-year	1	1
10-year	2	3
25-year	3	3
100-year	4	4

The Tripps Run subwatershed has an average sediment loading rate among the eight subwatersheds. The subwatershed has slightly above average loadings of total nitrogen and phosphorus. Based on anticipated future land-use conditions, the total nitrogen and phosphorus loading rates are predicted to increase by 6.4% and 5.8%, respectively. Table 4-10 compares the existing and future annual average pollutant loadings in the subwatershed.

Table 4-10. Average annual pollutant loadings (pounds/acre/year) in the Tripps Run sub-watershed

Pollutant	**Total Nitrogen**	**Total Phosphorus**	**Total Suspended Solids**	**Lead**	**Copper**	**Zinc**
Base year	10.1	1.2	222	0.013	0.054	0.293
Future	10.8	1.3	233	0.014	0.057	0.309
% Increase	6.4	5.8	4.7	5.2	5.2	5.5

4.2.2 State of Upper Holmes Run

4.2.2.1 Subwatershed Characteristics

Upper Holmes Run and its tributaries form a major subwatershed draining the northern portion of the Cameron Run watershed (Figure 4-16). It covers 19% of the watershed and includes part of the Lake Barcroft community. Twenty-five percent (25%) of the subwatershed is impervious; imperviousness is estimated to increase to 28% in the future. Medium-density residential development dominates land use within the subwatershed (Figure 4-17). Table 4-11 shows land use, percentage of impervious area for base-year and future conditions, and percent change in land use for the subwatershed. The headwaters of Upper Holmes Run originate just north of Interstate Route 66 in the northernmost section of Cameron Run watershed. The upper reach flows for 7.2 miles in a southerly direction paralleling the Capitol Beltway. It then winds eastward and empties into the south fork of Lake Barcroft. This stream section is marked by meandering areas with an associated pattern of scour and deposition. The channel bottom is composed of varying proportions of sand, gravel, cobble, and, in some areas, boulders (Parsons Brinckerhoff 1974).

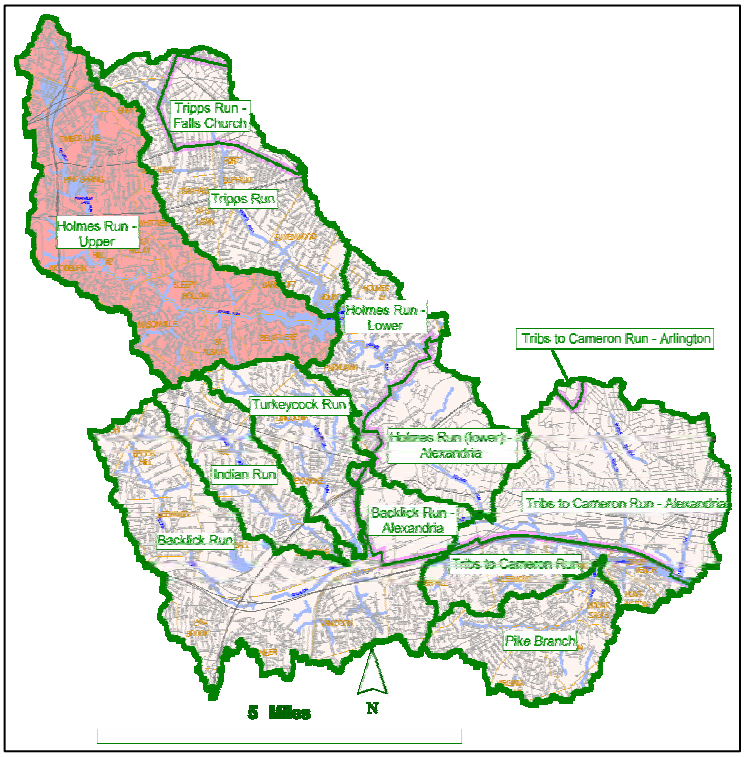

Figure 4-16. Upper Holmes Run subwatershed

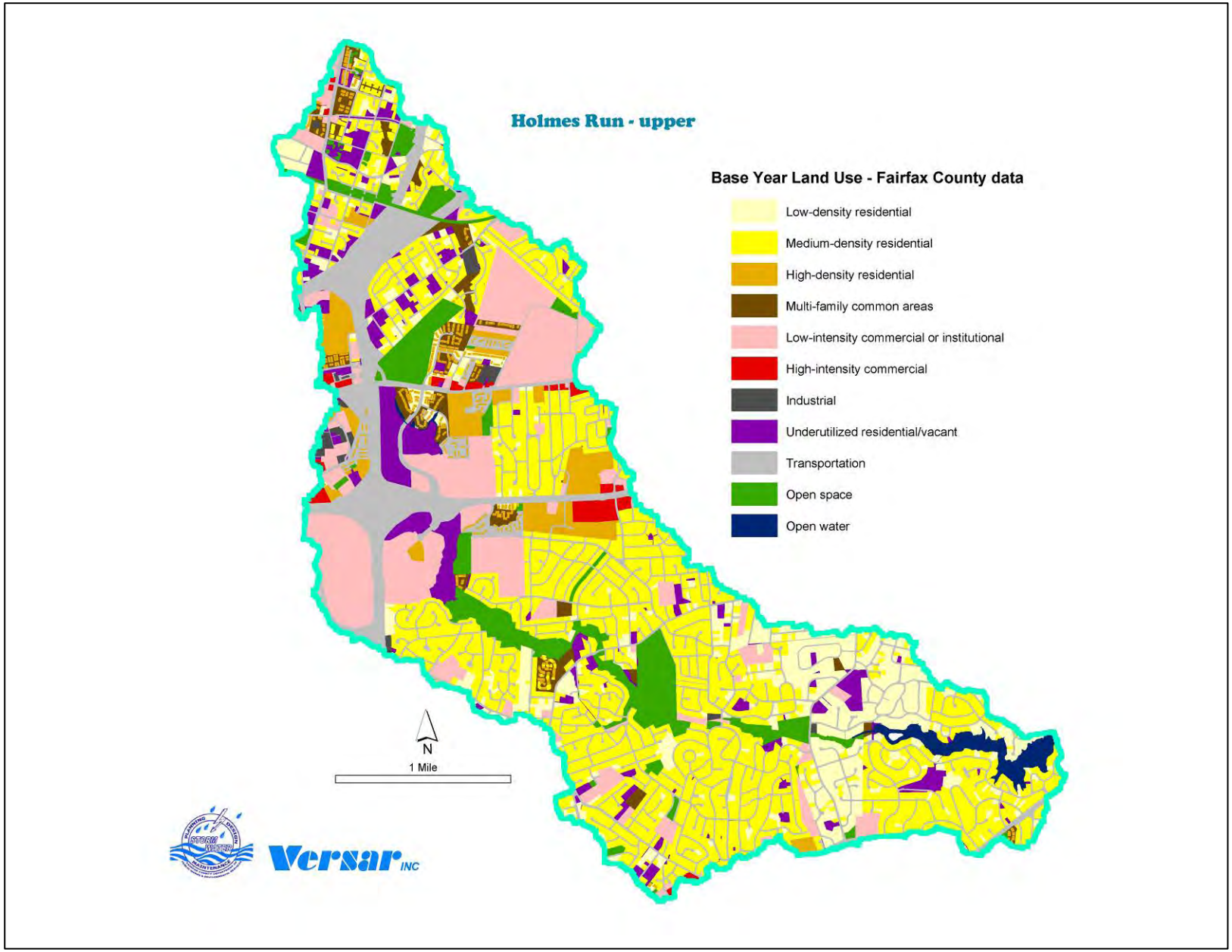

Figure 4-17. Land use map of Upper Holmes Run subwatershed

Table 4-11. Estimates of future land use and percentage of impervious area in the Upper Holmes Run subwatershed			
Subwatershed Area (acres)	5,400		
Land Use	**Base Year (% area)**	**Future (% area)**	**% Change**
Open space	9.7	7.1	-27.1
Multifamily common area	3.5	2.4	-31.4
Low-density residential	12.2	11.7	-4.7
Medium-density residential	33.3	37.2	11.6
High-density residential	4.75	4.82	1.4
Low-intensity commercial	13.2	12.5	-5.2
High-intensity commercial	1.1	1.4	27.6
Industrial	0.7	1.4	121.1
Transportation	19.9	19.9	0
Open water (Lake Barcroft and Fairview Lake)	1.7	1.7	0
Impervious Area	24.5	27.8	13.5

The county's list of drainage projects shows that 7 of the 26 projects in this subwatershed have been completed; 1 project is active with full funding, 2 projects are active with partial funding, 14 projects are inactive, and the status of the remaining 2 projects is not given. Table 4-12 summarizes the kind of drainage project, project name/ location, and current status. No cost estimates were available for these projects.

Table 4-12. Drainage projects in the Upper Holmes Run subwatershed	
Type of Work	**Project Name/Location**
Active Project - Fully Funded	
Replace culvert	Emma Lee Street
Active Project - Partially Funded	
Floodproof houses	Dearborn Drive
Streambank stabilization	Kings Glen Subdivision
Completed	
Streambank stabilization	Holmes Run Phase 1
Stream restoration	Holmes Run E""
Channel improvements	Locker Street
Reservoir construction	Holmes Run Reservoir 2A
Flood relief	Brush Drive
Regional detention pond	Morgan Lane
Regional detention pond	Pinewood Pond

Table 4-12. (Continued)	
Type of Work	**Project Name/Location**
Inactive	
Streambank stabilization with wall	Raleigh Rd. Ph. II
Streambank stabilization	Crest Drive
Streambank stabilization	Shadybrook
Streambank stabilization	Raleigh Road
Streambank stabilization	Brookcrest Place
Streambank stabilization	Rose Lane Holmes Run Ph II
Storm sewer and swale	Locker Street
Floodproof house	Hockett Street
Floodproof houses	Arnold Lane
Gabion/stabilization	Bradley Circle
Streambank stabilization	Annandale Road
Streambank stabilization	Arnold Lane
Streambank stabilization	Crosswoods Drive
Streambank stabilization	Holmes Run Upper
No Status	
Remediation of structure flooding	Holmes Run Upper
Road raising	Holmes Run Upper

Table 4-13 summarizes the condition of Upper Holmes Run. This information is based on data from the 2001 SPS Baseline Study and the SPA. According to the SPS, the overall condition of Upper Holmes Run is very poor.

Table 4-13. Summary of 2001 SPS Baseline Study and SPA results for the Upper Holmes Run subwatershed			
SPS Results		**SPA Results**	
Condition rating	V. Poor	Inadequate buffers (ft.)	93,950
Index of Biotic Integrity score	V. Poor	Eroded streambanks (ft.)	4,590
Fish taxa richness	Variable	Habitat assessment	Fair
Base year % impervious	28	Stormdrain pipes	124
		Dumping sites	6
		Headcuts	0
		Exposed utilities	11
		Obstructions	26
		Road crossings	68

4.2.2.2 Problems Areas Identified from SPA Data

An analysis of the SPA data indicates that the major problems within the subwatershed are inadequate buffers, eroded streambanks, and trash dumpsites (Figure 4-18).

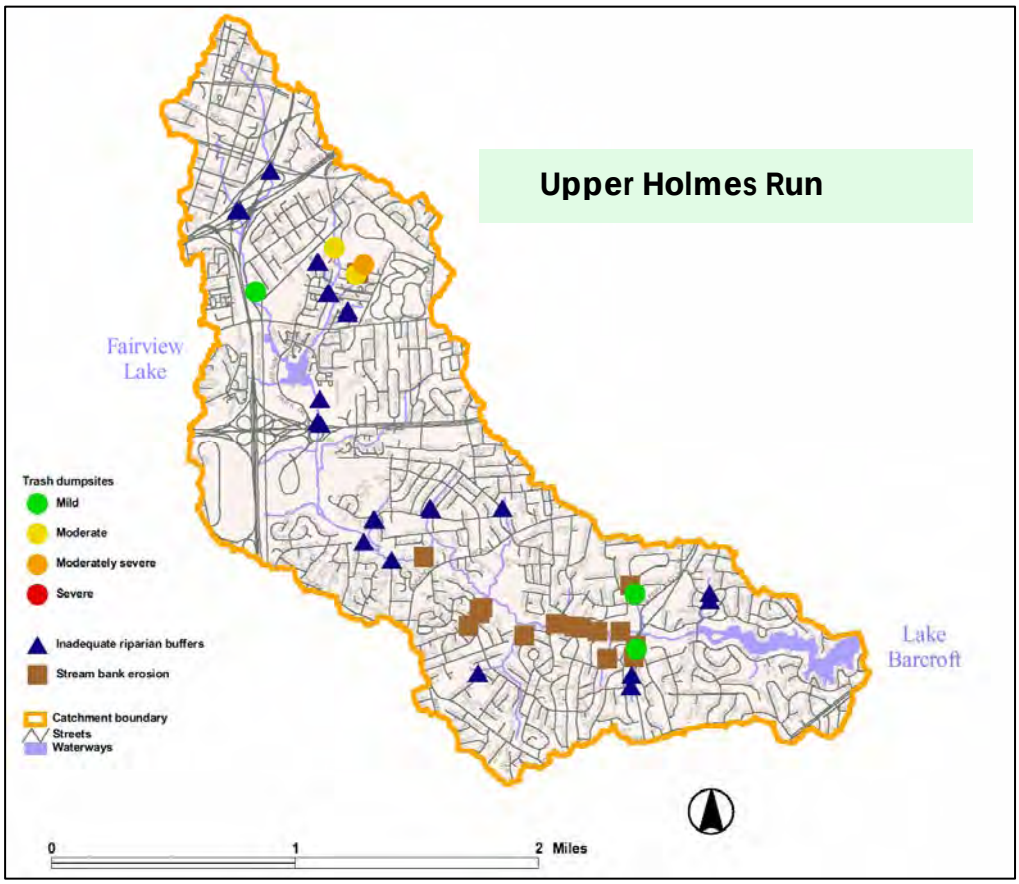

Figure 4-18. Location of major problem areas in Upper Holmes Run subwatershed as indicated by SPA data

4.2.2.3 Problem Areas Identified by the Public

Public input about problem areas within Upper Holmes Run was obtained through forums and other avenues. Table 4-14 describes problem areas and potential solutions discussed during these meetings.

Streambank erosion in Upper Holmes Run

Table 4-14. Problem areas in the Upper Holmes Run subwatershed identified by the public

Location of Problem	Description of Problem	Potential Solution
Holmes Run above Route 29	Dump site	Contact appropriate enforcement officials; provide community hazardous waste collections; install signage with information on collections and consequences of dumping.
Lowemans Plaza	Impervious surface, staging area for winter salting and de-icing	Require clean-up of salt and sand after release by dump trucks (street sweeping).
Valleycrest Drive	Streambank erosion	Stabilize the streambank.
Parcel A of Cloisters	Steep bank erosion	Streambank stabilization.
Glavis Property	Opportunity	Purchase Glavis property land for conservation easement.

4.2.2.4 Modeling Results

Hydrologic modeling for Upper Holmes Run indicates that stormwater runoff is lower than average for the Cameron Run watershed. Upper Holmes Run has a slightly lower than average percentage of imperviousness and the third largest percentage of area with stormwater controls. The expected increase in discharges due to future development is slightly less than average compared with the eight other subwatersheds. Table 4-15 compares the existing and future 1-, 2- and 10-year peak discharges in the subwatershed.

Table 4-15. Peak runoff flows in the Upper Holmes Run subwatershed			
Drainage Area (acres)	5,400		
	1-Year Storm	**2-Year Storm**	**10-Year Storm**
Existing peak flow (cfs)	209	276	647
Future peak flow (cfs)	217	285	649
Percent increase in peak flow	4.2	3.1	0.3

The HEC-RAS stream hydraulic model was used to simulate peak water velocity and water levels in stream channels in Cameron Run for storms of various sizes. Peak stream velocities greater than 5 feet per second (fps) indicate the potential for channel erosion. The percentages of stream channels in Upper Holmes Run with peak velocity greater than this value are 42% and 49%, for the 1-year and 2-year design storms, respectively. The number of buildings estimated to be in or touching the 100-year floodplain is 280 for Upper Holmes Run. Table 4-16 shows the number of roadway crossings overtopped by design storms of various sizes design for base-year and future conditions. Complete modeling details and results are provided in Appendix B.

Table 4-16. Number of roadway crossings (bridges) overtopped by design flows in the Upper Holmes Run subwatershed		
	Present	**Future**
1-year	0	0
2-year	2	2
10-year	2	2
25-year	2	2
100-year	2	2

The Upper Holmes Run subwatershed has a slightly higher than average sediment loading rate, possibly due to the presence of the highest percentage of low-intensity commercial/ institutional area in Cameron Run. The Upper Holmes Run subwatershed has slightly higher than average annual loadings of total nitrogen and phosphorus. For future land use conditions, the total nitrogen and phosphorus loadings are predicted to increase by 6.3% and 5.7%, respectively. Table 4-17 compares the existing and future annual average pollutant loadings in the subwatershed.

Table 4-17. Average annual pollutant loadings (pounds/acre/year) in the Upper Holmes Run subwatershed						
Pollutant	**Total Nitrogen**	**Total Phosphorus**	**Total Suspended Solids**	**Lead**	**Copper**	**Zinc**
Base year	10.0	1.16	236	0.013	0.068	0.350
Future	10.6	1.23	247	0.014	0.072	0.370
% Increase	6.3	5.7	4.7	6.7	4.9	5.7

4.2.3 State of Lower Holmes Run

4.2.3.1 Subwatershed Characteristics

Lower Holmes Run starts below the Barcroft Dam at Columbia Pike (Figure 4-19). The subwatershed covers 12.9% of the Cameron Run watershed and includes most of the Lake Barcroft community. Twenty-five percent (25%) of the subwatershed is impervious; imperviousness is predicted to increase to 28% in the future. Medium-density residential development dominates land use within the subwatershed (Figure 4-20). Table 4-18 shows land use, percentages of impervious area for the base-year and the future, and the percent change in land use for the subwatershed. Lower Holmes Run flows southeast toward its confluence with the mainstem of Cameron Run near the Cameron Station Military Reservation in Alexandria. Only a short portion of this stream lies in Fairfax County proper. This portion of the stream is relatively straight and wide; nevertheless, a few small bends have collected debris and are sites of severe erosion and heavy siltation (Parsons Brinckerhoff 1974).

Figure 4-19. Lower Holmes Run subwatershed

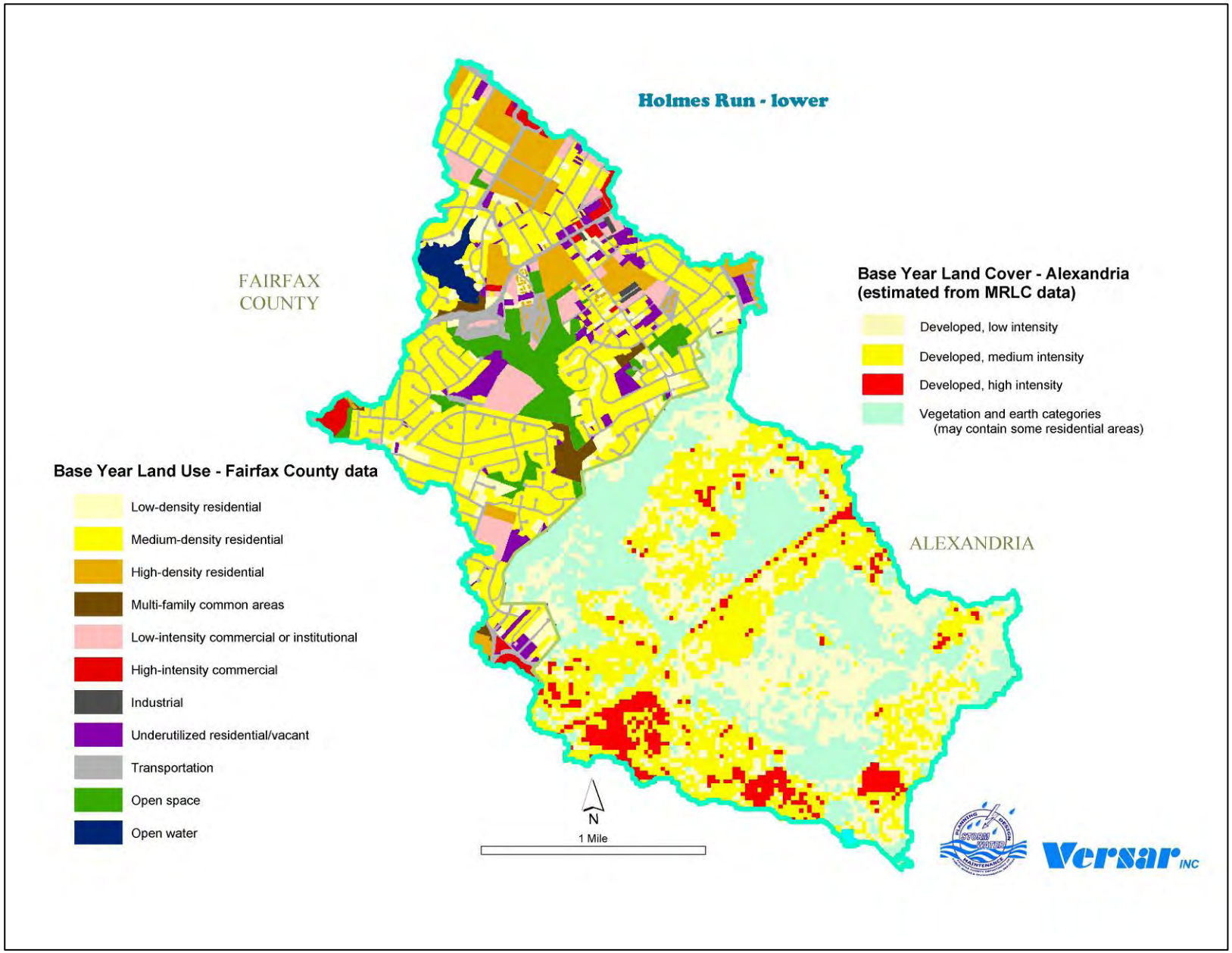

Figure 4-20. Land use map of Lower Holmes Run subwatershed

Table 4-18. Estimates of future land use and percentage of impervious area in the Lower Holmes Run subwatershed			
Subwatershed Area (acres)	3,201		
Land Use	**Base Year (% area)**	**Future (% area)**	**% Change**
Open space	23	20.5	-11.2
Multifamily common area	1	0.8	-22.2
Low-density residential	22.3	22	-1.5
Medium-density residential	34	36.8	8.1
High-density residential	5.40	5.60	3.7
Low-intensity commercial	4.37	4.44	1.7
High-intensity commercial	1.6	1.8	11.2
Industrial	0.7	0.6	-9.4
Transportation	6.7	6.7	-0.1
Open water # (Lake Barcroft only)	0.9	0.9	0
Impervious area	25.2	27.5	9.4

The county's list of drainage projects shows that one of the four projects in this subwatershed has been completed; one project is active with partial funding, and the remaining two projects are inactive. Table 4-19 summarizes the kind of drainage project, project name/location, and current status. No cost estimates were available for these projects.

Table 4-19. Drainage projects in the Lower Holmes Run subwatershed	
Type of Work	**Project Name/Location**
Active Project - Partially Funded	
Flood protection	Magnolia Lane PhII
Completed	
Gabion/stabilization	Downstream of Columbia Pike
Inactive	
Streambank stabilization	Alexandria City Line
Streambank stabilization	Drummond Drive

Table 4-20 summarizes the condition of Lower Holmes Run. This information is based on data from the 2001 SPS Baseline Study and the SPA. According to the SPS the overall condition of Lower Holmes Run is very poor.

Table 4-20. Summary of 2001 SPS Baseline Study and SPA results for the Lower Holmes Run subwatershed			
SPS Results		**SPA Results**	
Condition rating	V.Poor	Inadequate buffers (ft.)	10,300
Index of Biotic Integrity score	Fair	Eroded streambanks (ft.)	0
Fish taxa richness	Low	Habitat assessment	Fair
Base year % impervious	28	Stormdrain pipes	10
		Dumping sites	0
		Headcuts	0
		Exposed utilities	1
		Obstructions	1
		Road crossings	3

4.2.3.2 Problems Areas Identified from SPA Data

An analysis of the SPA data indicates that the major problems within the subwatershed are inadequate buffers and numerous stormdrain pipes (Figure 4-21).

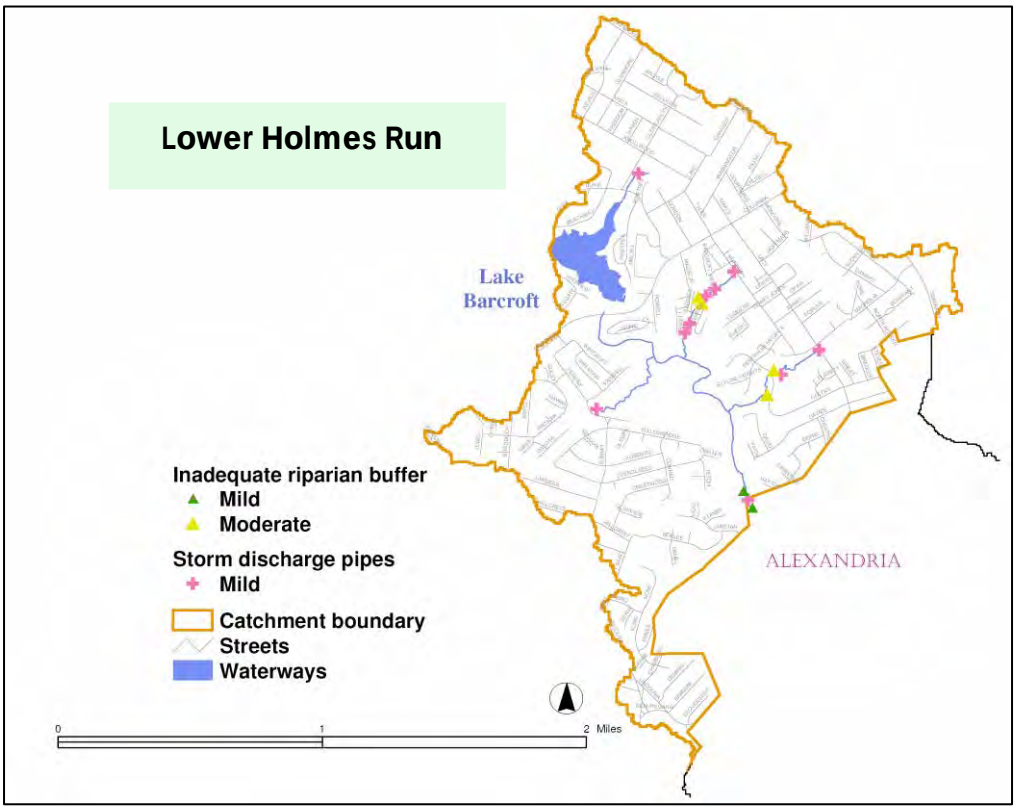

Figure 4-21. Location of problem areas in Lower Holmes Run subwatershed as indicated by SPA data

4.2.3.3 Problem Areas Identified by the Public

Public input about problem areas within Lower Holmes Run was obtained through forums and other avenues. Table 4-21 describes problem areas and potential solutions discussed during these meetings.

Table 4-21. Problem areas in the Lower Holmes Run subwatershed identified by the public

Location of Problem	Description of Problem	Potential Solution
Culmore Residential Area behind Culmore Shopping Center (along Glen Carlyn Road, off Route 7, down to Blair Rd. area)	Trash and oil on street; oil and auto fluids dumped into storm drains	Contact appropriate enforcement officials; provide community hazardous waste collections; install signage with information on collections and consequences of dumping.
Lower Holmes Run Park (below Lake Barcroft)	Degradation of habitats and bank erosion	Provide additional stormwater controls in upland areas to reduce the magnitude and frequency of flows; apply bioengineering and natural stream channel design approaches to stabilize streambanks and bed, and improve habitat conditions.
Culmore Creek	High bacteria levels in stream	Find source.
JEB Stuart Stream Valley	Invasives	Remove invasives and re-establish riparian buffer.
Marshall Property	Uncontrolled dumpsite	Clarify zoning issues and inspect the dumpsite.
"Barcroft Blight" Apartment Complex	Trash Undercut banks	Stabilize the streambank and remove trash.
Holmes Run Trail (below Barcroft Dam) Columbia Pike to Old Towne Alexandria to the Potomac River (ADC map 16/E13 is where the trail stops)	The trail runs from below the Lake Barcroft Dam to the Potomac except where the trail ends around the private pool.	Extend the walking path.
JEB Stuart High School Parking Lot	Excessive runoff	Install permeable pavers and bioretention areas.

4.2.3.4 Modeling Results

Hydrologic modeling for Lower Holmes Run indicates that stormwater runoff is about average. Imperviousness is also about average compared to Cameron Run as a whole. The increase in discharges due to future development is a little above average compared to the other subwatersheds. Table 4-22 compares the existing and future 1-, 2- and 10-year peak discharges in the subwatershed.

Table 4-22. Peak runoff flows in Lower Holmes Run			
Drainage Area (acres)	3201		
	1-Year Storm	**2-Year Storm**	**10-Year Storm**
Existing peak flow (cfs)	219	292	674
Future peak flow (cfs)	232	303	675
Percent increase in peak flow	5.9	3.9	0.1

The HEC-RAS stream hydraulic model was used to simulate peak water velocity and water levels in stream channels in Cameron Run for storms of various sizes. Peak stream velocities greater than 5 feet per second (fps) indicate the potential for channel erosion. The percentages of stream channels in Lower Holmes Run with peak velocity greater than this value are 86% and 89%, for the 1-year and 2-year design storms, respectively. The number of buildings estimated to be in or touching the 100-year floodplain is 16 for the portion of Lower Holmes Run that lies within Fairfax County. No roadway crossings were overtopped by storms of various sizes for base-year or future conditions in Lower Holmes Run. Complete modeling details and results are provided in Appendix B.

The Lower Holmes Run subwatershed has the second lowest sediment loading rate of the eight subwatersheds because it has smaller areas of commercial and industrial development. This subwatershed also has the second lowest annual loadings of total phosphorus and nitrogen of the eight subwatersheds. This can be attributed to the relatively small percentage of highly developed land in the watershed. This subwatershed is among the least in proportion of industrial development. For future land use conditions, the annual loadings of nitrogen and phosphorus are predicted to increase by 10.0% and 9.6%, respectively. Table 4-23 compares the existing and future annual average pollutant loadings in the subwatershed.

Table 4-23. Average annual pollutant loadings (pounds/acre/year) in Lower Holmes Run subwatershed						
Pollutant	**Total Nitrogen**	**Total Phosphorus**	**Total Suspended Solids**	**Lead**	**Copper**	**Zinc**
Base year	8.9	1.1	201	0.012	0.061	0.27
Future	9.8	1.2	215	0.013	0.065	0.295
% Increase	10.0	9.6	6.7	6.9	7.3	7.7

4.2.4 State of Turkeycock Run

4.2.4.1 Subwatershed Characteristics

This subwatershed covers 6.1% of the Cameron Run watershed and includes the Mason District Park (Figure 4-22). Twenty-one percent (21%) of the subwatershed is impervious; future imperviousness is estimated to be 26%. Medium-density residential development dominates land use within the subwatershed (Figure 4-23). Table 4-24 shows land use, percentage of impervious area for the base year and the future, and the percent change in land use for the subwatershed. Turkeycock Run is formed by the confluence of two tributaries below Little River Turnpike. The stream follows a southeasterly course toward its confluence with Backlick Run, just north of the Southern Railroad embankment.

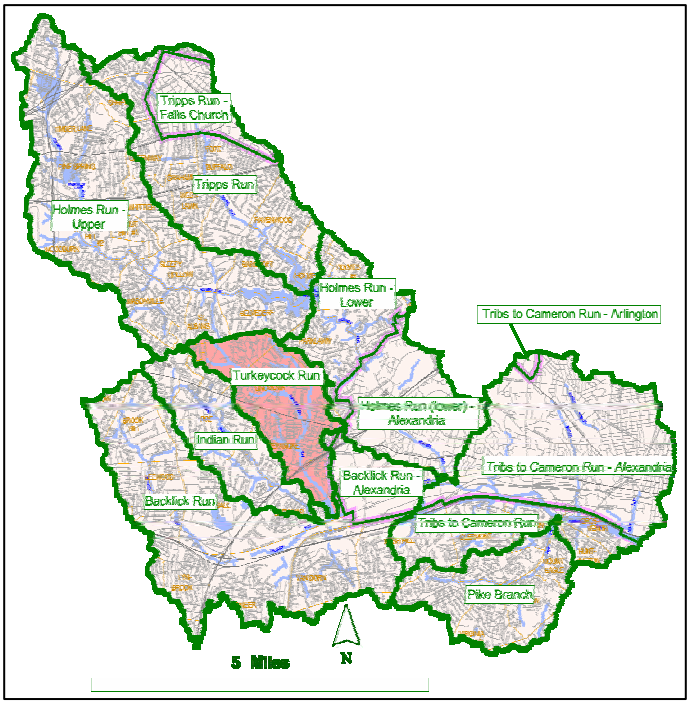

Figure 4-22. Turkeycock Run subwatershed

The stream can be divided into three sections defined by changes in character. (1) From Edsall Road to Backlick Run, the stream was straightened, and the channel is about 40 feet wide. There is little vegetative cover within the largely commercial flood plain. The banks are lined with riprap to control erosion. Heavy areas of sedimentation are common due to deposits transported from upstream reaches. (2) The stream meanders extensively in a 20-foot wide channel above Edsall Road and below Little River Turnpike, except for a section that was straightened and passes through culverts under I-395. Below I-395, the stream passes through a relatively undeveloped area; above the highway the land is largely residential. In this section the flood plain is relatively flat, and the vegetative cover varies from dense underbrush to cropped lawn cover. The pattern of meander in this section is accompanied by severe erosion and heavy

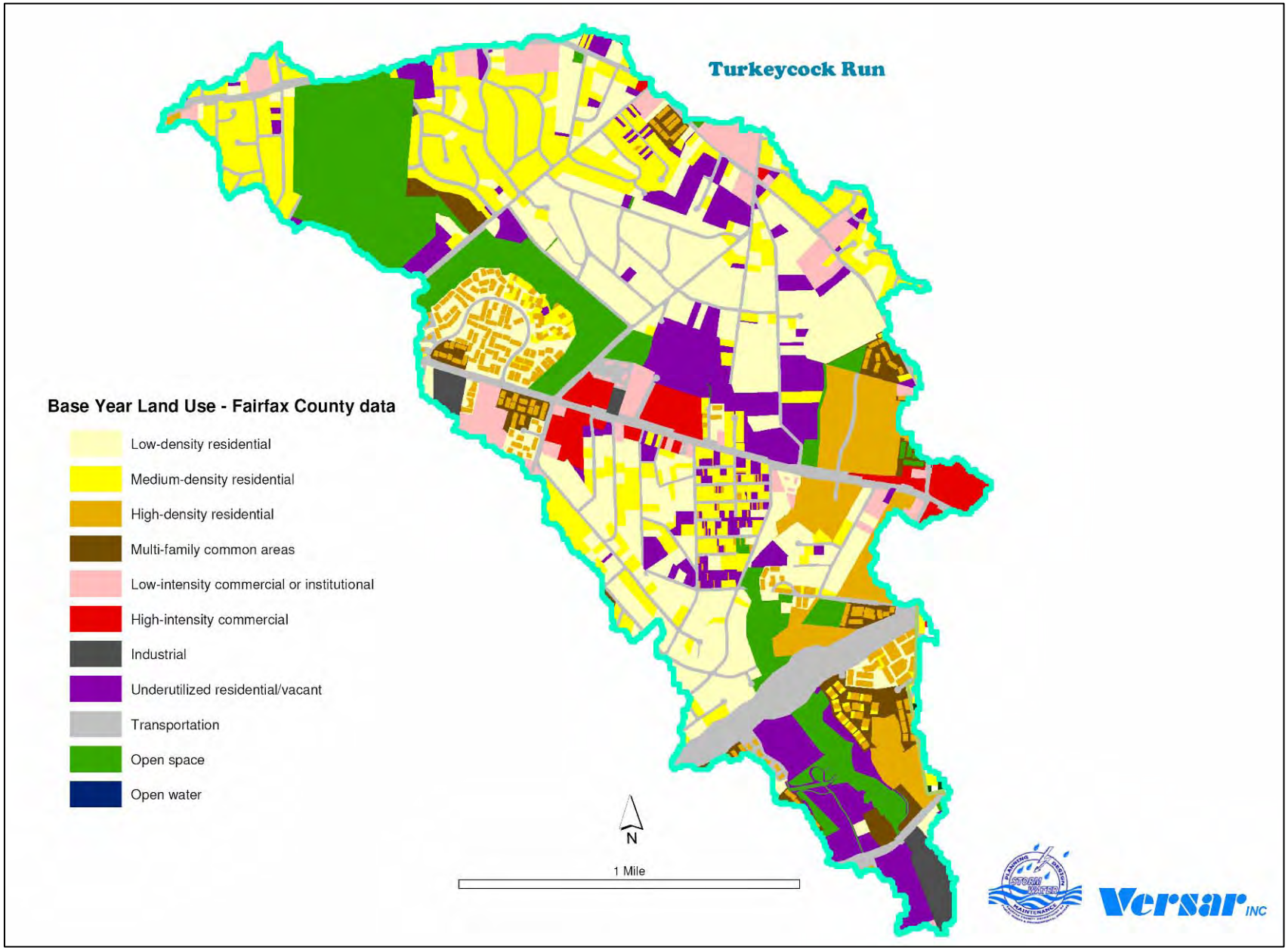

Figure 4-23. Land use map of Turkeycock Run subwatershed

Table 4-24. Estimates of future land use and percentage of impervious area in Turkeycock Run subwatershed			
Subwatershed Area (acres)	1,725		
Land Use	**Base Year (% area)**	**Future (% area)**	**% Change**
Open space	21.4	8.8	-59
Multifamily common area	7.2	4.4	-38.6
Low-density residential	23.0	27.5	19.8
Medium-density residential	15.9	23.2	46.1
High-density residential	9.5	9.6	1.6
Low-intensity commercial	4.5	7.6	69.9
High-intensity commercial	2.9	3.2	9.1
Industrial	1.4	1.4	-0.2
Transportation	14.4	14.4	0
Impervious area	21.3	26.3	23.3

sedimentation. (3) In the tributary headwaters, meander is greatly attenuated, and erosion is correspondingly reduced. The channel's inability to accommodate increased surface runoff causes minor flooding in many areas (Parsons Brinckerhoff 1974).

The county's list of drainage projects shows that 3 of the 11 projects in this subwatershed have been completed, and the remaining 8 projects are inactive. Table 4-25 summarizes the type of drainage project, project name/location, and current status. No cost estimates were available for these projects.

Table 4-25. Turkeycock Run Master Plan drainage projects	
Type of Work	**Project Name/Location**
Completed	
Gabion and riprap/stabilization	Turkeycock Creek
Floodproof houses	Chowan Avenue
Streambank stabilization	6481 Seventh Street
Inactive	
Streambank stabilization	Chowan Avenue
Streambank stabilization	Eighth St
Stormdrain improvement/reinforced concrete box culvert	Holyoke-Piney Lane
Culvert addition	Braddock Road
Culvert addition	Old Columbia Pike
Streambank stabilization	Edsall/Shirley Highway
Streambank stabilization	Downstream of Braddock Road
Streambank stabilization	Upstream of Braddock Road

Table 4-26 summarizes the condition of Turkeycock Run. This information is based on data from the 2001 SPS Baseline Study and the SPA. According to the SPS the overall condition Turkeycock Run is poor.

Table 4-26. Summary of 2001 SPS Baseline Study and SPA results for the Turkeycock Run subwatershed

SPS Results		SPA Results	
Condition rating	Poor	Inadequate buffers (ft.)	51,615
Index of Biotic Integrity score	V.Poor	Eroded streambanks (ft.)	4,295
Habitat score	Fair	Habitat assessment	36
Fish taxa richness	Low	Stormdrain pipes	1
Base year % impervious	23	Dumping sites	2
		Headcuts	4
		Exposed utilities	11
		Obstructions	38
		Road crossings	51,615

4.2.4.2 Problems Areas Identified from SPA Data

An analysis of the SPA data indicates that the major problems within the subwatershed are inadequate buffers, eroded streambanks, and obstructions of stream flow (Figure 4-24).

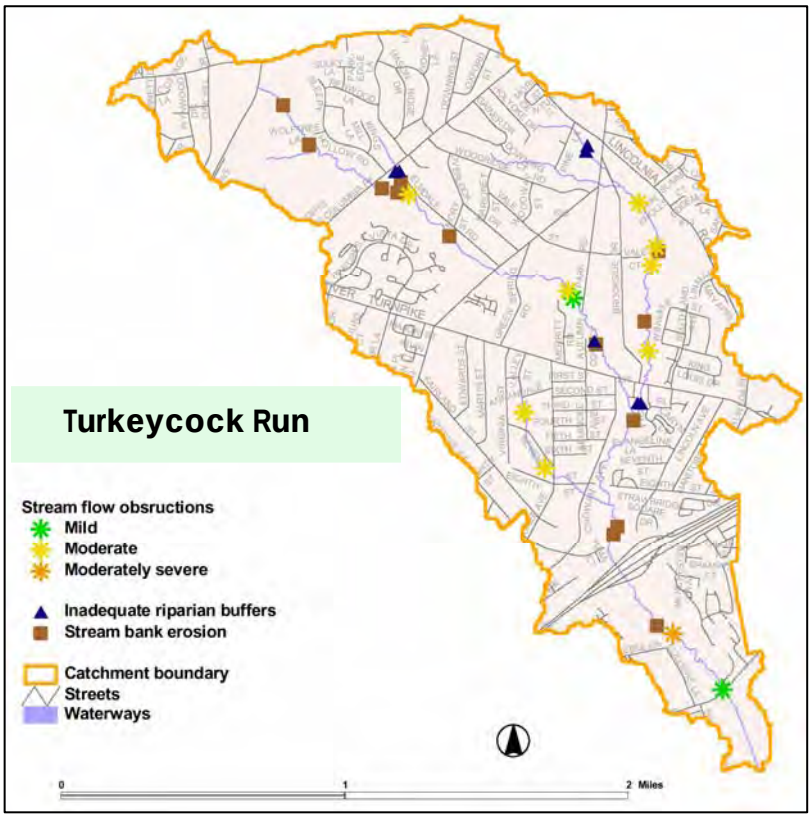

Figure 4-24. Location of major problems in Turkeycock Run subwatershed as indicated by SPA data

4.2.4.3 Problem Areas Identified by the Public

Public input on problem areas within Turkeycock Run was obtained through watershed forums and other avenues. Table 4-27 describes problem areas and potential solutions that were discussed during these meetings.

Streambank erosion along Turkeycock Run

Table 4-27. Problem areas in the Turkeycock Run subwatershed identified by the public

Location of Problem	Description of Problem	Potential Solution
Predominantly industrial area/ boating companies	Collection of upstream trash.	Organize stream clean-up.
Turkeycock/Braddock Rd.	Dog walking. Look into golf course management. Lots of geese, bad water quality downstream of golf course.	Doggy mitts/clean-up.
Mason District Park	Bank erosion and channel instability. Riparian buffer loss in the park.	Provide additional stormwater controls in upland areas to reduce the magnitude and frequency of flows; apply bioengineering and natural stream channel design approaches to stabilize streambanks and bed, and improve habitat conditions. Plant riparian vegetation along stream.

4.2.4.4 Modeling Results

Hydrologic modeling indicates that stormwater runoff in the Turkeycock Run subwatershed is the lowest within Cameron Run due to the lower density of development in this area. This subwatershed has the second lowest imperviousness within Cameron Run as a whole and the greatest percentage of area with stormwater controls. The increase in discharges due to future development is also lowest compared to the other subwatersheds. Table 4-28 compares the existing and future 1-, 2- and 10-year peak discharges in the subwatershed.

Table 4-28. Peak runoff flows in the Turkeycock Run subwatershed			
Drainage Area (acres)	1,725		
	1-Year Storm	**2-Year Storm**	**10-Year Storm**
Existing peak flow (cfs)	182	244	611
Future peak flow (cfs)	185	242	614
Percent increase in peak flow	1.9	-0.7	0.5

The HEC-RAS stream hydraulic model was used to simulate peak water velocity and water levels in stream channels in Cameron Run for storms of various sizes. Peak stream velocities greater than 5 feet per second (fps) indicate the potential for channel erosion. The percentages of stream channels in Turkeycock Run with peak velocity greater than this value are 36% and 59%, for the 1-year and 2-year design storms, respectively. The number of buildings estimated to be in or touching the 100-year floodplain is 46 for Turkeycock Run. No roadway crossings were overtopped by storms of various sizes for base-year or future conditions in Turkeycock Run. Complete modeling details and results are provided in Appendix B.

The Turkeycock Run subwatershed has the lowest sediment loading rate of the eight subwatersheds due to the lower density of development in the area. Turkeycock Run subwatershed also has the lowest annual loadings of total nitrogen and phosphorus of the eight subwatersheds. For future land use conditions, the total nitrogen and phosphorus loadings are predicted to increase by 19.7% and 19.0%, respectively. This is the greatest anticipated increase in loadings within Cameron Run and is due to the greater increase in development expected in the subwatershed. Table 4-29 compares the existing and future annual average pollutant loadings in the subwatershed.

Table 4-29. Average annual pollutant loadings (pounds/acre/year) in the Turkeycock Run subwatershed.						
Pollutant	**Total Nitrogen**	**Total Phosphorus**	**Total Suspended Solids**	**Lead**	**Copper**	**Zinc**
Base year	8.0	1.0	176	0.011	0.057	0.253
Future	9.6	1.1	203	0.012	0.067	0.303
% Increase	19.7	19.0	15.1	12.7	18.2	19.6

4.2.5 State of Indian Run

4.2.5.1 Subwatershed Characteristics

Indian Run subwatershed covers 5.6% of the Cameron Run watershed (Figure 4-25). Twenty-five percent (25%) of the subwatershed is impervious; future imperviousness is estimated to increase to 29%. Medium-density residential development dominates land use within the subwatershed (Figure 4-26). Table 4-30 shows land use and percentages of impervious area for base-year and future conditions, and percent change in land use for the subwatershed. The headwaters of Indian Run originate near Little River Turnpike. From there, the stream flows southeast for approximately 3.6 miles toward its confluence with Backlick Run near Bren Mar Park. Streambank cover below Bren Mar Drive is dense, consisting mainly of low brush and trees. From Bren Mar Drive to Edsall Road the stream flows through a residential park, where the floodplain is covered with cropped lawn.

Severe stream meanders, along with erosion and sedimentation, are characteristic of Indian Run and its main tributary, Poplar Run. Severe erosion, sedimentation, and debris restricts flow at a large bend in the stream about 300 feet upstream of Edsall Road (Parsons Brinckerhoff 1974).

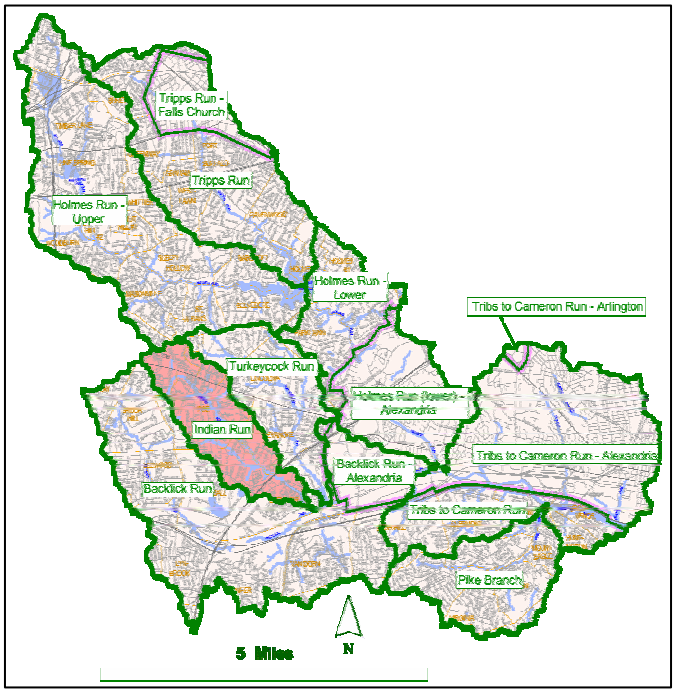

Figure 4-25. Indian Run subwatershed

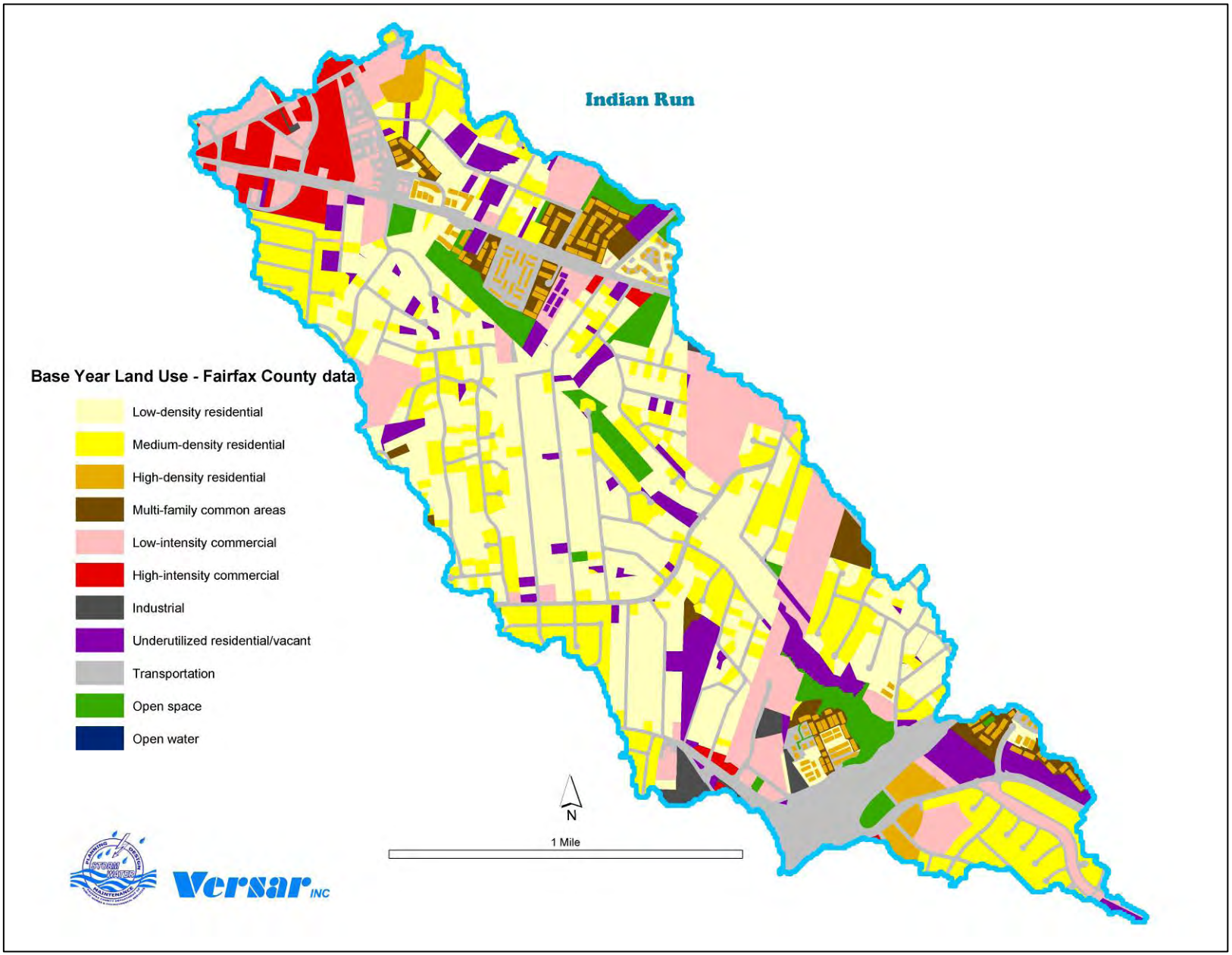

Figure 4-26. Land use map of Indian Run subwatershed

Table 4-30. Estimates of future land use and percentage of impervious area in the Indian Run subwatershed			
Subwatershed Area (acres)	1,586		
Land Use	**Base Year (% area)**	**Future (% area)**	**% Change**
Open space	8.2	4	-51.7
Multifamily common area	4.1	2.8	-30.3
Low-density residential	30.8	32.5	5.2
Medium-density residential	17.8	20.6	15.8
High-density residential	3.7	3.7	0
Low-intensity commercial	13.2	11.8	-10.8
High-intensity commercial	3.2	4.7	45.8
Industrial	0.9	1.9	109.2
Transportation	18	18	0
Impervious area	25.2	28.6	13.3

The county's list of drainage projects shows that 6 of the 16 projects in this subwatershed have been completed; 1 project is active with full funding, and the remaining 9 projects are inactive. Table 4-31 summarizes the kind of drainage project, project name/location, and status. No cost estimates were available for these projects.

Table 4-31. Drainage projects in the Indian Run subwatershed	
Type of Work	**Project Name/Location**
Active Project - Fully Funded	
Streambank stabilization	Indian Run Ph IV
Completed	
Gabion and rip rap/stabilization	Indian Run Ph II
Gabion/stabilization	Upstream of Braddock, Randolph
Streambank stabilization	Indian Run Ph I
Floodproof houses	Ridgewood
Retaining wall	Indian Run, Bren Mar Subdivision
Streambank stabilization	Brekke Property
Inactive	
Stream restoration	Spring Vall
Streambank stabilization	Braddock Hills
Streambank stabilization	Upstream of Braddock Road, Willow Run Subdivision
Channel improvements	Birch Lane
Streambank stabilization	Indian Run Ph III
Install retaining walls	Indian Run
Streambank stabilization	Bren Mar Ph II
Streambank stabilization	Fairland
Streambank stabilization	Indian Run

Table 4-32 summarizes the condition of Indian Run. This information is based on data from the 2001 SPS Baseline Study and the SPA. According to the SPS the overall condition of Indian Run is very poor.

Table 4-32. Summary of 2001 SPS Baseline Study and SPA results for the Indian Run subwatershed

SPS Results		SPA Results	
Condition rating	V.Poor	Inadequate buffers (ft.)	42,850
Index of Biotic Integrity score	Fair	Eroded streambanks (ft.)	4,840
Fish taxa richness	Very Low	Habitat assessment	Fair
Base year % impervious	27	Stormdrain pipes	25
		Dumping sites	0
		Headcuts	0
		Exposed utilities	6
		Obstructions	9
		Road crossings	29

4.2.5.2 Problems Areas Identified from SPA Data

An analysis of the SPA data indicates that the major problems within the subwatershed are inadequate buffers, eroded streambanks, storm discharge pipes, and obstructions of stream flow (Figure 4-27).

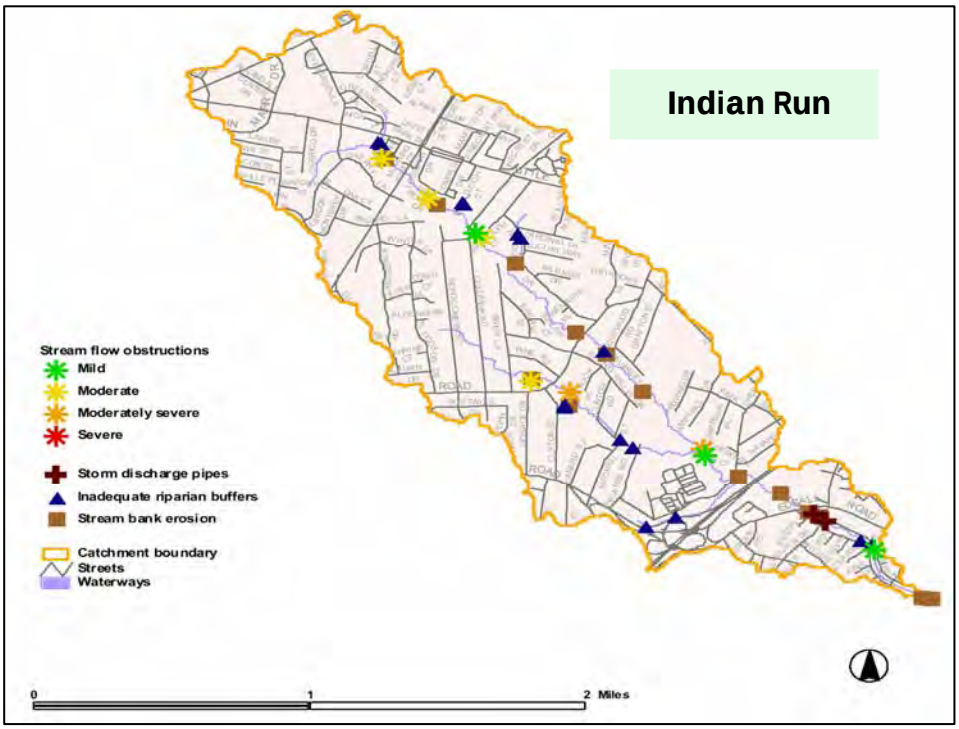

Figure 4-27. Location of the major problem areas in Indian Run subwatershed as indicated by SPA data

4.2.5.3 Problem Areas Identified by the Public

Public input about problem areas within Indian Run was obtained through watershed forums and other avenues. Table 4-33 describes problem areas and potential solutions that were discussed during these meetings.

Bank erosion and inadequate buffer along Indian Run

Table 4-33. Problem areas in the Indian Run subwatershed identified by the public

Location of Problem	Description of Problem	Potential Solution
Dog park	Concern about management	Review management of dog park.
Wooded lots below Holmes Middle School	Streambank erosion and high flows within nice wooded areas south of Holmes Middle School	Stormwater control upstream to increase the good areas.
Turkeycock/Braddock Rd.	Dog walking. Look into golf course management. Lots of geese, bad water quality downstream of golf course.	Doggy mitts/clean-up
Cherokee Rd, Shawnee Rd, Windy Hill Community	Pollution from "abandoned" Atlantic Research site, possibly polluting Indian Run	Investigate potential pollution source and identify opportunities to improve water quality from this site.

4.2.5.4 Modeling Results

Hydrologic modeling indicates that stormwater runoff in the Indian Run subwatershed is the greatest in Cameron Run due to dense development in the upper portions of the area. Overall, imperviousness in the subwatershed is about average compared to all of Cameron Run. The expected increase in discharges due to future development is average compared to the other subwatersheds. Table 4-34 compares the existing and future 1-, 2- and 10-year peak discharges in the subwatershed.

Table 4-34. Indian Run peak runoff flows

Drainage Area (acres)	1586		
	1-Year Storm	**2-Year Storm**	**10-Year Storm**
Existing peak flow (cfs)	263	349	809
Future peak flow (cfs)	277	361	818
Percent increase in peak flow	5.0	3.3	1.2

The HEC-RAS stream hydraulic model was used to simulate peak water velocity and water levels in stream channels in Cameron Run for storms of various sizes. Peak stream velocities greater than 5 feet per second (fps) indicate the potential for channel erosion. The percentages of stream channels in Indian Run with peak velocity greater than this value are 49% and 58%, for the 1-year and 2-year design storms, respectively. The number of buildings estimated to be in or touching the 100-year floodplain is 60 for Indian Run. Table 4-35 shows the number of roadway crossings overtopped by storms of various sizes for base-year and future conditions. Complete modeling details and results are provided in Appendix B.

Table 4-35. Number of roadway crossings (bridges) overtopped by design flows for Indian Run subwatershed

	Present	**Future**
1-year	1	1
2-year	1	1
10-year	2	2
25-year	2	2
100-year	2	2

The Indian Run subwatershed has a sediment loading rate a little below average among the eight subwatersheds and average annual loadings of total nitrogen and phosphorus. This subwatershed contains the greatest proportion of low-density commercial development. For future land use conditions, the total nitrogen and phosphorus loadings are predicted to increase by 9.3% and 8.6%, respectively. Table 4-36 compares the existing and future annual average pollutant loadings in the subwatershed.

Table 4-36. Average annual pollutant loadings (pounds/acre/year) in the Indian Run subwatershed

Pollutant	**Total Nitrogen**	**Total Phosphorus**	**Total Suspended Solids**	**Lead**	**Copper**	**Zinc**
Base year	9.6	1.1	218	0.012	0.063	0.332
Future	10.5	1.2	234	0.014	0.068	0.359
% Increase	9.3	8.6	7.6	11.4	6.6	8.2

4.2.6 State of Backlick Run

4.2.6.1 Subwatershed Characteristics

Backlick Run subwatershed covers 19.9% of the Cameron Run watershed (Figure 4-28). Thirty-one percent (31%) of the subwatershed is impervious; imperiousness is estimated to increase to 36% in the future. Medium-density residential development dominates land use within the subwatershed (Figure 4-29). Table 4-37 shows land use and percentage of impervious area for base-year and future conditions, and percent change in land use for the subwatershed. Backlick Run and its tributaries drain the southwest portion of Cameron Run watershed. Turkeycock and Indian runs are the two major tributaries of this system. The headwaters of Backlick Run originate in the vicinity of Ravensworth Road. The stream flows southeast toward the "mixing bowl," the interchange of I-95, I-395, and I-495, and then east toward its confluence with Holmes Run in Alexandria, a length of 7.2 miles.

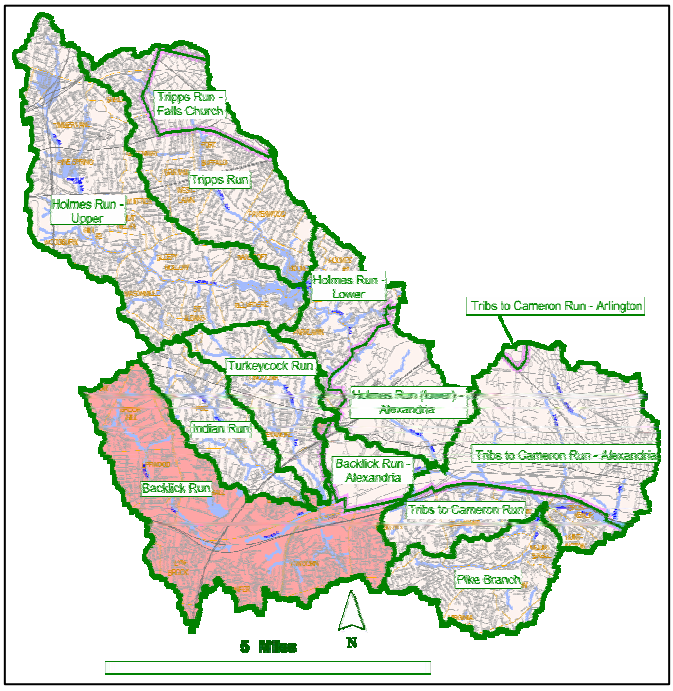

Figure 4-28. Backlick Run subwatershed

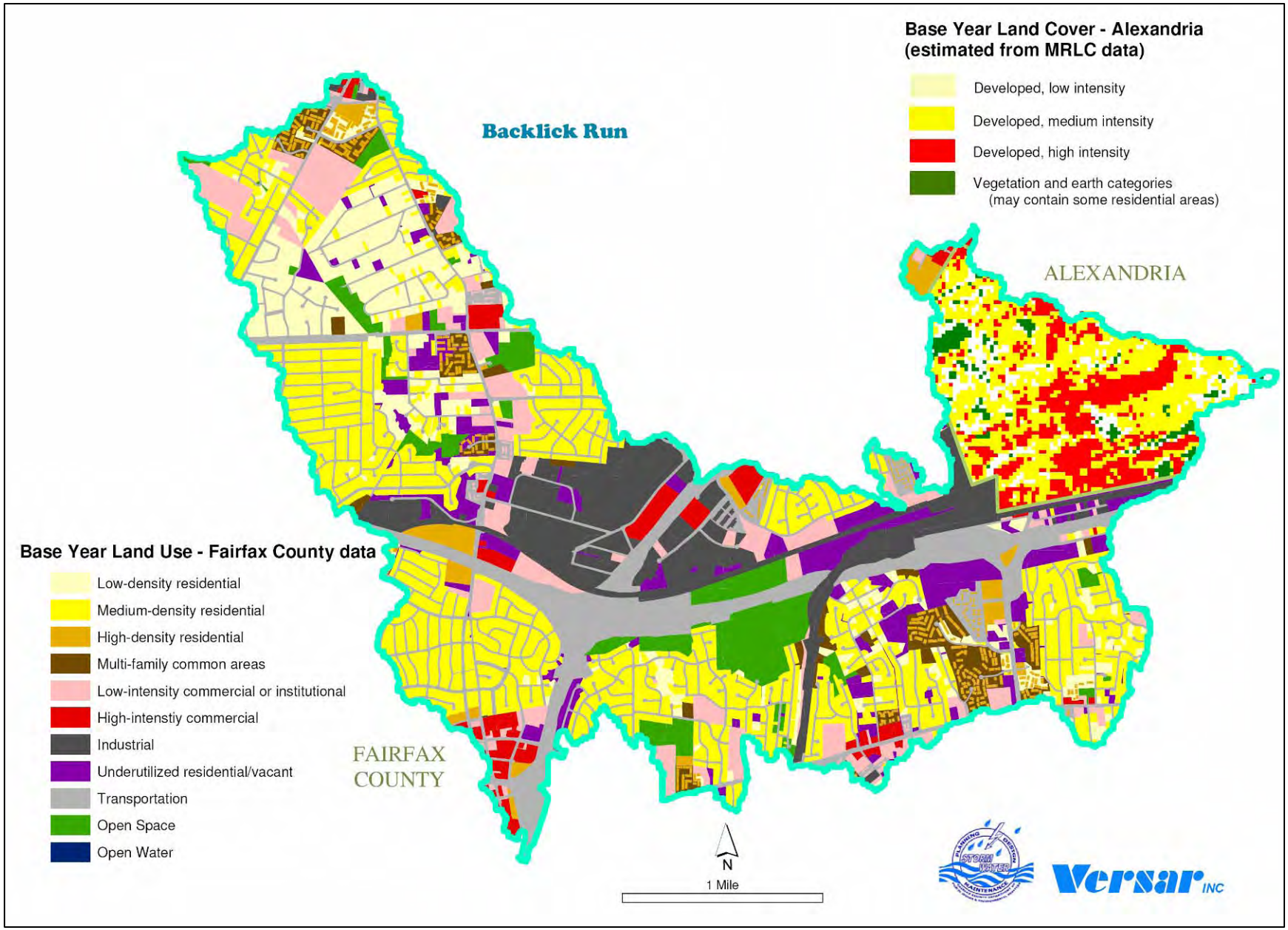

Figure 4-29. Land use map of Backlick Run subwatershed

Table 4-37. Estimates of future land use and percentage of impervious area in the Backlick Run subwatershed			
Subwatershed Area (acres)	5,659		
Land Use	**Base Year (% area)**	**Future (% area)**	**% Change**
Open space	10.8	6.4	-40.7
Multifamily common area	3.4	2.6	-21.8
Low-density residential	11.7	11.9	1.8
Medium-density residential	29.5	31.5	6.7
High-density residential	5.1	5.2	2.4
Low-intensity commercial	7.7	7.7	0.2
High-intensity commercial	2.9	3.3	14.2
Industrial	10.7	13.1	22.3
Transportation	18.1	18.1	0
Impervious area	30.7	35.9	16.9

In the uppermost section of the stream, northwest of Backlick Road, the stream passes through a lightly populated area and wooded stream valleys. From Backlick Road to the mouth of Indian Run, the stream is flanked by the Southern Railroad and the Capitol Beltway. The railroad and highway act as barriers against the encroachment of development. The section of the stream passing through Fairfax County (from the mouth of Indian Run to the confluence with Holmes Run) was channelized when the railroad was built in 1850 and passes through an intensely developed area (Parsons Brinckerhoff 1974).

The county's list of drainage projects shows that 4 of the 15 projects in this subwatershed have been completed; 1 project is active with partial funding, and the remaining projects are inactive. Table 4-38 summarizes the kind of drainage project, project name/location, and status. No cost estimates were available for these projects.

Table 4-38. Drainage projects in the Backlick Run subwatershed	
Type of Work	**Project Name/Location**
Active Project - Partially Funded	
Regional pond	Vine Street - 2
Completed	
Storm sewer	Valley View Drive
Gabion and rip rap/stabilization	Backlick Run
Streambank stabilization	Backlick Run Ph. 4
Gabion/stabilization	Wilburdale Park

Table 4-38. (Continued)	
Type of Work	**Project Name/Location**
Inactive	
Storm sewer	Leewood Subdivision
Storm sewer	Old Rolling/Nedra
Streambank stabilization	Southern Railroad
Streambank stabilization	Southern Railroad/South Van Dorn/Runnymeade
Storm sewer, ditch and berm	Clemons Court
Construction of earthen berm	Bren Mar Drive
Streambank stabilization	Shirley Highway
Streambank stabilization and gabion	RR
Streambank stabilization	Downstream of Backlick Run
Streambank stabilization study	Annandale Acres

Table 4-39 summarizes the condition of Backlick Run. This information is based on data from the 2001 SPS Baseline Study and the SPA. According to the SPS the overall condition of Backlick Run is very poor.

Table 4-39. Summary of 2001 SPS Baseline Study and SPA Results for the Backlick Run subwatershed			
SPS Results		**SPA Results**	
Condition rating	V.Poor	Inadequate buffers (ft.)	70,485
Index of Biotic Integrity score	Poor	Eroded streambanks(ft.)	3,725
Fish taxa richness	Low	Habitat assessment	Fair
Base year % impervious	30	Stormdrain pipes	2
		Dumping sites	1
		Headcuts	2
		Exposed utilities	4
		Obstructions	7
		Road crossings	59

4.2.6.2 Problems Areas Identified from SPA Data

An analysis of the SPA data indicates that the major problems within the subwatershed are inadequate buffers, eroded streambanks, exposed utilities, storm discharge pipes, and obstructions of flow (Figure 4-30). Backlick Run was included on EPA's list of impaired waters for fecal coliform contamination.

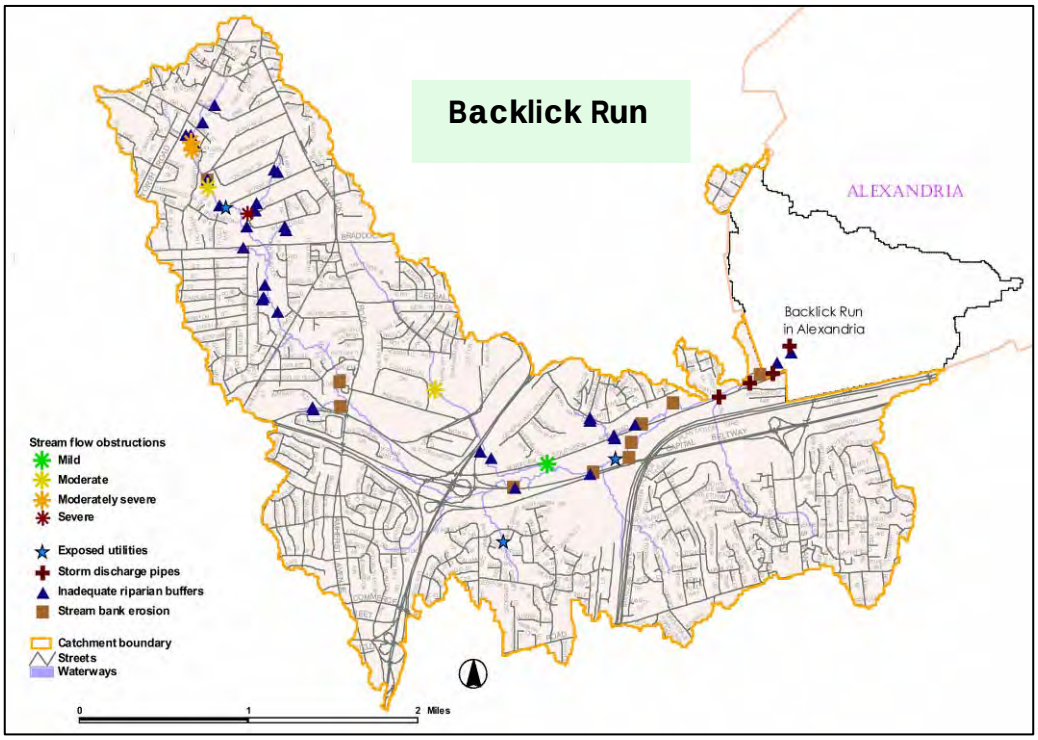

Figure 4-30. Location of major problem areas in Backlick Run subwatershed as indicated by SPA data

4.2.6.3 Problem Areas Identified by the Public

Public input about problem areas within Backlick Run was obtained through forums and other avenues. Table 4-40 describes problem areas and potential solutions discussed during these meetings.

Backlick Run at Interstate 495

Table 4-40. Backlick Run problem areas from public forum		
Location of Problem	**Description of Problem**	**Potential Solution**
Backlick Run in the Brookhill area	Bank erosion and channel instability along Backlick Run	Provide additional stormwater controls in upland areas to reduce the magnitude and frequency of flows; apply bioengineering approaches and natural stream channel design to stabilize streambanks and bed, and improve habitat conditions.
Edsall Road Industrial Park	Toxic polluted runoff	Implement pollution prevention programs; install stormwater controls to capture and treat runoff.
Cameron Run mainstem	Channelized ditch	River edge park/ dechannelizing (ex. Four Mile Run is in the process of retrofits)
Wilburdale Park	Urbanized stream	Earth Sangha - Stream planting project
Calvert Street.	Severe erosion	Stabilize the streambank.
Wilburdale Park, Backlick Run	Stream degradation and erosion of Backlick Run	Provide additional stormwater controls in upland areas to reduce the magnitude and frequency of flows; apply bioengineering approaches and natural stream channel design to stabilize streambanks and bed, and improve habitat conditions.
I-395 and I-495 intersection at Backlick Run	Impervious surfaces of I-395, I-495, and three industrial parks force heavy runoff into the floodplain area.	Install additional stormwater controls to capture, detain, and treat highway runoff.

4.2.6.4 Modeling Results

Hydrologic modeling indicates that stormwater runoff in the Backlick Run subwatershed is relatively high due to dense development in the middle and lower portions of this subwatershed; this subwatershed also has the largest percentage of impervious area within Cameron Run, at 30.7% overall. The estimated increase in discharges due to future development is average compared to the other subwatersheds. Table 4-41 compares the existing and future 1-, 2- and 10-year peak discharges in the subwatershed.

Table 4-41. Peak runoff flows in the Backlick Run subwatershed			
Drainage Area (acres)	5,659		
	1-Year Storm	**2-Year Storm**	**10-Year Storm**
Existing peak flow (cfs)	212	277	622
Future peak flow (cfs)	224	289	626
Percent increase in peak flow	5.4	4.2	0.6

The HEC-RAS stream hydraulic model was used to simulate peak water velocity and water levels in stream channels in Cameron Run for storms of various sizes. Peak stream velocities greater than 5 feet per second (fps) indicates the potential for channel erosion. The percentages of stream channels in Backlick Run with peak velocity greater than this value are 52% and 55%, for the 1-year and 2-year design storms, respectively. The number of buildings estimated to be in or touching the 100-year floodplain is 108 for the county portion of Backlick Run. Table 4-42 shows the number of roadway crossings overtopped by storms of various sizes for base-year and future conditions. Complete modeling details and results are provided in Appendix B.

Table 4-42. Number of roadway crossings (bridges) overtopped by design flows for Backlick Run subwatershed

	Present	**Future**
1-year	0	0
2-year	0	0
10-year	3	3
25-year	3	3
100-year	4	4

The Backlick Run subwatershed has the highest sediment loading rate of the eight subwatersheds due to the larger commercial and industrial areas present. The Backlick Run subwatershed also has large annual loadings of total phosphorus. This can be attributed to the relatively high percentage of developed land in the watershed. This subwatershed contains the greatest proportion of industrial development. For future land use conditions, the nitrogen and phosphorus loadings are predicted to increase by 10.0% and 8.9%, respectively. Table 4-43 compares the existing and future annual average pollutant loadings in the subwatershed.

Table 4-43. Average annual pollutant loadings (pounds/acre/year) in the Backlick Run subwatershed

Pollutant	**Total Nitrogen**	**Total Phosphorus**	**Total Suspended Solids**	**Lead**	**Copper**	**Zinc**
Base year	10.1	1.1	250	0.016	0.075	0.419
Future	11.1	1.3	265	0.017	0.082	0.459
% Increase	10.0	8.9	6.3	8.8	8.6	9.5

4.2.7 State of Pike Branch

4.2.7.1 Subwatershed Characteristics

Pike Branch subwatershed covers 6.4% of the Cameron Run watershed (Figure 4-31). Twenty-one percent (21%) of the subwatershed is impervious; imperviousness is estimated to increase to 26% in the future.. Medium-density residential development dominates land use within the subwatershed (Figure 4-32). Table 4-44 shows land use, percentage of impervious area for base-year and future conditions, and percent change for the subwatershed. Pike Branch drains the extreme southeastern section of the watershed and flows northeast to Cameron Run. Telegraph Road parallels the stream most of the way.

The portion of Pike Branch mainstem that lies to the east of Telegraph Road passes through a developed area. The channel was straightened. About 150 feet of channel have sheet-metal sides and a concrete bottom; concrete walls line 450 feet. Although the improvements have reduced erosion, they have also considerably altered the stream.

The lowest reach of Pike Branch, west of Telegraph Road, shows the effects of its passage through a highly developed commercial area. Upstream of the confluence with Cameron Run, the stream falls sharply at the end of a concrete-lined section, causing bed scour. A sheet of corrugated metal in the channel has created a deep pond (Parsons Brinckerhoff 1974).

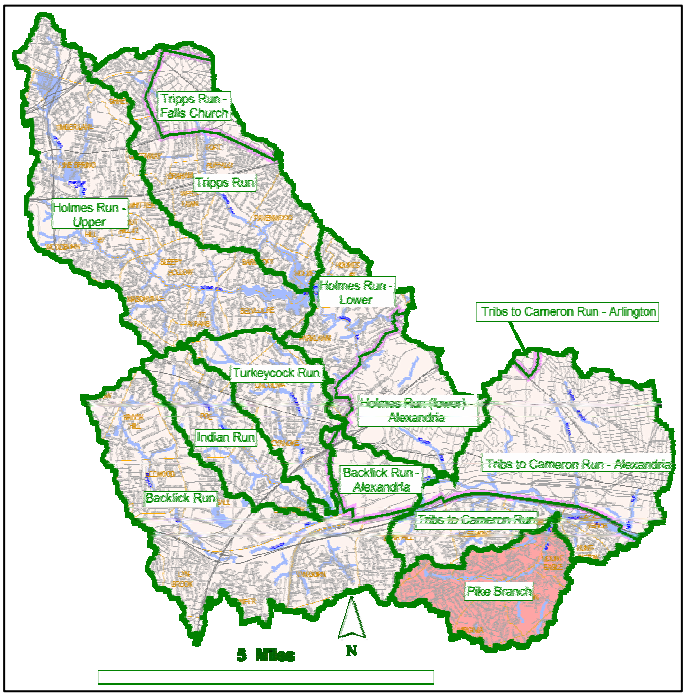

Figure 4-31. Pike Branch subwatershed

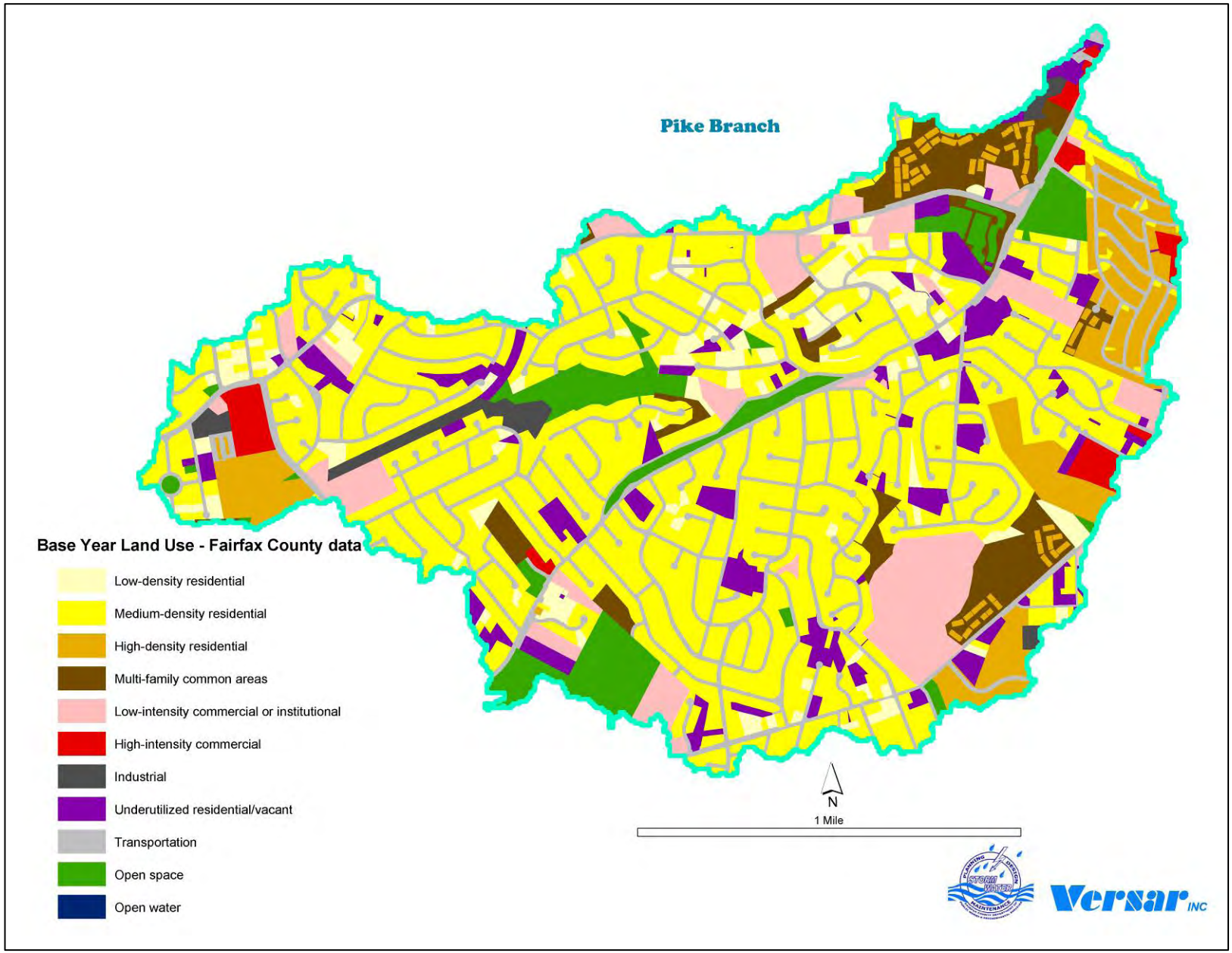

Figure 4-32. Land use map of Pike Branch

Table 4-44. Estimate of future land use and percentage of impervious area in the Pike Branch subwatershed			
Subwatershed Area (acres)	1,814		
Land Use	**Base Year**	**Future**	**% Change**
Open space	7.6	4.2	-44.3
Multifamily common area	6.7	5.2	-22.3
Low-density residential	7.8	5.4	-31.1
Medium-density residential	44.4	51.0	14.8
High-density residential	7.3	7.4	1.5
Low-intensity commercial	8.5	9.0	5.2
High-intensity commercial	1.7	1.8	7.6
Industrial	1.4	1.4	0
Transportation	14.6	14.6	0
Impervious area	20.8	25.5	22.5

The county's list of drainage projects shows that four of the nine projects in this subwatershed have been completed, and the remaining five projects are inactive. Table 4-45 summarizes the kinds of drainage projects, project name/location, and current status. No cost estimates were available for these projects.

Table 4-45. Drainage projects in the Pike Branch subwatershed	
Type of Work	**Project Name/Location**
Completed	
Floodproof house	Wilton Road, Pike Branch Ph 2
Gabion/stabilization	Tipton Lane, Sunny Ridge Estate
Gabion/replace culvert	Pike Branch Ph I
Stream stabilization/gabion repair	Pike Branch I00216
Inactive	
Streambank stabilization	Pike Branch Ph III
Channel improvements	Franconia/Leewood
Channel improvements	Wilton Woods
Stream restoration and stabilization	Pike Branch
Streambank stabilization	Pike Branch

Table 4-46 summarizes the condition of Pike Branch. This information is based on data from the 2001 SPS Baseline Study and the SPA. According to the SPS the overall condition of Pike Branch is very poor.

Table 4-46. Summary of 2001 SPS Baseline Study and SPA results for the Pike Branch Run subwatershed			
SPS Results		**SPA Results**	
Condition rating	V.Poor	Inadequate buffers (ft.)	27,450
Index of Biotic Integrity score	Fair	Eroded streambanks (ft.)	75
Fish taxa richness	V.Low	Habitat assessment	Fair
Base year % impervious	25	Stormdrain pipes	29
		Dumping sites	1
		Headcuts	0
		Exposed utilities	2
		Obstructions	5
		Road crossings	13

4.2.7.2 Problems Areas Identified from SPA Data

An analysis of the SPA data indicates that the major problems within the subwatershed are inadequate buffers, obstructions of stream flow, and stormdrain pipes (Figure 4-33).

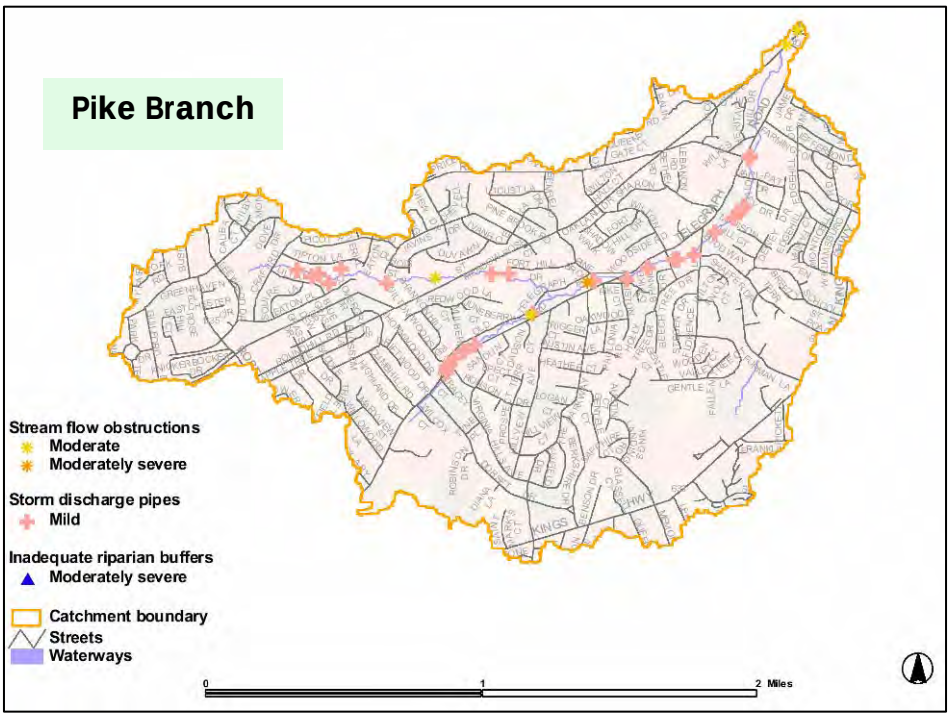

Figure 4-33. Location of major problem areas in Pike Branch subwatershed as indicated by SPA data

4.2.7.3 Problem Areas Identified by the Public

Public input about problem areas within Pike Branch was obtained through forums and other avenues. Table 4-47 describes problem areas and potential solutions discussed during these meetings.

Channelization in Pike Branch

Table 4-47. Problem areas identified by the public in the Pike Branch subwatershed

Location of Problem	Description of Problem	Potential Solution
Pike Branch at Burgundy Road crossing	Concrete wall across stream and banks overrun with porcelain berry; area is part of Woodrow Wilson Bridge Project.	Control exotic plants with assistance from existing or newly formed native plant group; provide resources to replant with native species.
Pike Branch intersection with Cameron Run	Construction run off due to Wilson Bridge project	
Jefferson Manor neighborhood (and many others)	Trash, leaves, and runoff going down stormdrains (many times intentionally)	Stencil stormdrains.
Jefferson Manor Park	Channelized stream	Dechannelize and retrofit (ex. Four Mile Run is in the process of being retrofitted).

4.2.7.4 Modeling Results

Hydrologic modeling indicates that stormwater runoff in the Pike Branch subwatershed is about average among the subwatersheds of Cameron Run, although Pike Branch has the lowest imperviousness within Cameron Run as a whole. The predicted increase in discharges due to future development is average compared to the other subwatersheds. Table 4-48 compares the existing and future 1-, 2- and 10-year peak discharges in the subwatershed.

Table 4-48. Peak runoff flows in the Pike Branch subwatershed

Drainage Area (acres)	1,814		
	1-Year Storm	**2-Year Storm**	**10-Year Storm**
Existing peak flow (cfs)	221	297	742
Future peak flow (cfs)	235	308	742
Percent increase in peak flow	6.4	3.6	0

The HEC-RAS stream hydraulic model was used to simulate peak water velocity and water levels in stream channels in Cameron Run for storms of various sizes. Peak stream velocities greater than 5 feet per second (fps) indicate the potential for channel erosion. The percentages of stream channels in Pike Branch Run with peak velocity greater than this value are 13% and 38%, for the 1-year and 2-year design storms, respectively. The number of buildings estimated to be in or touching the 100-year floodplain is 22 for Pike Branch Run. Table 4-49 shows the number of roadway crossings overtopped by various size design storms for base year and future conditions. Complete modeling details and results are provided in Appendix B.

Table 4-49. Number of roadway crossings (bridges) overtopped by design flows for Pike Branch subwatershed

	Present	**Future**
1-year	0	0
2-year	0	0
10-year	0	0
25-year	0	0
100-year	3	3

The Pike Branch subwatershed has an average sediment loading rate among the eight subwatersheds and relatively high annual loadings of total nitrogen and phosphorus. This can be attributed to the relatively high percentage of medium-density residential development in the watershed. For future land use conditions, the total nitrogen and phosphorus loadings are predicted to increase by 10.1% and 9.2%, respectively. Table 4-50 compares the existing and future annual average pollutant loadings in the subwatershed.

Table 4-50. Average annual pollutant loadings (pounds/acre/year) in the Pike Branch subwatershed

Pollutant	**Total Nitrogen**	**Total Phosphorus**	**Total Suspended Solids**	**Lead**	**Copper**	**Zinc**
Base year	10.1	1.2	222	0.13	0.065	0.314
Future	11.2	1.3	240	0.014	0.071	0.345
% Increase	10.1	9.2	8.1	8.0	9.5	9.9

4.2.8 State of Cameron Run Mainstem and Direct Tributaries

4.2.8.1 Subwatershed Characteristics

The subwatershed of Cameron Run and its direct tributaries covers 18.8% of the Cameron Run watershed (Figure 4-34). Medium-density residential development dominates land use within the subwatershed (Figure 4-35). Table 4-51 shows land use and percentages of impervious area for base-year and future conditions, and percent change for the subwatershed. The mainstem of Cameron Run is the portion of stream that flows from the confluence of Holmes and Backlick runs to a point just upstream of the Jefferson Davis Highway crossing. The stream from here to the Potomac River is known as Hunting Creek and receives drainage from the Belle Haven watershed.

Throughout its length, the stream flows through an area of dense development. The section upstream of Pike Branch is similar to the disturbed, downstream reaches of Backlick Run. The channel is wide, straight, and shallow, with only sporadic vegetative cover. Sections of concrete lining are found throughout the course of the stream.

The tidal effect of the Potomac River is pronounced, extending upstream as far as Telegraph Road. At high tide, this influence is significant in bringing poorer quality water into the lower reaches of the basin. The stream quality is further degraded by the sediment load delivered to this area. It is the heaviest in the basin, having accumulated from upstream feeder tributaries. Concrete walls protect streambanks from scouring in critical areas; consequently, erosion is not a significant problem. The stream receives flows from Alexandria, has tidal influence near the

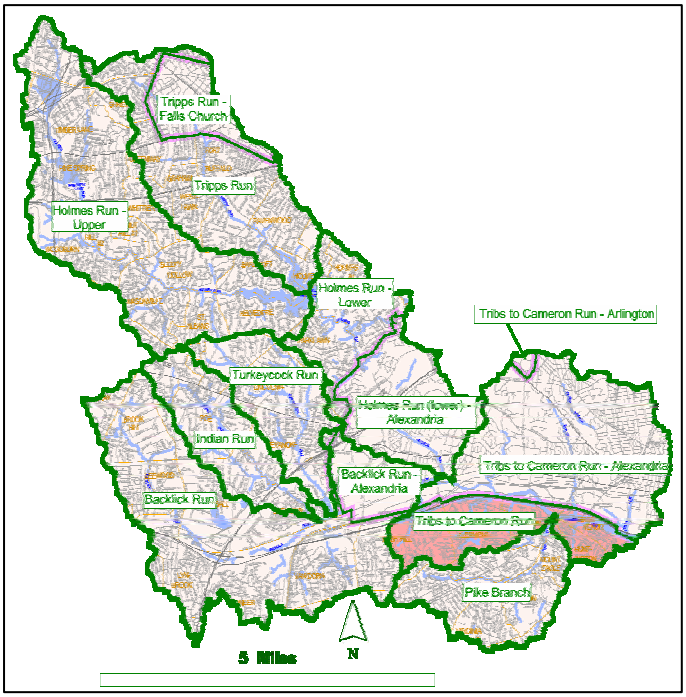

Figure 4-34. Cameron Run subwatershed

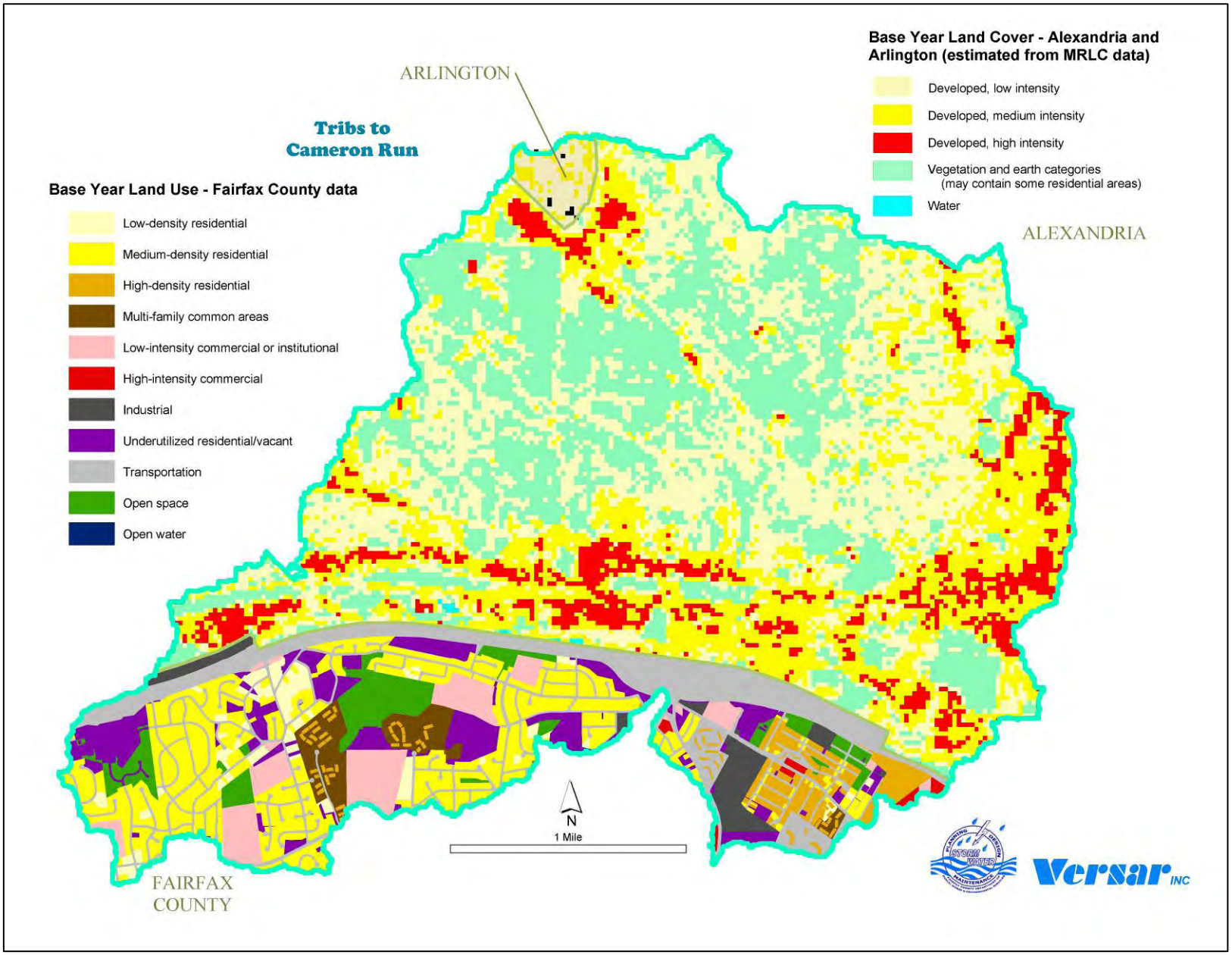

Figure 4-35. Land use map of Cameron Run subwatershed

Wilson Bridge, and includes the proposed Huntington Stream Valley Trail along its mainstem. Many streams are buried or channelized (especially in the lower Capitol Beltway area), disconnecting them from their floodplains (Parsons Brinckerhoff 1974).

Table 4-51. Estimates of future land use and percentage of impervious area in the Cameron Run mainstem and direct tributaries.*

Subwatershed Area (acres)	1,708		
Land Use	**Base Year (% area)**	**Future (% area)**	**% Change**
Open space	16.8	7.8	-53.7
Multifamily common area	6.1	4.0	-34
Low-density residential	12.8	11.0	-14.2
Medium-density residential	28.2	39.2	39
High-density residential	5.8	6.0	5.1
Low-intensity commercial	8.1	9.5	17.8
High-intensity commercial	0.9	1.0	20.6
Industrial	3.9	3.9	0
Transportation	17.5	17.5	-0.1
Impervious area	23.7	29.5	24.6

* Includes area in Alexandria upstream of USGS gage on Cameron Run

The county's list of drainage projects shows that three of the seven projects in this subwatershed have been completed, and the remaining four projects are inactive. Table 4-52 summarizes the kind of drainage project, project name/location, and current status. No cost estimates were available for these projects.

Table 4-52. Drainage projects in the Cameron Run mainstem and direct tributaries

Type of Work	**Project Name/Location**
Completed	
Streambank stabilization	Norton Road
Storm sewer system	Clermont Drive
Streambank stabilization	Burgundy Manor
Inactive	
Infrastructure replacement	Elmwood Drive
Floodwall construction	Arlington Terrace
Streambank stabilization	Telegraph Road/Beltway
Streambank stabilization	Norton Villa

During June, 2006, intense tropical downpours resulted in significant flooding of the Arlington and Huntington communities located adjacent to the Cameron Run mainstem. Approximately 160 duplex homes in the area were severely damaged during the storm.

In September 2006, Fairfax County entered into an agreement with the U.S. Army Corps of Engineers to complete a flood-damage-reduction study for Huntington. This study will investigate structural and combination structural/non-structural alternatives for reducing the effects of flooding and include an economic analysis of various alternatives. The study will be completed in approximately 18 months and will include a 65% engineering design for the recommended improvement.

Table 4-53 summarizes the condition of Cameron Run. This information is based on data from the Fairfax County SPA. The 2001 SPS Baseline Study did not include sites within this subwatershed.

Table 4-53. Summary of SPA results for the Cameron Run subwatershed

Inadequate buffers (ft.)	27,500
Eroded streambanks (ft.)	800
Habitat assessment	Poor
Stormdrain pipes	9
Dumping sites	2
Headcuts	1
Exposed utilities	0
Obstructions	2
Road crossings	17

4.2.8.2 Problems Areas Identified from SPA Data

An analysis of the SPA data indicates that the major problems within the subwatershed are inadequate buffers, trash dumpsites, and stormdrain pipes (Figure 4-36). These waters are included on EPA's list of impaired waters for acute ammonia and fecal coliform contamination. PCBs were found in fish tissues, which prompted the Virginia Department of Health to issue a health advisory. A 1985 study in Alexandria identified poor groundwater conditions (high sodium chloride, iron, and total dissolved solids), which can influence baseflow water quality.

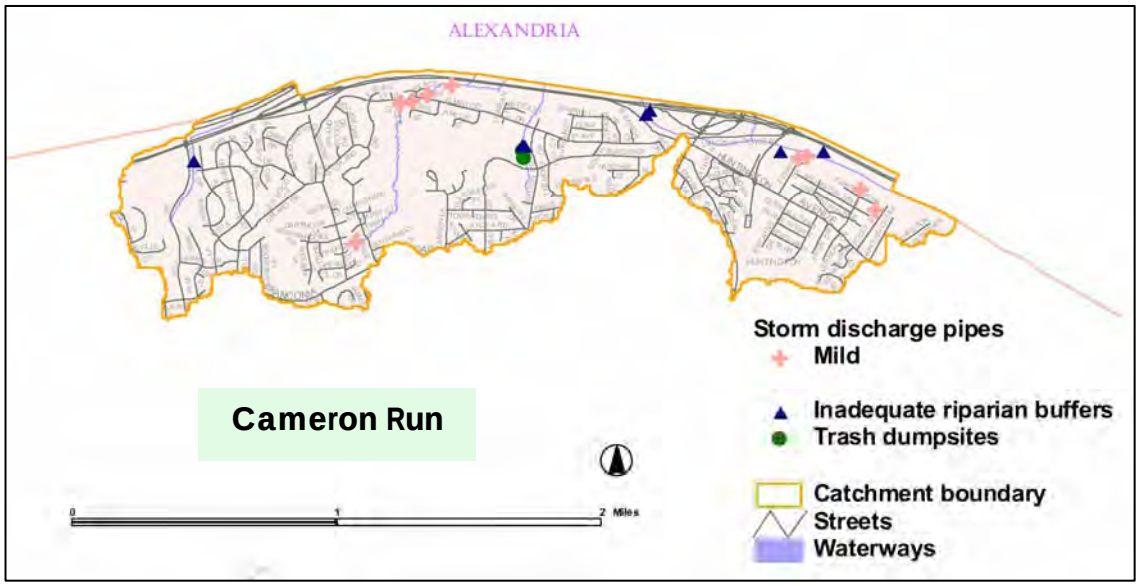

Figure 4-36. Location of major problem areas in Cameron Run subwatershed as indicated by SPA data

4.2.8.3 Problem Areas Identified by the Public

Public input about problem areas within Cameron Run mainstem and direct tributaries was obtained through forums and other avenues. Table 4-54 describes problem areas and potential solutions that were discussed during these meetings.

A view of Cameron Run facing upstream

Table 4-54. Problem areas identified by the public in Cameron Run mainstem and direct tributaries

Location of Problem	Description of Problem	Potential Solution
Cameron Run along Eisenhower Avenue in Alexandria	Cameron Run is an ugly, boulder strewn wasteland; trail is too far from water; water provides no benefit to trail users.	Integrate recreational and aesthetic amenities, as well as stormwater controls, into Cameron Run trail projects during maintenance and upgrade cycles.
Huntington Avenue and Telegraph Road	Woodrow Wilson Bridge construction degrades the area.	Coordinate with the Woodrow Wilson Bridge consultants to discuss and mitigate construction impacts.

Table4-54. (Continued)		
Location of Problem	**Description of Problem**	**Potential Solution**
Cameron Run mainstem	Lack of recreation opportunities along the Cameron Run mainstem	Integrate recreational and aesthetic amenities into future stormwater and flood control projects. Acquire new parkland if possible, and improve existing parks.
Urban areas along Cameron Run, such as Eisenhower East	Along the Cameron Run mainstem, there are no urban areas to enjoy the waterfront.	Integrate recreational, commercial, and aesthetic amenities into an urban redevelopment project along mainstem Cameron Run that will encourage the adoption of Cameron Run as a community focal point.
Cameron Run between Holmes Run and Hunting Creek	Already identified as severely degraded habitat	Add recreational amenities in addition to environmental remedies. Light boating and kayaking could be readily accomplished in conjunction with the Northern Virginia Regional Park Authority.
Cameron Run	Between Telegraph Road and Route 1 access to stream is available only by car.	Create pedestrian walk along the stream and across the stream to Eisenhower Ave.
Tributary to Cameron Run	No public access to stream	

4.2.8.4 Modeling Results

Hydrologic modeling indicates that stormwater runoff in the mainstem of Cameron Run is about average due to the average density of development in this subwatershed. Imperviousness in this area is below average compared to the entire watershed. The predicted increase in discharges due to future development is relatively high compared to the other subwatersheds. Table 4-55 compares the existing and future 1-, 2- and 10-year peak discharges in the subwatershed.

Table 4-55. Peak runoff flows in Cameron Run mainstem			
Drainage Area (acres)	1708		
	1-Year Storm	**2-Year Storm**	**10-Year Storm**
Existing peak flow (cfs)	231	306	711
Future peak flow (cfs)	249	322	731
Percent increase in peak flow	,8.1	5.3	2.8

The HEC-RAS stream hydraulic model was used to simulate peak water velocity and water levels in stream channels in Cameron Run for various size rainfall events. Peak stream velocities greater than 5 feet per second (fps) indicate the potential for channel erosion. The percentages of stream channels in Cameron Run mainstem with peak velocity greater than this value are 50% and 66%, for the 1-year and 2-year design storms, respectively. The number of buildings

estimated to be in or touching the 100-year floodplain is 8 for the portion of the Cameron Run mainstem that lies within Fairfax County. Table 4-56 shows the number of roadway crossings overtopped by storms of various sizes for base-year and future conditions. Complete modeling details and results are provided in Appendix B.

Table 4-56. Number of roadway crossings (bridges) overtopped by design flows for Cameron Run mainstem and tributaries

	Present	**Future**
1-year	0	0
2-year	0	0
10-year	0	1
25-year	1	1
100-year	1	1

The Cameron Run mainstem subwatershed has an average sediment loading rate among the eight subwatersheds due to the average percentage of commercial areas and higher percentage of industrial areas in the subwatershed. This subwatershed receives average loadings of total nitrogen and phosphorus. For future land use conditions, the total nitrogen and phosphorus loadings are predicted to increase by 14.9% and 14.0%, respectively. Table 4-57 compares the existing and future annual average pollutant loadings in the subwatershed.

Table 4-57. Average annual pollutant loadings (pounds/acre/year) in the Cameron Run mainstem

Pollutant	**Total Nitrogen**	**Total Phosphorus**	**Total Suspended Solids**	**Lead**	**Copper**	**Zinc**
Base year	9.9	1.2	229	0.014	0.068	0.343
Future	11.4	1.3	254	0.015	0.076	0.387
% Increase	14.9	14.0	11.0	9.9	12.4	12.9

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Chapter 5
Development of the Watershed Plan

Development of this management plan for the Cameron Run watershed was a coordinated process involving Fairfax County's Stormwater Planning Division; Versar, Inc., as the consultant; the Advisory Committee of watershed stakeholders (see the Acknowledgments); and the public. At times the process was decidedly iterative; in general, however, the process followed the diagram below:

The vision and goals that guided the development process are presented with the plan in Chapter 6. The results of stream characterizations, modeling, and public meetings that contributed to the assessment of problems throughout the watershed are presented in Chapter 4. This chapter describes the range of solutions considered and the method for selecting specific projects to be included in the plan.

5.1 FINAL LIST OF PROBLEMS

As described earlier, the stream characterization, modeling, and public involvement components of the process produced the following final list of problems to be addressed in the watershed plan:

Ultimate Sources of Stream Problems

- loss of forest cover
- increase in impervious surfaces
- rapid stormwater delivery system
- sources of point and nonpoint pollution

Proximal Stressors Causing Stream Degradation

- lack of riparian buffers
- loss of instream habitat
- bank erosion and sedimentation
- irregular flows
- channel alteration
- pollution
- bacteria
- flooding
- trash

5.2 POTENTIAL SOLUTIONS

Given this list of watershed problems, the Project Team identified two classes of solutions, physical and programmatic:

Physical Solutions
- decrease impervious surfaces
- restore culverts and eroded channels to natural shapes
- preserve or add trees and open space
- sweep streets
- capture storm flows and sediment

Programmatic Solutions
- decrease trash and pollution
- enact new regulations and policies
- tighten enforcement
- increase public awareness and transparency of government projects

Among the physical solutions, four categories of actions were identified:

New or Retrofit Structural Stormwater Controls
- dry pond
- wet pond
- manufactured devices to improve water quality
- sediment forebays and multiple cells
- redesigned control structures

Low Impact Development
- bioretention (e.g., rain gardens)
- grass swale
- green roofs
- cisterns and rain barrels
- porous pavement
- tree box filters
- better site design

Stream and Wetland Restoration
- bank stabilization
- natural channel design
- daylighting piped streams
- wetland restoration and creation
- riparian planting and reforestation

Pollution Reduction
- street sweeping
- trash cleanup
- recycling and dumping facilities
- education in pollution prevention

5.3 FINAL LIST OF SOLUTIONS

The Project Team and Advisory Committee discussed different strategies for managing the watershed management and selecting projects. Overall the group agreed that a balance of preserving the best remaining places, protecting the most vulnerable, restoring degraded places to acceptable condition, and reducing the influence of the worst streams on downstream areas (e.g., via loadings to the Chesapeake Bay) was the best approach.

In addition to developing a diverse list of programmatic ("policy") recommendations, the process focused on the following five categories of physical solutions that address site-specific conditions:

- LID – any of a number of innovative practices integrated into single projects, such as bioretention at the edges of large parking lots, off-line bioretention from stormwater discharge outfalls, or distributed LID techniques (e.g., rain barrels/cisterns) in neighborhoods

- New Ponds or Small Detention Areas – new stormwater management facilities or smaller extended-detention dry ponds in headwaters (streams draining 10 to 50 acres) created by constructing a control structure at the upstream end of a road culvert and excavating a micropool

- Retrofit Existing Ponds – retrofitting existing, dry detention ponds by adding storage (deeper, higher, or smaller outlet) or increasing the flowpath (baffles, earthen berms, microtopography) or incorporating infiltration trenches

- Stream Restoration – physically restoring natural stream morphology and habitat where the stream is stable (i.e., CEM score of 4 or 5) and habitat is degraded (i.e., a low habitat score)

- Riparian Planting and Reforestation – riparian planting will be undertaken as a countywide program

5.4 PROJECT SELECTION APPROACH

Developing the content of the plan involved selecting specific projects from this final list of solutions and designing them to meet the plan's goals and objectives. Selecting projects required choosing actions that will address the goals effectively (e.g., reducing high flows of stormwater) and finding locations where it is practical to implement those actions.

In the urbanized Cameron Run watershed, controlling stormwater flows (and their constituent pollutants) is the primary goal. Reductions in water quantity (peak flow velocities) and improvements of water quality (reductions in pollutant loadings) of 10% were determined to be reasonable goals for the plan. It was also determined that physical stream restoration should be conducted where the likelihood of success is the greatest (i.e., where streams are degraded but

are physically stable or stabilizing). This recognizes that attempting to restore stream morphology without controlling hydrology will not succeed.

The number of projects allocated to each subwatershed was based on the amount of uncontrolled impervious surface in the subwatershed. The amount of impervious surface area without storm-water controls (e.g., existing dry or wet ponds) was used to allocate the percentage of all projects that ideally would be selected for each subwatershed. This ideal allocation ranged from 6% to 27% of all projects as follows:

Tripps Run	15
Upper Holmes Run	19
Lower Holmes Run	14
Turkeycock Run	6
Indian Run	5
Backlick Run	27
Tributaries to Cameron Run	8
Pike Branch	6
	100%

It is not feasible to implement actions for every opportunity to improve stormwater management in an older, urbanized watershed like Cameron Run. Therefore, the following three-step process was used to identify, screen, and rank projects according to priority in this watershed plan. Candidate projects were (1) identified by reviewing maps of the watershed, (2) screened to identify an initial list of high-value projects, and (3) ranked to develop a list of projects that offer the best opportunities for implementation via avenues available to the county. This plan identifies projects in three tiers:

- **Tier 1** – Projects with the highest priority scores that represent the best opportunities for the county's efforts, are located on public land, and were ranked using the Stormwater Management Division's framework for defining priorities in rough proportion to the relative amount of uncontrolled impervious surface within the subwatershed
- **Tier 2** – Sites with slightly lower priority scores that represent projects on public land or sites on private lands, present good opportunities, and have received various levels of support from members of the Advisory Committee or the public at large
- **Tier 3** – The rest of the approximately 650 sites identified during the initial map review and public involvement process

The following sections describe the site identification and prioritization process.

5.4.1 Identifying Candidate Projects

The first step in selecting projects was to identify the problem stream segments (i.e., those with degraded conditions determined by stream characterization, modeling results, and local knowledge). In this step, the integrated habitat score from the SPA was mapped and used to identify degraded segments. Additional maps were produced with scores for variables diagnostic

of the problems of concern, such as bank instability and erosion. Detailed topographic and aerial maps were then reviewed for the specific cause of these problems, primarily upstream impervious surface (e.g., large parking lots). This process identified hundreds of degraded stream segments and their contributing causes.

The next step in selecting projects was to identify opportunities for addressing these widespread problems. Because stormwater contributes to many discrete problems in Cameron Run watershed, as well as to overall degradation, selecting projects required reviewing maps in detail to search for appropriate locations for the types of solutions planned: LID, new ponds, retrofits of existing ponds and small detention areas, and stream restoration. The key to this step was reviewing the topography and land cover near each stream to find (1) impervious areas in the headwaters of degraded streams and (2) available land (or infrastructure such as culverts) suitable for stormwater-control facilities and LID. Existing ponds were obvious opportunities for retrofits to increase stormwater detention or pollutant removal. Open public lands, such as parks, schools, and Chapter-2 roads, are most suitable for new stormwater facilities. Chapter-2 roads are county-owned rights-of-way that were never developed. In general, constructing new facilities on wooded land is not desirable. This process yielded 647 candidate projects (Figure 5-1).

5.4.2 Screening Projects for Feasibility

After defining candidates, projects were screened to identify those that the county would most likely be able to implement. Projects were grouped by land ownership, with publicly owned land in one group of sites, and privately owned land and area-wide/neighborhood projects in the second group. In most cases, the first group of sites presented the best opportunity for implementing projects and improving water quality and flow conditions expediently. Public ownership avoids costly land acquisition, allowing more resources to be directed toward actual improvements. Through the public involvement and review process, several sites from the second group were moved to the first group because of strong public support and substantial opportunity for improvement. Stream restoration sites were also included in the first group of sites. Stream restoration sites were identified using information about stream condition (e.g., erosion, exposed pipe, riparian buffer width) and stream stability (e.g., a CEM score of 4 [stabilizing] or 5 [stable]). This first group of most feasible sites contained 235 sites.

The remaining 412 projects in the second group (i.e., privately owned land) were not evaluated further and were assigned to Tier 3. Many of the projects in this group represent good opportunities for improving watershed conditions, but their location on private property raises major hurdles for implementation via avenues available to the county. Other avenues of implementation (e.g., non-profit groups, county-funded grant programs) may be more effective and efficient for working with volunteer landowners to implement Tier 3 projects.

5.4.3 Ranking Projects into Tiers

Additional analysis was conducted on the first group of sites to rank them according to the best opportunities for implementation via avenues available to the county, to help refine the conceptual restoration plan, and to estimate cost for each site.

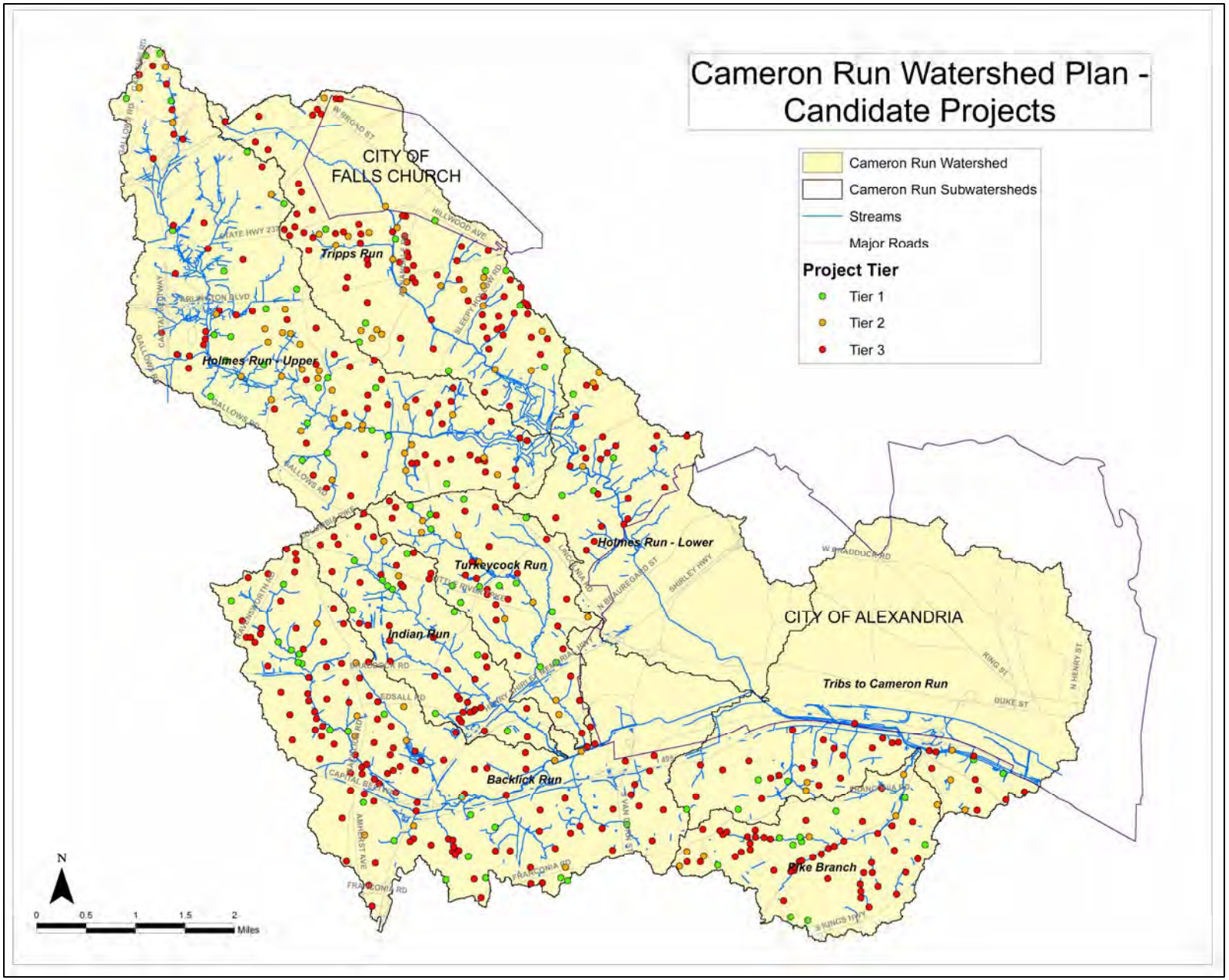


Figure 5-1. Candidate watershed restoration projects identified in Cameron Run

During the fall of 2005, Versar's field crews visited candidate project sites in Cameron Run watershed to visually assess and photograph opportunities for improving stormwater controls. Field crews observed drainage pathways, available space, uses of the site, land cover, and potential constraints (e.g., location of utilities, new buildings) that were not evident on maps and aerial photographs to develop site-specific restoration plans. Approximately 40 sites were found to be unsuitable and were dropped from further consideration. Data on drainage areas and appropriate solutions for specific locations were mapped in GIS for subsequent analysis and presentation.

Versar used guidance developed by Fairfax County's Stormwater Planning Division for the Pope's Head Creek Watershed Plan to rank candidate projects in tiers according to priority for implementation. The procedure scores candidate projects on a scale of 1 (worst) to 5 (best) for each of five criteria. The criteria are weighted to reflect their relative importance to the county. The weighted scores are summed to obtain a total score for each project; higher scores represent better opportunities. The criteria and their weights are as follows:

1. Board-adopted Stormwater Control Project Prioritization Categories (40%)
   - Projects that are mandated by state or federal regulations for immediate implementation and projects that address critical/emergency dam safety issues.
   - Projects that protect structures from damage by flood waters or from being undermined by severe erosion.
   - Projects that achieve stormwater quality improvement in specific conformance with the county's obligation under the Chesapeake Bay initiatives and/or the VPDES permit for storm-sewer discharges.
   - Projects that alleviate severe erosion of streambanks and channels.
   - Projects that alleviate moderate and minor erosion of streambanks and channels.
   - Projects that alleviate yard flooding.
   - Projects that alleviate road flooding.
2. Direct Regulatory Contribution (10%)
   - Hybrid projects that accomplish multiple objectives.
   - Projects that contribute directly to complying with the county's Municipal Stormwater Permit (MS4) and Virginia Tributary Strategies.
   - Projects that contribute to complying only with TMDLs.
   - Projects that have indirect water quality benefits.
   - Projects that mitigate flooding.
3. Public Support (10%)
   - Citizen's Advisory Committee support.
   - Support for projects by affected residents.

4. Effectiveness/Location (25%)
   - Quantity control projects are more desirable in "headwaters" areas that lack stormwater management controls.
   - Quality control projects are desirable in areas that previously lacked controls.
   - An indication of relative costs and benefits of a project, such as pollutant reduction or efficiency, increased retrofit area, etc.

5. Ease of Implementation (15%)
   - Simple projects will be easier to implement than more complex projects.
   - Projects that do not require purchasing land will be easier to implement.

To further define and help rank the candidate projects, Versar worked with the county's staff to perform a cost-benefit analysis to identify projects that would provide the most environmental benefit for the least cost. To accomplish this, costs were normalized per acre, and the following formula was applied:

$$\text{Cost-Benefit} = \frac{\text{Estimated Cost from Draft Report}}{\text{Drainage Area Treated}} \div \text{Total Score for SWPD Prioritization}$$

Because stream restoration projects cannot be considered to treat a particular drainage area, we replaced Drainage Area Treated in this formula with Project-site Footprint (acres), calculated from

Project Site Footprint (acres) = Stream Project Length (feet) x 200 feet ÷ 43,560 square feet/acre

to determine the cost-benefit ratio for candidate restoration projects. The project-site footprint assumes that projects will improve conditions within a 100-foot buffer along both sides of the stream. Results from this analysis were ranked in ascending order by subwatershed, noting that a smaller cost-benefit ratio is more desirable than a higher ratio.

The top-ranked sites in each subwatershed became Tier 1. The remaining sites became Tier 2. The final allocation of sites in Tier 1 is as follows:

Watershed-wide	3
Tripps Run	10
Upper Holmes Run	24
Lower Holmes Run	4
Turkeycock Run	13
Indian Run	10
Backlick Run	20
Tributaries to Cameron Run	6
Pike Branch	10
	100

This project selection approach produced 100 Tier 1 projects, 92 Tier 2 projects, and 407 Tier 3 projects, totaling 599 projects in the Cameron Run Watershed Plan (Figure 5-1).

Chapter 6
Watershed Plan

The Cameron Run Watershed Plan is consistent with Fairfax County's Policy Plan (the county-wide element of the comprehensive plan). The Board of Supervisors' goal for environmental protection, as stated in the Policy Plan, reads

> "The amount and distribution of population density and land uses in Fairfax County should be consistent with environmental constraints inherent in the need to preserve natural resources to meet or exceed federal, state, and local standards for water quality, ambient air quality, and other environmental standards. Development in Fairfax County should be sensitive to the natural setting to prevent degradation of the county's natural environment."

The county policy document also notes that

> "The protection and restoration of the ecological quality of streams is important to the conservation of ecological resources in Fairfax County. Therefore, efforts to minimize adverse impacts of land use and development on the county's streams should be pursued."

This Cameron Run Watershed Plan is intended to complement and supplement the county's policies and comprehensive plans over the next 25 years and to support its commitment to the Clean Water Act and Virginia's commitment to the Chesapeake Bay Preservation Ordinance. The county and community members of the Cameron Run watershed are committed to protecting Cameron Run and its tributaries from future degradation by promoting management actions that work to restore streams and other areas throughout the watershed to an environmentally healthy ecosystem. This commitment emphasizes the importance of protecting the county's valuable natural resources, including surface waters, and supports the sustainability and improvement of the environment, which directly affects the quality of life of the county's residents.

Specifically, the Cameron Run Watershed Plan was written to manage changes in the watershed so it can be enjoyed by future generations. The plan also will help the county meet federal, state, and local regulatory water quality requirements. This chapter summarizes the Watershed Plan, providing the vision, goals and objectives, policy recommendations, project actions, implementation, and benefits.

6.1 VISION

The Project Team and Advisory Committee jointly developed the following vision to guide development and implementation of the plan:

> *A fishable, swimmable, and biologically diverse Cameron Run watershed that supports a safe and enjoyable environment for people and property*

6.2 GOALS AND OBJECTIVES

Drawing on knowledge of the ultimate causes and proximate stresses affecting the watershed, the Project Team and Advisory Committee developed the following goals and objectives that are consistent with the vision defined for Cameron Run:

Goal A: Reduce the effects of stormwater runoff from impervious areas to help restore and protect streams within the Cameron Run watershed

Objective A1: Increase the effectiveness of existing BMPs by improving maintenance or "retrofitting" them to further reduce the effects of impervious areas (altered flows and poor water quality).

Objective A2: Install new BMP and LID facilities in areas that do not have existing stormwater management controls.

Objective A3: Require (1) reduction of the rate and volume of runoff following the development of new commercial and residential sites to the minimum possible levels and (2) reduction of post-development runoff at redevelopment sites by targeted percentages from the pre-development rate and volume.

Objective A4: Increase the participation of residents in decreasing the amount of stormwater runoff from impervious surfaces in residential areas.

Objective A5: Reduce the effects of stormwater runoff from existing and proposed roadways by instituting new countywide watershed management requirements.

Goal B: Preserve, maintain, and improve watershed habitats to support appropriate native flora and fauna

Objective B1: Preserve, restore, and manage riparian buffers to benefit appropriate native flora and fauna (and reduce the effects of stormwater runoff).

Objective B2: Preserve, restore, and manage habitat in streams and on stream banks to benefit appropriate native flora and fauna (and water quality).

Objective B3: Preserve, restore, and manage wetlands to benefit appropriate native flora and fauna.

Goal C: Preserve, maintain, and improve water quality within streams to benefit humans and aquatic life

Objective C1: Reduce and mitigate the effects of bank erosion and sedimentation.

Objective C2: Reduce the amount of pollutants such as fecal coliform, phosphorous, and nitrogen in stormwater runoff.

Objective C3: Reduce the amount of trash and number of dumping sites in the watershed to help protect and improve the streams.

Goal D: Improve stream-based quality of life and environmentally friendly recreational opportunities for residents of and visitors to Cameron Run watershed

Objective D1: Create additional access and trails for stream-based recreational opportunities in the watershed.

Objective D2: Increase public awareness and appreciation of streams in the watershed.

The substance of the plan is the policy recommendations and project actions developed by the Project Team, Advisory Committee, and public to accomplish these goals and objectives. Implementation of new or revised policies will be undertaken by Fairfax County on a county-wide basis. Project actions include both government-sponsored and private structural or non-structural initiatives that would be implemented at specific locations. These policy recommendations and project actions are presented in separate sections below.

6.3 POLICY RECOMMENDATIONS FOR CAMERON RUN WATERSHED

Policy recommendations include proposals that would typically involve amendments of the county Code or other supporting documents such as the Public Facilities Manual. The current approach for processing policy recommendations from the Cameron Run Watershed Plan is to combine them with the recommendations that have been developed in the Little Hunting Creek, Popes Head Creek, Cub Run, and Difficult Run watershed plans for consideration by the appropriate county decision makers. It is expected that this separate process will consider policy recommendations in the context of legal and administrative constraints, and will result in more specific and more effective recommendations. This plan advocates that the county consider all policy recommendations from all the plans when deciding how to amend the County Code or other guidance.

Goal A: Reduce the effects of stormwater runoff from impervious areas to help restore and protect streams within the Cameron Run watershed.

Objective A1: Increase the effectiveness of existing BMPs by improving maintenance or "retrofitting" them to further reduce the effects of impervious areas (altered flows and poor water quality).

- *Policy Recommendation A1.1*: The county and the Virginia Department of Transportation (VDOT) should develop an inspection protocol; inspect BMPs, ditches, pipes, and outfalls within the watershed every five years;

and make repairs as necessary. Establish a hotline for citizens to report problems, and fund projects that address citizen-reported problems. Support legislation that provides incentives for VDOT to use LID techniques in its projects and replace grass with more native trees and vegetation along highways. Adopt the same policies for any county-owned roads.

- *Policy Recommendation A1.2:* Provide additional staff and resources to the county for review and inspection of privately owned and county-owned BMPs.

- *Policy Recommendation A1.3:* Increase the frequency of inspection for private BMPs with maintenance agreements from approximately once every three-to-five years to annually and provide education, including written materials, to owners to ensure proper maintenance.

- *Policy Recommendation A1.4:* Evaluate the county's current list of recommended BMPs (dated October 2, 2001) to determine their effectiveness based on current literature. Expand the list to include newer practices such as porous pavement, bioretention, and green rooftops. These practices are currently in use in the county and a number of LID practices have recently been incorporated into the Public Facilities Manual. The county will consider adoption of additional LID measures in the future. Adding them to the recommended list will make it easier for developers to include these in their site plans for review. Allow for the siting of integrated LID management practices on individual residential lots. Prepare materials to give to builders, remodelers, and developers to educate them about these LID practices and the county's preference for them. Adopt a policy preferring these practices where they are effective.

- *Policy Recommendation A1.5:* Retrofit and upgrade existing stormwater management facilities and BMPs, where feasible, to make them more effective in managing stormwater runoff. Construct new public BMPs including LID practices to detain the runoff from surrounding development that does not currently have stormwater management controls. Construct LID demonstration projects at publicly owned locations such as schools, parks, and other county properties.

- *Policy Recommendation A1.6:* Enact a new policy to more stringently require all land disturbance, remodeling, building, and redevelopment to retain on-site all runoff that would normally infiltrate (on natural landscapes), and prevent it from flowing onto adjacent properties, unless an exception is granted (e.g., property is next to a stream or natural area). Do not grant final residency permits until stormwater controls are properly installed and tested.

- *Policy Recommendation A1.7:* Fairfax County should not grant waivers of water quality controls for nonbonded lots exceeding 18% imperviousness. Nonbonded lots refer to existing lots (new construction, redevelopment, expansion, or renovation) that were created as part of an older development project for which the performance bond has been released.

- *Policy Recommendation A1.8:* Increase fines for noncompliance with BMP or LID requirements.

- *Policy Recommendation A1.9:* Coordinate county stormwater management activities with those of neighboring jurisdictions and review this coordination annually.

Objective A2: Install new BMP and LID facilities in areas that do not have existing stormwater management controls.

- *Policy Recommendation A2.1:* Encourage approval of LID facilities as acceptable stormwater management and adopt a policy preferring LID projects where they are effective.

Objective A3: Require development of new commercial and residential sites to reduce the post-development rate and volume of runoff to the minimum possible levels, and redevelopment sites to reduce the post-development runoff by targeted percentages from the pre-development rate and volume.

- *Policy Recommendation A3.1:* Amend the Fairfax County Erosion and Sedimentation Control Ordinance, Chesapeake Bay Preservation Ordinance, and other applicable ordinances to require that commercial and residential redevelopment of sites demonstrate a 10% net decrease in runoff if possible. Adopt graduated incentives for projects that exceed the 10% minimum, and do not allow residency permits until the site owners demonstrate that this has been achieved.

- *Policy Recommendation A3.2:* Amend zoning regulations or plans to encourage better design of new development (both public and private) to reduce or eliminate post-development runoff.

- *Policy Recommendation A3.3:* Consider providing incentives for developers, redevelopers, builders, and remodelers to reduce runoff, through zoning incentives or an expedited review process for developers who include conservation design techniques and LID components in their site plans.

- *Policy Recommendation A3.4:* Limit removal of mature trees and native vegetation in any new development, redevelopment, or renovation of

commercial and residential sites by making associated permits contingent on landscape requirements directed by the county.

- *Policy Recommendation A3.5:* Conduct frequent inspections during the building process to ensure compliance with permit conditions pertaining to landscaping requirements and adequate prevention of stormwater runoff. Rigorous fines and Stop Work Orders should be employed for noncompliance.

- *Policy Recommendation A3.6:* Allocate sufficient dedicated funding to adequately staff, educate, and otherwise support county inspection and enforcement related to preventing the removal of native mature trees and landscape or requiring restorative landscaping in accordance with permits.

Objective A4: Increase the participation of residents in decreasing the amount of stormwater runoff from impervious surfaces in residential areas.

- *Policy Recommendation A4.1:* Facilitate, through technical assistance, financial support, and other incentives, the construction and use of LID practices such as rain gardens, cisterns, and rain barrels throughout the watershed, initially targeting areas near the headwaters of streams to detain the runoff from developments that do not have stormwater management controls. The county should investigate mini grants, county tax abatements, or county property tax credits to facilitate implementation of LID practices.

- *Policy Recommendation A4.2:* Involve the public early in the planning of watershed projects and maintain transparency between the county and the public throughout the process. Improve coordination with and early notification of affected residents at both the study and implementation stages of proposed stormwater projects and notify affected civic associations.

Objective A5: Reduce the effects of stormwater runoff from existing and proposed roadways by instituting new countywide watershed management requirements.

- *Policy Recommendation A5.1:* In coordination with VDOT, require that road widening projects be designed to control the runoff from existing paved areas that do not have stormwater management controls and reduce the existing peak runoff rate by a minimum of 5%.

- *Policy Recommendation A5.2:* In coordination with VDOT, replace grasses on medians and sides of roadway with native trees and vegetation where possible.

Goal B: Preserve, maintain, and improve watershed habitats to support appropriate native flora and fauna.

Objective B1: P Preserve, restore, and manage riparian buffers to benefit appropriate native flora and fauna (and reduce the effects of stormwater runoff).

- *Policy Recommendation B1.1:* Plant buffers using native vegetation and trees adjacent to the stream in areas identified as good candidates for riparian buffer restoration. Monitor the condition of restored and existing riparian buffers for at least five years with annual stream walks to evaluate the condition and identify areas needing improvement.

- *Policy Recommendation B1.2:* Provide additional staff and dedicated funding to the county to ensure protection of riparian buffers and adequate review of waivers under the Chesapeake Bay RPA Ordinance. Ensure that county personnel are adequately trained with respect to the requirements of the RPA Ordinance and encourage strict enforcement of such requirements. Grant waivers very judiciously.

- *Policy Recommendation B1.3:* Require restoration of vegetation in the riparian buffer for development or redevelopment sites within the RPA that do not have existing buffer vegetation. Native vegetation mixes, suitable for local habitats, should be mandated in a BMP document identifying specific plants and trees that meet this definition.

- *Policy Recommendation B1.4:* Provide educational and technical assistance, including written materials, to owners of property with tidal shoreline and land adjacent to streams to help them manage existing buffers, including information about Virginia's wetlands' laws and the county's permitting process. Technical and educational assistance may include information about the benefits of riparian buffers, the value of native vegetation, identification and removal of invasive species, and healthy pruning.

- *Policy Recommendation B1.5:* Amend the county's tree cover policy to expand existing woodland habitat and prevent further deforestation. Conduct an inventory of significant native trees in the county. Strengthen the requirements of building permits and site plans to preserve native trees, encourage the planting of native trees, and protect trees with good construction practices. Require the planting of native trees and vegetation on all commercial properties where appropriate.

- *Policy Recommendation B1.6:* Determine the current level of mature tree canopy coverage existing in each subwatershed. Establish a reforestation goal, ensuring new native tree planting throughout each subwatershed to increase its canopy coverage by a minimum of 5% in five years. New reforestation targets should be adopted every five to seven years.

Objective B2: Preserve, restore, and manage habitat in streams and on stream banks to benefit appropriate native flora and fauna (and water quality).

- *Policy Recommendation B2.1:* Monitor and report on the condition of streams by performing a stream physical assessment every five years to track the improvement or degradation of streams from the baseline condition.

- *Policy Recommendation B2.2:* Facilitate the acquisition by and donation of conservation easements to community groups and land trust organizations for protection of streams and riparian buffers, as well as provision of public/private open space, for the environmental quality corridors described in the Fairfax County Comprehensive Plan and not adequately protected through the zoning process.

- *Policy Recommendation B2.3:* Adopt a county policy of implementing natural and water conserving landscaping approaches at all of its facilities in the watershed, implementing these beneficial watershed management approaches as models for future development.

- *Policy Recommendation B2.4:* Notify property owners of steps they could take to improve water quality in their streams (e.g., by providing information on reducing chemicals and fertilizers on lawns, using native plants, and performing natural landscaping).

Objective B3: Preserve, restore, and manage wetlands to benefit appropriate native flora and fauna.

- *Policy Recommendation B3.1:* Perform a wetlands functions-and-values survey to identify the location, size, owner, type, and quality of existing wetlands in the watershed to determine the baseline information.

- *Policy Recommendation B3.2:* Working with local communities, construct and restore wetlands at suitable locations in the watershed as identified by the wetlands functions-and-values survey.

- *Policy Recommendation B3.3:* Purchase private land, designate public land, or acquire easements for land conservation of critical wetland habitat areas as identified in the wetlands functions-and-values survey.

- *Policy Recommendation B3.4:* Create and distribute outreach materials that inform the public about the value and benefit of wetlands, the permits required for activities in wetlands, and the Wetlands Board's preference for LID techniques and "living shorelines."

- *Policy Recommendation B3.5:* Strengthen county policy and ordinances, in the event that impacts to wetlands are unavoidable, to require mitigation such as buying into a wetlands bank or creating compensatory wetlands. Wetland banks used for mitigation should be approved by state and federal regulatory agencies.

Goal C: Preserve, maintain, and improve water quality within streams to benefit humans and aquatic life.

Objective C1: Reduce and mitigate the effects of bank erosion and sedimentation.

- *Policy Recommendation C1.1:* Provide additional staff and resources to the county to inspect development projects and apply necessary penalties to ensure compliance with land disturbance prohibitions (and applicable erosion and sediment requirements) under the Chesapeake Bay Preservation Ordinance. Impose fines on persons or companies not complying with the requirements, and require restoration of the sites. Strengthen the current erosion and sediment control laws, policies, and regulations (e.g., Chapter 104 of the Fairfax County Code) to provide the penalties and restoration requirements described above."

- *Policy Recommendation C1.2:* Encourage application of bioengineering and natural stream channel design approaches to stabilize streambanks and improve stream habitat conditions.

- *Policy Recommendation C1.3:* Reduce the amount of county-applied de-icing materials such as sand and/or chemicals entering surface waters of the watershed, and require that excess de-icing materials be swept up in a timely manner to prevent them from reaching surface waters and causing sedimentation or impacting water quality. Limit the use of de-icing materials that impair water quality and recommend products and practices that will be specified in the county review and update of BMPs. Coordinate with VDOT to achieve the above goals on state roadways within the county.

Objective C2: Reduce the amount of pollutants such as fecal coliform, phosphorous, and nitrogen in stormwater runoff.

- *Policy Recommendation C2.1:* Identify sources of fecal coliform in the watershed (i.e., from humans, domesticated animals, or wildlife) and prepare an action plan to reduce the amount of fecal coliform.

- *Policy Recommendation C2.2:* Perform additional water quality monitoring that includes a macroinvertebrate and aquatic plant survey of Cameron Run

and its tributaries, and report the results to the public. Prepare an action plan based on the results.

- *Policy Recommendation C2.3:* Identify and investigate illicit discharges in the watershed from commercial and residential activities such as car repair and painting. Take enforcement actions to stop such illicit discharges.

- *Policy Recommendation C2.4:* Educate the public on ways to reduce the amount of pollutants in stormwater runoff. This can include, but is not limited to, storm drain stenciling, providing 'doggie mitts' in public parks, brochures, advertising, and working with community groups. Provide materials on natural landscaping, using native plants, and reducing use of chemicals and fertilizers.

- *Policy Recommendation C2.5:* Encourage all lawn management companies to participate in the Virginia Water Quality Improvement Program, and sign agreements requiring them to apply nutrients within established criteria to better control application rates and timing, thus creating a "green label" for lawn and landscaping companies. Provide a list of these companies to residential and commercial property owners and homeowners associations. Use only those companies on county-owned properties.

- *Policy Recommendation C2.6:* Strengthen enforcement of the "pooper scooper" regulation by instituting a $100 fine for violators.

Objective C3: Reduce the amount of trash and number of dumping sites in the watershed to help protect and improve the streams.

- *Policy Recommendation C3.1:* Work with community groups to clean up trash, woody debris that impedes stream flow, and dumpsites throughout the watershed.

- *Policy Recommendation C3.2:* Conduct a vigorous public information campaign, including installing signs throughout the watershed and coordinating with community groups, to deter littering and the dumping of trash.

- *Policy Recommendation C3.3:* Place containers at all public and other high-traffic facilities that have openings for recycling paper, glass, and aluminum with signs requesting sorting of trash and stating fines for littering.

- *Policy Recommendation C3.4:* Enforce the solid waste ordinance and the erosion and sedimentation control ordinance prohibitions against illegal dumping. Target locations experiencing frequent dumpings of trash and identify private, potentially illegal dumpsites located in the watershed. Impose fines on persons caught dumping illegally, take legal action against the property owners who create or knowingly allow illegal dumpsites, and

require restoration of the sites. Consider fencing or lighting on chronic dumping sites on both public and private land, where they would not cause adverse environmental impacts.

Goal D: Improve stream-based quality of life and environmentally friendly recreational opportunities for residents of and visitors to Cameron Run watershed.

Objective D1: Create additional access and trails for stream-based recreational opportunities in the watershed.

- *Policy Recommendation D1.1:* Identify stream corridors for purchase or acquisition of easements for public access and environmentally friendly recreation.

- *Policy Recommendation D1.2:* Develop a master plan for increased environmentally friendly recreational opportunities along the Cameron Run mainstem and major tributaries.

Objective D2: Increase public awareness and appreciation of streams in the watershed.

- *Policy Recommendation D2.1:* Post signage that publicizes the existence of RPAs and their importance for stream protection and environmentally sensitive recreation.

- *Policy Recommendation D2.2:* Install signage at public facilities to explain the reasons and benefits of rain gardens, green roofs, porous pavement, increased mature tree canopy coverage, and other LID features. Include this information in mailings to park users. Identify sources for interested citizens to obtain more information about these types of BMPs.

- *Policy Recommendation D2.3:* Evaluate, through a literature review or formal study, the effectiveness of public education programs for watershed stewardship. This could result in an addendum to this plan that identifies mechanisms for reaching watershed residents (e.g., through public and private schools, clubs, civic groups, service organizations, foreign-language communities). This addendum would also include the best methods for changing individual behaviors for better watershed stewardship. It would also include methods for monitoring the effectiveness of these methods, and adapting public education programs for success.

6.4 PROJECT ACTIONS

The proposed project actions for the Cameron Run Watershed Plan are based on analysis done by the Project Team with contributions from the Advisory Committee and the public. The

actions were selected to help meet the goals and objectives stated above. Specifically, these projects will address the following objectives:

Objective A1: Increase the effectiveness of existing BMPs by improving maintenance or "retrofitting" them to further reduce the effects of impervious areas (altered flows and poor water quality).

Objective A2: Install new BMP and LID facilities in areas that do not have existing stormwater management controls.

Objective A4: Increase the participation of residents in decreasing the amount of stormwater runoff from impervious surfaces in residential areas.

Objective B1: Preserve, restore, and manage riparian buffers to benefit appropriate native flora and fauna (and reduce the effects of stormwater runoff).

Objective B2: Preserve, restore, and manage habitat in streams and on stream banks to benefit appropriate native flora and fauna (and water quality).

Objective C1: Reduce and mitigate the effects of bank erosion and sedimentation.

Objective C2: Reduce the amount of pollutants such as fecal coliform, phosphorous, and nitrogen in stormwater runoff.

These actions may be structural or nonstructural projects of the following types:

- Projects initiated by the county via the Capital Improvement Program
- Projects initiated by developers via the Zoning Approval Process (proffers and development conditions) or waiver approval process
- Projects implemented by volunteer groups

The projects recommended in the plan fall into the following four categories:

- **Low impact development** – LID approaches are innovative practices designed to mimic natural flows by reducing the volume of stormwater runoff at the source, not just by managing flows as they leave a site. Distributed LID features are a series of smaller landscape features that function as retention/detention areas integrated with developed areas. These features are designed and constructed to detain and treat stormwater through natural processes such as infiltration, soil storage, and uptake by vegetation. Special attention should be paid to the composition of existing soils, as well as new soils or amended soils used. These solutions are increasingly being used to reduce the adverse environmental effects of stormwater and other urban stressors in developed areas (in addition to being incorporated into new development).

- **New storm water management ponds** – Placing new stormwater management (SWM) ponds, including small extended detention dry ponds, at locations that currently have no stormwater quantity or quality controls.
- **SWM retrofits** – Modifying existing SWM ponds to provide additional quantity or quality controls.
- **Stream restoration –** Modifying stream channels, banks, and instream habitat to improve degraded and unstable conditions.

As discussed in Chapter 5, the projects were separated into the following three groups to help prioritize the approximately 650 opportunities for watershed improvements identified during this study:

- **Tier 1** – Projects that represent the best opportunities for the county's efforts because they are located on public lands and were selected using SWMD's prioritization framework and in rough proportion to the amount of uncontrolled impervious surface within the subwatershed.
- **Tier 2** – Sites representing lower-priority projects on public land, or sites on private lands that present good opportunities and have received various levels of support from Advisory Committee members or the general public.
- **Tier 3** – The remainder of the approximately 650 sites identified during the initial map review and public involvement process.

The remainder of the plan focuses on the Tier 1 projects because they represent the best opportunities for the county to implement watershed improvements (Figure 6-1). The Tier 2 and Tier 3 sites present additional good opportunities, particularly if projects at these sites could be implemented through the development review process or other means; maps of these sites and tables containing descriptive information are included in Appendix A.2 and Appendix A.3.

In addition, the drainage complaints filed with the Fairfax County Maintenance and Stormwater Management Division were used to develop a supplemental list of projects that addressed drainage-related problems (see Section 6.4.7). Project fact sheets containing recommended actions for the 25 selected drainage complaint projects are included in Appendix A-4.

Table 6-1 shows a breakdown of all projects by project type and tier.

Table 6-1. The number of projects for each project type and tier

Project Type	Tier 1	Tier 2	Tier 3	Total
Non-structural projects and special studies	3	-	21	24
LID	77	54	306	437
New SWM pond	1	1	-	2
SWM pond retrofit	15	5	78	98
Stream restoration	4	32	2	38
Drainage Complaint Projects	25	-	-	25
Total	125	92	407	624

Implementing watershed improvement projects offers an opportunity to educate the surrounding community. To take advantage of this opportunity, the county should consider including an educational component (e.g., interpretive signs, brochures, public meetings, etc.) for each project that is implemented.

The sections that follow describe the various kinds of projects and include tables that list the specific project actions. More detailed information on projects is provided in Appendix A. Project fact sheets for the Tier 1 projects and the Drainage Complaint Projects are located in Appendix A-1 and Appendix A-4, respectively. Information on the Tier 2 and Tier 3 projects are provided in Appendix A-2 and Appendix A-3.

Implementation costs stated in the plan are order-of-magnitude estimates. Structural and non-structural projects will typically require additional design work, possible land rights acquisition, agreements, or other coordination during the implementation phase. It is assumed that the county will hire contractors to execute individual projects. The use of volunteer labor on appropriate projects will reduce costs. As the projects are evaluated further, more detailed cost estimates will be possible. In addition, site conditions may change over time as a result of maintenance, site improvements, natural processes, or other factors, and these changes may require modifying the proposed action at the time of implementation.

The projects for the plan are identified using the county's 6-digit numbering convention (XX9YZZ), where

XX9 = Watershed Code = CA9

Y = 1 for new SWM ponds or SWM retrofits
2 for stream restoration or stabilization projects
6 for flood control projects
7 for nonstructural projects and special studies throughout the watershed
8 and 9 for LID projects

ZZ = Digits representing locations in the watershed starting with 00 indicating the most downstream point in the watershed through 99 indicating the most upstream point.

6.4.1 Nonstructural Projects and Special Studies

Several nonstructural projects have been identified to address widespread issues and opportunities throughout the Cameron Run watershed (Table 6-2). Two of these projects provide educational and funding mechanisms to promote greater community support and participation in watershed improvements annually over the 25-year life of the plan.

6.4.2 Low Impact Development

LID includes the use of innovative practices designed to mimic natural flows by reducing the volume of stormwater runoff at the source. Usually these practices are integrated to fit specific site needs. In this plan, LID projects may include any combination of the practices listed and

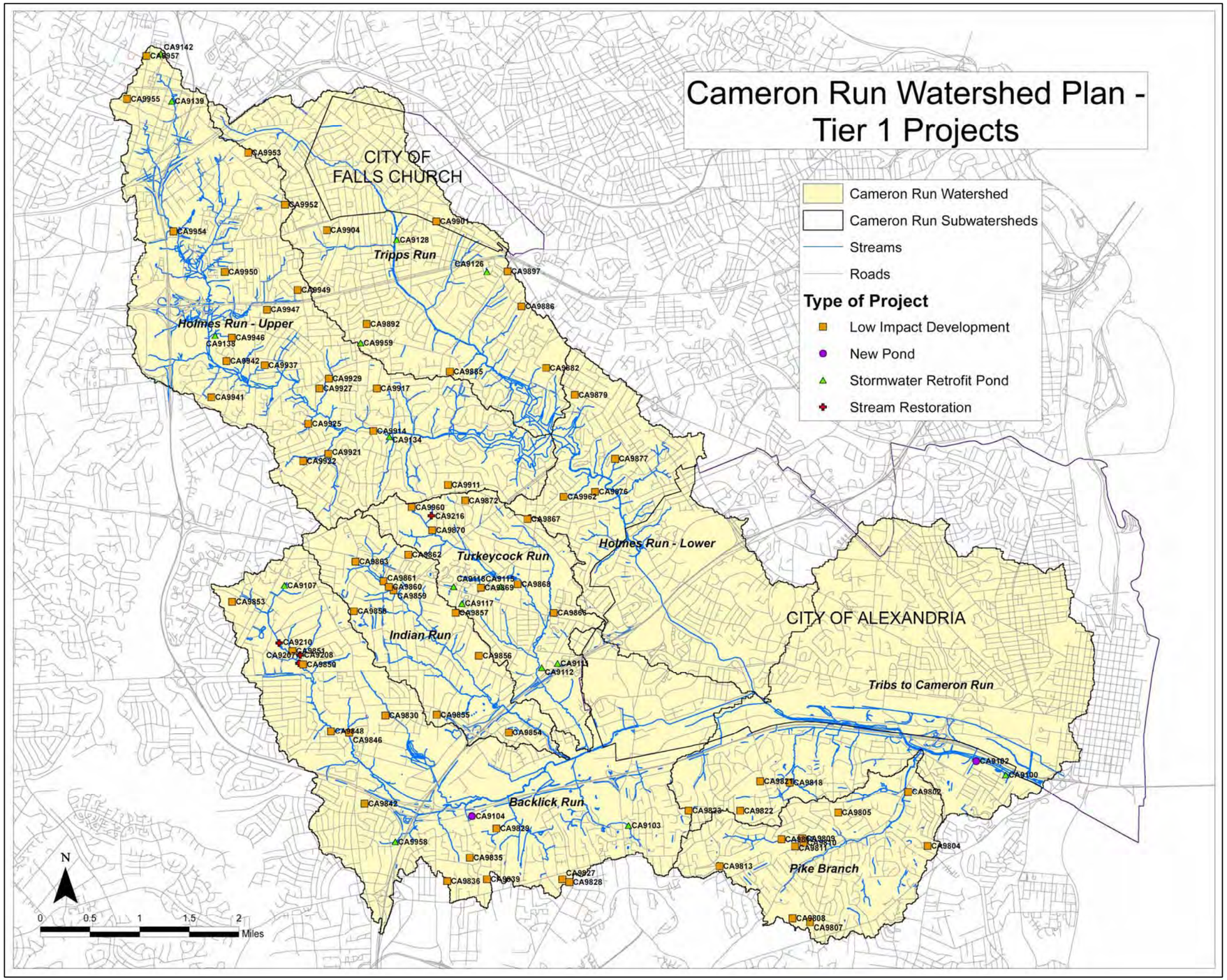


Figure 6-1. Location of Tier 1 candidate watershed restoration projects

Table 6-2. Nonstructural projects and special studies

Project ID	Project Name	Subwatershed	Proposed Action	Benefit	Estimated Cost
CA9700	Debris Jam Removal	Watershed-wide	Locate, evaluate, and remove debris jams observed to cause excessive erosion.	Improve stream stability, erosion, and instream habitat. Prevent property and structural loss. Reduce road flooding. Opportunity for public education.	$286,000
CA9701	Community Watershed Restoration Support	Watershed-wide	Provide education and technical assistance to encourage restoration practices on private property. Explain the need for restoration and describe effective techniques. Distribute "how to" information on creating rain gardens, backyard riparian buffers, and other LID projects. Provide technical assistance with individual LID projects.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion. Opportunity for public education.	$1,407,000 (over 25 years)
CA9702	Small Watershed Grant Program	Watershed-wide	Establish and administer an annual program that provides small grants to local organizations, residents, and businesses to facilitate education, capacity building, small retrofit and restoration projects, and monitoring activities. For example, grants could be used to off-set the costs to purchase and install rain barrels or other LID projects on private property via a coupon program or other sales mechanism, to cover staff time for a watershed organization, or to provide field equipment for a volunteer watershed monitoring program.	Improve stormwater quantity controls. Improve stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion.	$1,094,000 (over 25 years)

described in more detail below. LID projects have the best potential to control diffuse stormwater problems and restore natural hydrology throughout the watershed. They make up the majority of projects included in the plan.

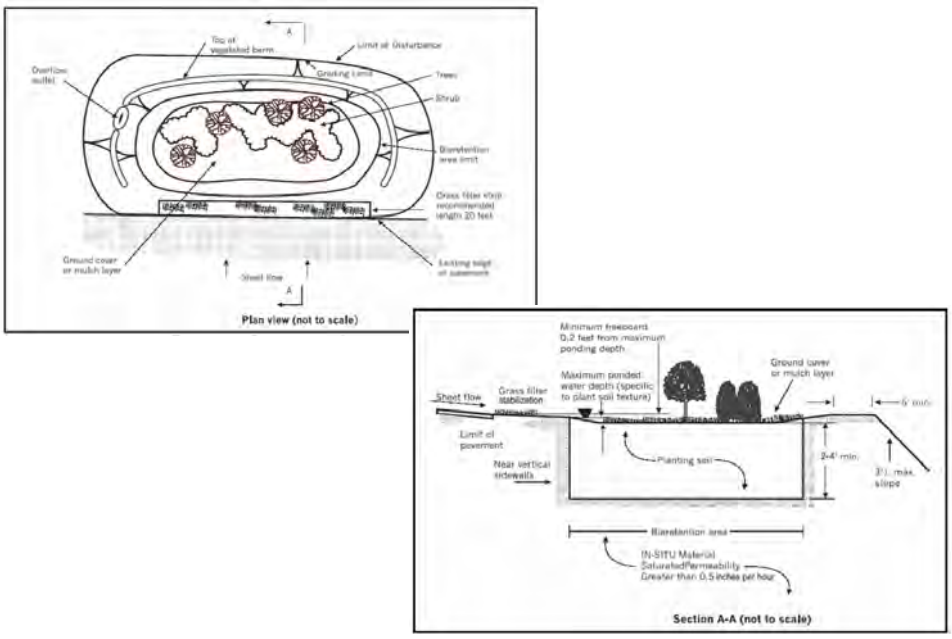
The following sections provide general descriptions of common LID techniques:

- bioretention areas (rain gardens)
- pipe outfall retrofits (off-line bioretention)
- infiltration trenches
- grassed swales
- tree box filters
- rain barrels/cisterns
- permeable pavers

6.4.2.1 Bioretention Area ("Rain Garden")

Description: A bioretention area is a shallow depression designed to detain and treat stormwater runoff from small, frequent storms by using a conditioned planting soil bed and planting materials (AMEC 2005). Pollutants are adsorbed by the soil and plant material, improving water quality. Water slowly infiltrates through the soil bed to recharge ground-water or is used by the plants via transpiration. In some cases, an underdrain system can be installed to carry treated water draining through the system to an existing stormdrain network.

Maintenance: Inspect the treatment area's components and repair or replace as necessary. This area is akin to a landscape feature in general maintenance needs, such as removal of accumulated sediment and debris, replacement of dead or stressed plants, and annual mulching (or as necessary). These facilities have an expected life span of 25 years.

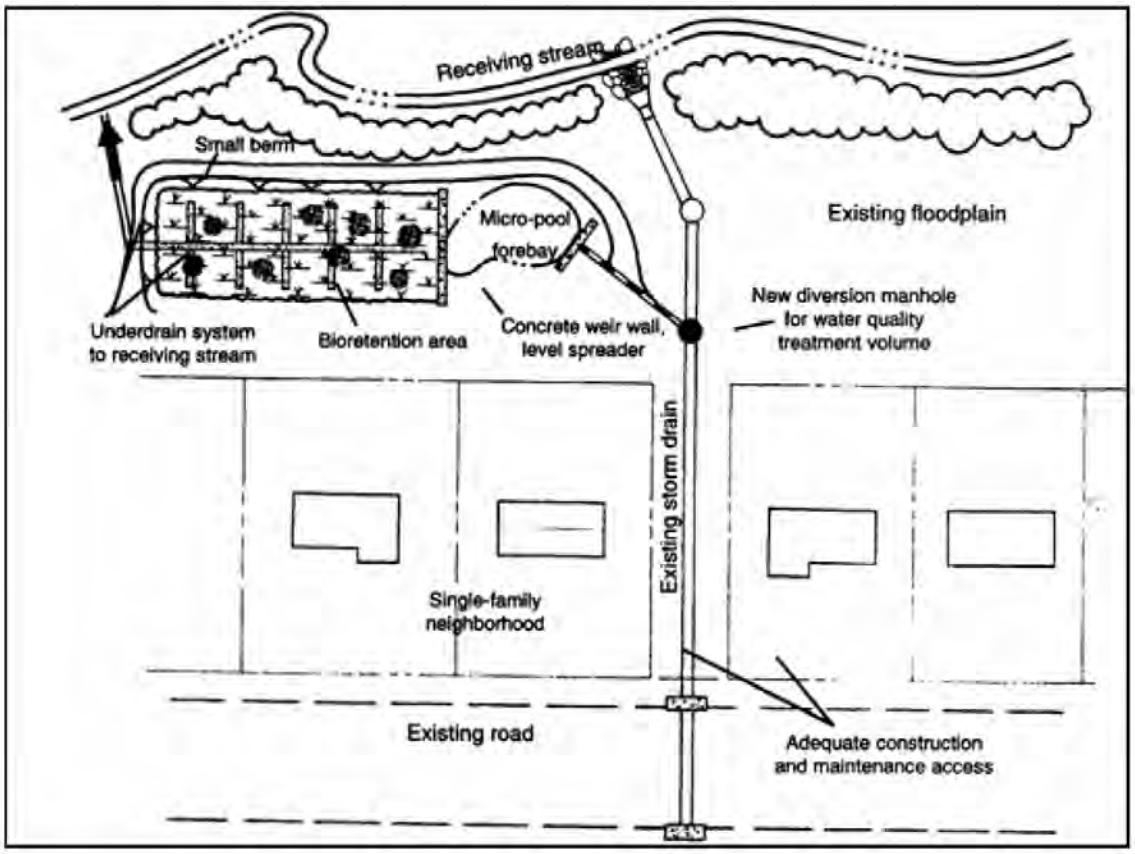


Bioretention Area (Source: Prince George's County 1999)

6.4.2.2 Pipe Outfall Retrofits (Off-line Bioretention)

Description: This retrofit option is installed immediately downstream of a stormwater drainage pipe outfall. Flow splitters can be used to convey water to a sand filter, bioretention area, off-line wetland, or wet pond for water quality treatment, while larger storms that exceed the treatment capacity are allowed to bypass the retrofit (AMEC 2005).

Maintenance: Inspect the treatment area's components and repair or replace as necessary. This area is akin to a landscape feature in general maintenance needs, such as removal of accumulated sediment and debris, replacement of dead or stressed plants, and annual mulching (or as necessary). An observation well can be used to make sure the underdrain is not clogged and is working properly. These facilities have an expected life span of 25 years.

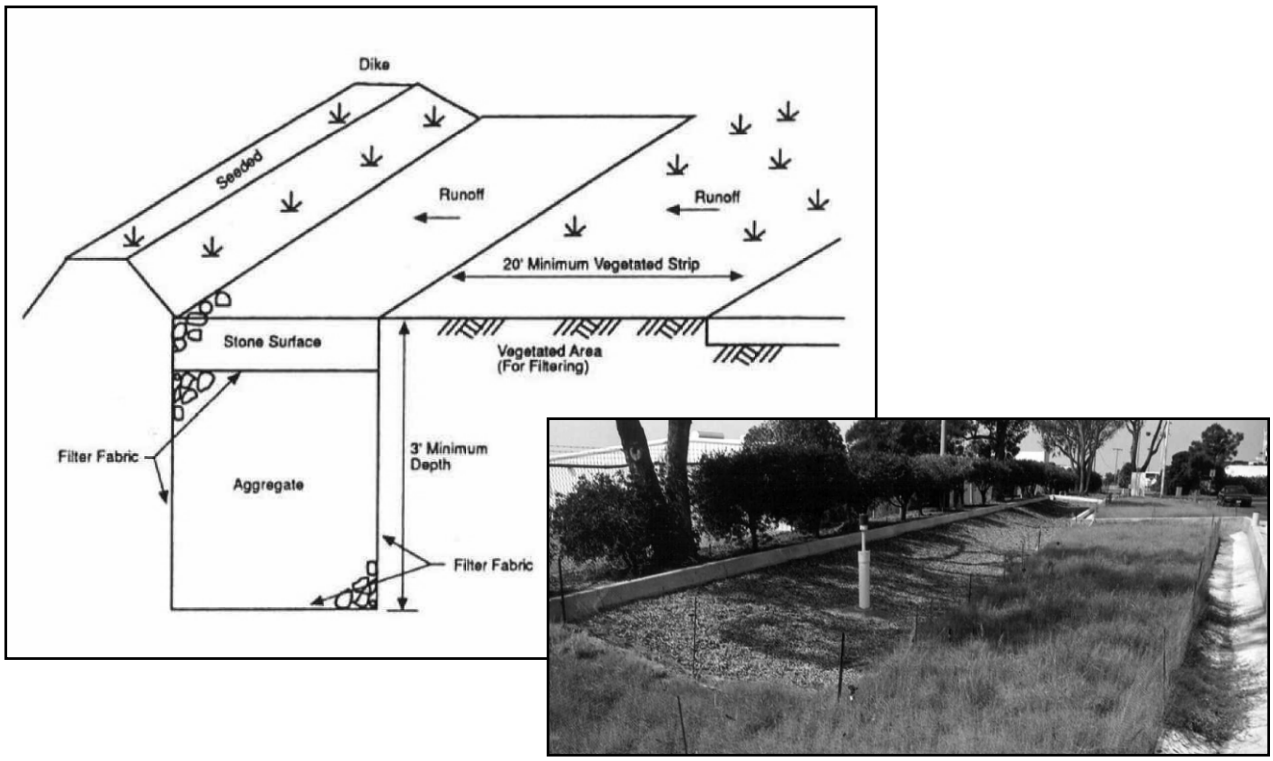


Pipe Outfall Retrofit (Source: Schueler et al. 2000)

6.4.2.3 Infiltration Trench

Description: An infiltration trench is an excavated trench that has been backfilled with stone to form a subsurface basin. Stormwater runoff is diverted into the trench and is stored until it can be infiltrated into the soil, usually over a period of several days. These structures are ideal for small urban drainage areas and have a longer life cycle when some form of pretreatment to remove sediment, such as a grass swale, is included in the design. Infiltration trenches can be installed in areas adjacent to parking lots, roads, and other impermeable surfaces to capture runoff (AMEC 2005).

Maintenance: Prevent sediments and debris from accumulating on the drained area, which could enter and clog the trench. Sediment and debris could be removed by routinely sweeping or by installing a grass filter strip or other pretreatment BMP. Maintenance of the pretreatment BMP is very important to prevent clogging. Filter strip maintenance consists of reseeding any eroded areas and periodically mowing to a height equal to or greater than the design flow height. These trenches have an expected life span of 10 years.

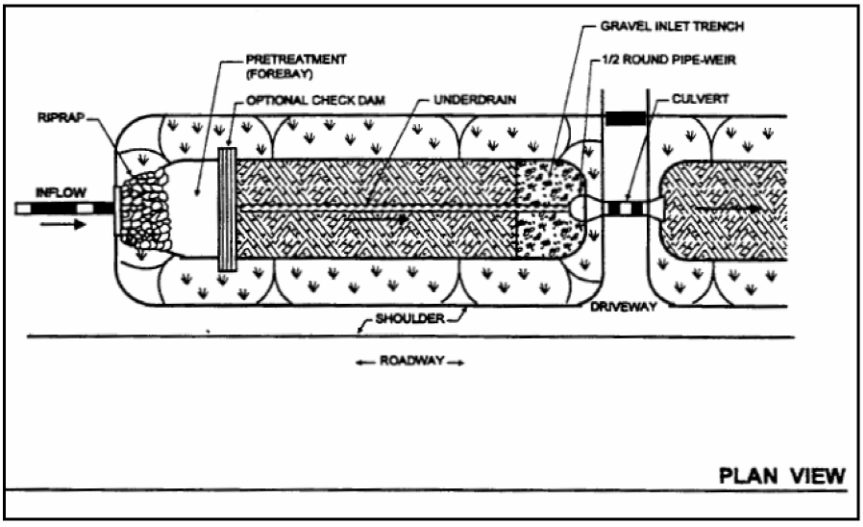


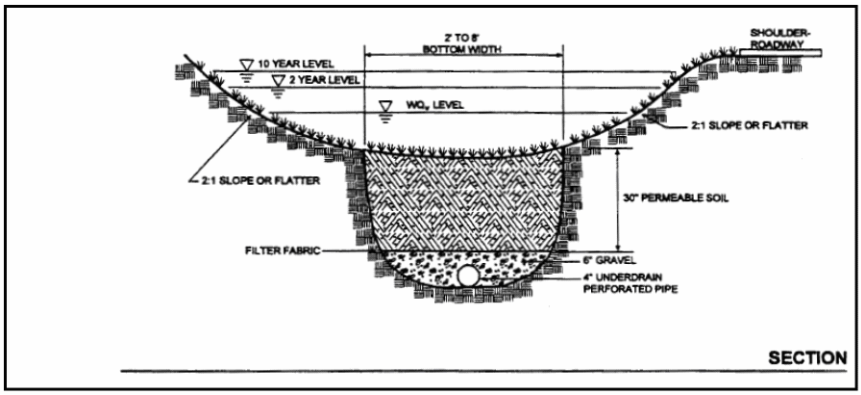
Infiltration Trench (Source: American Groundwater Trust and California Stormwater Quality Association in MAPC Undated)

6.4.2.4 Grassed Swale

Description: Grassed swales control both the quantity and quality of water. Stormwater travels more slowly in a grass swale than it does in a concrete ditch, reducing runoff volume and downstream erosion (AMEC 2005). Stormwater also infiltrates into the soil, further reducing volume and removing pollutants.

Maintenance: Maintain a dense, healthy grass cover through periodic mowing, keeping grass height at or above the design flow depth. In addition, weeding, watering, reseeding of bare areas, and clearing of debris and blockages may be necessary. Swales should be inspected periodically, especially after significant rain storms to correct sediment buildup and erosion. If sediment accumulates, sediments should be removed manually rather than with heavy machinery, which tends to reshape the swale and concentrate erosive flows. Fertilizers and pesticides should be avoided or used only when the grass cover is diseased or dying. Compaction of the swale, from parking cars and other uses, should also be avoided. Swales have an expected life span of 25 years.



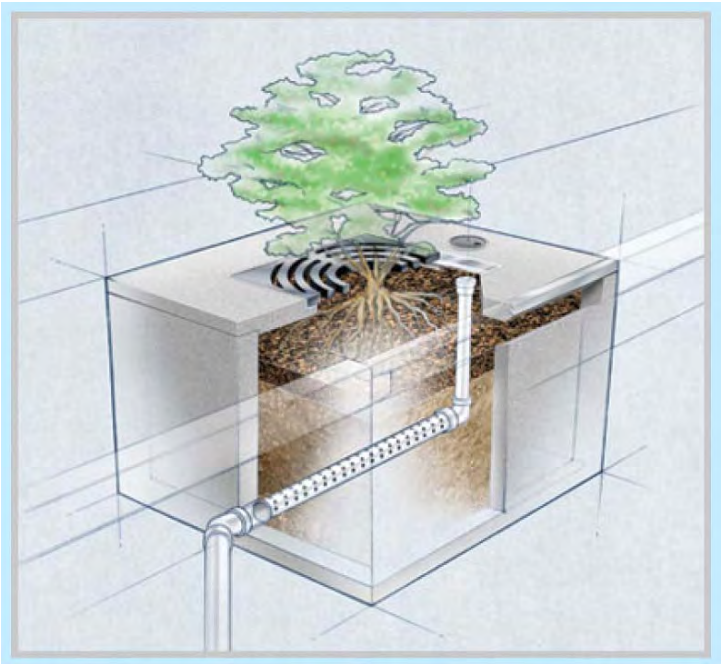


Grassed Swale (Source: Prince George's County 1999)

6.4.2.5 Tree Box Filter

Description: Tree box filters, such as the Filterra® Stormwater Bioretention Filtration System (or a comparable alternative), allow stormwater to flow through a specially designed filter mixture contained in a landscaped concrete container (AMEC 2005). These devices are typically used to retrofit traditional storm drain inlets with a bioretention function. The filter mixture inside the device immobilizes pollutants. Those pollutants are then decomposed, volatilized, and incorporated into the biomass of the unit. Stormwater runoff flows through the media and into an underdrain system at the bottom of the container, where the treated water is discharged to the stormdrain network.

Maintenance: Remove debris and sediment, replace dead or stressed plants, and mulch as necessary. Most manufactured LID devices come with an observation well that is used to make sure the underdrain is not clogged and is working properly. If the system becomes clogged, the filter mixture is replaced. Most manufacturers specify maintenance guidelines to maintain performance level. Manufactured LID devices have an expected life span of 25 years.

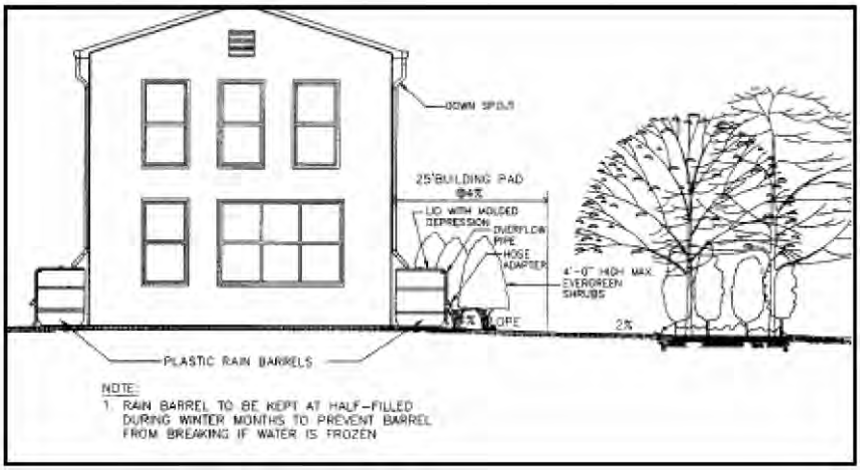


Schematic of a tree box filter in a storm drain inlet and recently installed filter at Providence RECenter (Sources: filterra.com; photo by P. Emerson, Versar, Inc.)

6.4.2.6 Rain Barrels/Cisterns

Description: Rain barrels are low-cost, effective, and easily maintainable retention devices that can be used in both residential and commercial/industrial sites. They are connected to downspouts to retain rooftop runoff. Rain barrels can be used to store runoff for later use in lawn and garden watering (AMEC 2005). Cisterns are larger rainwater storage containers placed either above or below ground. The water they capture is suitable for nonpotable uses.

Maintenance: Rain barrels and cisterns require very little maintenance. The container and attachments should be inspected for clogging several times a year and after significant storms. Minor parts, including spigots, screens, filters, downspouts, or leaders, may require replacement. Rain barrels and cisterns have an expected life span of 25 years.

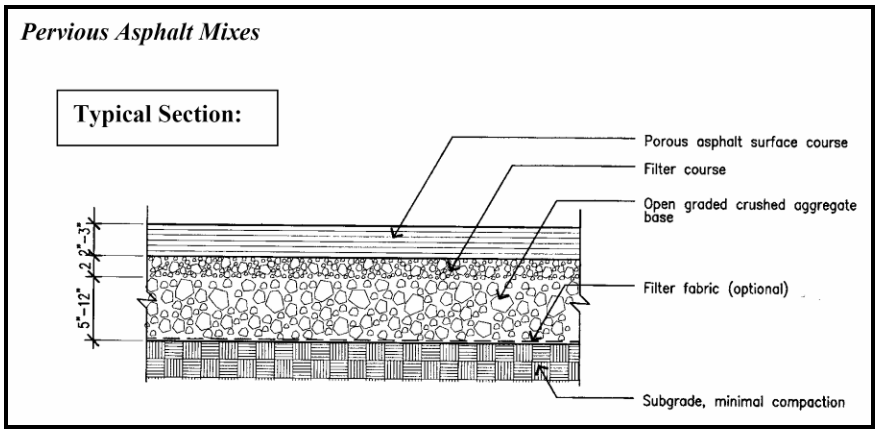


Rain barrel & above-ground cistern (Sources: Prince George's County 1999; www.aridsolutions.com; and www.plastmo.com)

6.4.2.7 Permeable Pavers

Description: Advances in paving technology have provided a variety of paving materials that allow water to move through the pavement section and into the subgrade and underlying soil. Three main types of permeable pavers are interlocking block systems, porous asphalt, and porous concrete. Each paving system is laid down on a specially constructed bed that allows downward and lateral transmission of water to provide a well-drained subgrade. Although such pavers have been used in high traffic and weight-load situations, they are ideal for lower-volume areas such as parking spaces, overflow parking lots, playing surfaces, and footpaths.

Maintenance: Permeable paving systems require periodic vacuum sweeping to keep the pore spaces clear of debris and infiltrating properly. Porous asphalt can be ground and resurfaced as needed, similar to traditional asphalt pavement, to keep the surface free of blemishes.



Permeable pavers – asphalt, concrete, and block (Source: City of Portland 2003)

Specific LID projects in the Cameron Run watershed are shown in Table 6-3.

Table 6-3. Low impact development projects included in the plan

Project ID	Project Name	Sub-watershed	Proposed Action	Benefit	Estimated Cost
CA9802	Jefferson Manor Park Bioretention	Pike Branch	Construct bioretention area below parking lot and detention micro-berm along edge of baseball field.	Provide stormwater quantity controls. Provide stormwater quality controls.	$73,000
CA9804	Mount Eagle Elementary School LID	Pike Branch	Construct bioretention areas in traffic island, at parking lot margins, SW corner of trailers, and SW corner of property; direct roof drains to bioretention areas; install infiltration trench along W side of new parking lot.	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$210,000
CA9805	Wilton Administration Center LID	Pike Branch	Construct bioretention areas in traffic islands along front and side parking lot, at inlet on south side of school, and at storm drain outlet on west side; install infiltration trenches and porous pavement in parking lots and asphalt court. This facility may be renovated within the next five years, and these proposed retrofits, or similar stormwater improvements, should be incorporated into the renovation plans.	Provide stormwater quality controls. Improve stormwater quantity controls. Opportunity for public education.	$460,000
CA9807	Virginia Hills Administration Center (School) LID	Pike Branch	Construct linear bioretention areas along outside of bus loop and along rear parking lot; direct roof drains at front wing to bioretention areas; install infiltration trench in NW corner of bus parking area. This facility may be renovated within the next five years, and these proposed retrofits, or similar stormwater improvements, should be incorporated into the renovation plans.	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$352,000
CA9808	Lee District Park LID	Pike Branch	Retrofit SWM pond control structure to improve detention control and add micropool areas in pond bottom to improve water quality; construct bioretention areas along N parking lot, in south central swale, and in parking lot islands/road margins; install infiltration trench in tennis court parking lot and porous pavement in E parking lot; convert athletic fields to artificial turf; add tree cover throughout. Note that athletic fields are scheduled for conversion to artificial turf in 2008. Facility maintenance and renovation is an on-going process, and proposed retrofits, or similar stormwater improvements, should be incorporated into site improvement plans.	Improve stormwater quantity controls. Improve stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion. Improve community usage. Opportunity for public education.	$1,589,000
CA9809	Ridgeview Park LID - A	Pike Branch	Construct off-line bioretention in existing swale; plant meadow in lawn areas that extend into park/ROW; build detention micro-berm parallel to ROW in meadow areas; use integrated vegetation management practices to encourage shrub/low growing trees beneath power lines.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion.	$59,000

Table 6-3. (Continued)

Project ID	Project Name	Sub-watershed	Proposed Action	Benefit	Estimated Cost
CA9810	Ridgeview Park LID - B	Pike Branch	Install off-line bioretention areas to intercept flow before reaching stormwater outfall.	Provide stormwater quality controls. Improve stormwater quantity controls. Opportunity for public education.	$414,000
CA9811	Redwood Lane - LID	Pike Branch	Construct off-line bioretention area at stormwater pipe outfall below Mulberry Ct.; use integrated vegetation management practices to encourage shrub/low growing trees beneath power lines.	Provide stormwater quantity controls. Provide stormwater quality controls.	$211,000
CA9812	Ridge View Drive - LID	Pike Branch	Construct off-line bioretention area at stormwater pipe outfall.	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$249,000
CA9813	John Marshall Library LID	Pike Branch	Construct linear bioretention areas along edge of rear parking lot and in swale to NW; construct bioretention areas in islands along front of bldg. and in parking lot; install infiltration trench in rear parking lot.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion. Opportunity for public education.	$246,000
CA9818	Clermont School Site Park LID	Tributaries to Cameron Run	Construct bioretention area below houses on Gypsy Ct.	Provide stormwater quantity controls. Provide stormwater quality controls.	$49,000
CA9821	Clermont Elementary School LID	Tributaries to Cameron Run	Construct bioretention areas in bus loop traffic island and NW of building; construct linear bioretention area S of building and along west end of fields; replace inlet at NE corner of parking lot with a tree box filter.	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$308,000
CA9822	Twain Middle School LID	Tributaries to Cameron Run	Construct bioretention areas in bus loop traffic island and in grass island SW of bldg.; construct linear bioretention areas along E side of property; install infiltration trenches and tree box filters in SE parking lot.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve community usage. Opportunity for public education.	$660,000
CA9823	Bush Hill Elementary School LID	Tributaries to Cameron Run	Construct bioretention areas in traffic/sidewalk islands; install infiltration trenches in parking lots; construct off-line bioretention at end of concrete trench from eastern parking lot and detention micro-berm along northern tree line.	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$183,000
CA9827	Lee District Government Center LID	Backlick Run	Construct bioretention areas in traffic islands; install infiltration trench in lane SW of bldg.; install tree box filters and porous pavement.	Provide stormwater quantity controls. Provide stormwater quality controls.	$209,000
CA9828	Fire Station - Company No. 5 LID	Backlick Run	At Fire Station, divert roof drains to cistern for filling fire trucks; install porous pavement in W parking lot; construct bioretention area in SE corner; install tree box filter.	Provide stormwater quantity controls. Provide stormwater quality controls.	$71,000

Table 6-3. (Continued)

Project ID	Project Name	Sub-watershed	Proposed Action	Benefit	Estimated Cost
CA9829	Franconia Park LID	Backlick Run	Construct bioretention areas in islands of both parking lots; plant trees between soccer fields and other locations to provide shade; repair streambank erosion and downcutting. Note that athletic fields are scheduled for conversion to artificial turf. Facility maintenance and renovation is an on-going process, and proposed retrofits, or similar stormwater improvements, should be incorporated into site improvement plans.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion. Opportunity for public education.	$126,000
CA9830	Edsall Administration Center LID	Backlick Run	Install infiltration trenches in parking lots; construct bioretention areas in islands/borders; install tree box filters.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion. Improve community usage.	$139,000
CA9835	Springfield Elementary School LID	Backlick Run	Create bioretention areas in bus loop and landscape islands in front of bldg.; install infiltration trenches and tree box filters in parking lot; construct linear bioretention areas and filter strip adjacent to asphalt play yard; convert soccer/football field from grass to artificial turf with cistern and underdrain system.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion. Improve community usage. Opportunity for public education.	$1,356,000
CA9836	Lee High School LID	Backlick Run	Construct off-line bioretention area at outfall S of Deepford St.; construct infiltration trenches and bioretention areas in parking lots around school bldg.; linear bioretention areas along tennis courts and concrete swale E of trailers; build detention micro-berm around 2 inlets; reforest unused open space.	Provide stormwater quantity controls. Provide stormwater quality controls.	$3,421,000
CA9839	Key Middle School LID	Backlick Run	Construct bioretention areas, infiltration trenches, and tree box filters in parking lots; convert NE parking lot to porous pavement; provide depression storage N of bldg. in trailer area (not shown in aerial); convert two fields from grass to artificial turf with cistern and underdrain system.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion. Improve community usage. Opportunity for public education.	$2,745,000
CA9842	Lynbrook Elementary School LID	Backlick Run	Construct bioretention in bus loop island, in front of school building, and to E of bldg.; direct roof drainage to cistern to water fields; install infiltration trenches and tree box filters in parking lot.	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$254,000
CA9846	Leewood Park LID - A	Backlick Run	Restore grass swale; install bioretention area next to stormwater outfall pipe. Use woodland species.	Provide stormwater quality controls. Opportunity for public education.	$39,000
CA9848	Leewood Park LID - B	Backlick Run	Install riprap and infiltration trench at the end of stormwater outfall.	Provide stormwater quality controls. Opportunity for public education.	$13,000

Table 6-3. (Continued)

Project ID	Project Name	Sub-watershed	Proposed Action	Benefit	Estimated Cost
CA9850	Wilburdale Park LID - A	Backlick Run	Install bioretention areas next to court and along street; construct off-line bioretention area at outfall into concrete ditch; reforest unused areas in park.	Provide stormwater quality controls. Opportunity for public education. Improve community usage.	$156,000
CA9851	Wilburdale Park LID - B	Backlick Run	Develop/restore grass swales along road to deliver runoff to new bioretention area at end of roadway.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion.	$97,000
CA9853	Annandale High School LID	Backlick Run	Incorporate grass swale along roadway; construct linear bioretention areas and infiltration trenches along parking lots and courts; install tree box filters.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion. Improve community usage. Opportunity for public education.	$420,000
CA9854	Bren Mar Park Elementary School LID	Indian Run	Construct linear bioretention areas in grass areas along Beryl Rd. and along E edge of parking lot; install infiltration trench and tree box filter in rear of parking lot; plant shade trees between new basketball court and baseball field (not shown on aerial).	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$230,000
CA9855	Fire Station - Company No. 26 LID	Indian Run	At Fire Station, divert roof drains to cistern for filling fire trucks; construct bioretention areas in sodded ditch to north and along western edge of parking lot.	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$131,000
CA9856	Holmes Middle School LID	Indian Run	Construct linear bioretention areas in grass along Montrose St.; construct area bioretention areas in traffic islands in NW and E lots; install infiltration trenches in road ways and next to rear of bldg.; install tree box filters in front lot and filter strip along edge of rear parking lots; create multisport, artificial-turf playing fields.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve community usage. Opportunity for public education.	$1,593,000
CA9857	Weyanoke Elementary School LID	Indian Run	Construct bioretention area in Braddock Rd. traffic island and at edge of asphalt courts; install filter strip around asphalt courts; install linear bioretention area, tree box filters, and infiltration trenches in S parking lot	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$124,000
CA9858	Poe Middle School LID	Indian Run	Construct linear bioretention area in loop island; install infiltration trenches, tree box filters, and traffic island bioretention areas in parking lots.	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$248,000
CA9859	Indian Run Stream Valley Park LID - C	Indian Run	Install off-line bioretention area at end of stormwater outfall.	Provide stormwater quality controls. Improve stormwater quantity controls.	$516,000
CA9860	Indian Run Stream Valley Park LID - A	Indian Run	Install bioretention area at end of stormwater outfall.	Provide stormwater quality controls. Improve stormwater quantity controls.	$334,000

Table 6-3. (Continued)

Project ID	Project Name	Sub-watershed	Proposed Action	Benefit	Estimated Cost
CA9861	Indian Run Stream Valley Park LID - B	Indian Run	Install bioretention area at end of stormwater outfall.	Provide stormwater quality controls. Improve stormwater quantity controls.	$543,000
CA9862	Columbia Elementary School LID	Indian Run	Construct linear and area bioretention areas in traffic islands; install infiltration trenches in front parking lots and side road; replace inlets with tree box filters; restore existing grass swale in back of bldg.; add filter strips around two inlets.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion. Opportunity for public education.	$134,000
CA9863	George Mason Regional Library LID	Indian Run	Construct bioretention in traffic islands along Little River Turnpike, in parking lot, between bldg. and Hillbrook Dr., and at SW corner of bldg.; install infiltration trench along several parking rows; install tree box filter inserts.	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$403,000
CA9866	Turkeycock Run Stream Valley Park LID	Turkeycock Run	Install off-line bioretention area at end of stormwater outfall; repair concrete ditch and add riprap protection.	Provide stormwater quality controls. Improve stormwater quantity controls. Opportunity for public education.	$198,000
CA9867	Parklawn Elementary School LID	Turkeycock Run	Retrofit small dry pond to wet detention pond; construct bioretention areas in traffic islands; install infiltration trenches and one tree box filter in parking lots; install linear bioretention strips along large trailer (not shown) SW of bldg.; direct roof drains to cistern to water fields; reforest unused lawn areas.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve community usage. Opportunity for public education.	$168,000
CA9868	Green Spring Gardens LID	Turkeycock Run	Install linear bioretention area along parking spaces and infiltration trenches in traffic circle.	Provide stormwater quality controls. Improve stormwater quantity controls. Opportunity for public education.	$99,000
CA9869	Pinecrest Golf Course LID	Turkeycock Run	Implement stormwater retrofits based on the Park Authority's existing LID retrofit concept plan.	Provide stormwater quality controls. Improve stormwater quantity controls. Opportunity for public education.	$78,000
CA9870	Wolftree Lane LID	Turkeycock Run	Linear bioretention area to capture end of pipe stormwater.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion.	$286,000
CA9872	Mason Government Center LID	Turkeycock Run	Retrofit SWM pond control structure to improve detention control and add micropool areas in pond bottom to improve water quality; construct bioretention area along Columbia Pike to collect roadway runoff; install linear bioretention strips, bioretention areas, and tree box filters in parking lot.	Improve stormwater quantity controls. Improve stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion. Opportunity for public education.	$220,000

Table 6-3. (Continued)

Project ID	Project Name	Sub-watershed	Proposed Action	Benefit	Estimated Cost
CA9876	Glasgow Middle School LID	Holmes Run - Lower	Install off-line bioretention areas at stormwater pipe outfall on E side of entrance road. Note: school to be rebuilt by fall 2008.	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$703,000
CA9877	Baileys Community Center LID	Holmes Run - Lower	Construct linear and area bioretention areas in traffic islands along front and east sides, by tennis courts, west side of building, and end of Summers Lane; build detention micro-berm along north side of baseball field, NW corner of tennis court, and edge of southwestern lot; install tree box filter in inlet on Summers Ln.	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$351,000
CA9879	Baileys Elementary School LID	Holmes Run - Lower	Construct bioretention areas in traffic islands for bus loop and parking lots, near asphalt courts, and near portable classrooms; install infiltration trenches in parking areas and porous pavement in play yards; create artificial turf field with underdrains and cistern.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve community usage. Opportunity for public education.	$1,535,000
CA9882	JEB Stuart High School LID	Tripps Run	Construct linear bioretention area along Peace Valley Ln. median; construct a stepped bioretention areas along S edge of parking lot and SE corner of fields; construct bioretention areas in parking islands and around playing fields; plant wildflowers along SE side of baseball field; upgrade fields to multisport artificial turf with underdrains and cistern.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve community usage. Opportunity for public education.	$1,881,000
CA9885	Sleepy Hollow Elementary School LID	Tripps Run	Install infiltration trenches in parking lot and bioretention areas at yard drain inlets.	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$455,000
CA9886	Nicholson St - Ch. 2 Street LID	Tripps Run	Construct bioretention area in Chapter-2 street lot, divert road runoff into area.	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$100,000
CA9892	Westlawn Elementary School LID	Tripps Run	Install bioretention area, infiltration trenches, and tree box filters in parking lots; construct linear bioretention along asphalt courts; and construct grass swale around two sides of fields.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion. Opportunity for public education.	$117,000
CA9897	Fire Station - Company No. 28 LID	Tripps Run	At Fire Station, divert roof drains to cistern for filling fire trucks; construct bioretention areas in SW and SE corners of traffic islands in parking lot; construct linear bioretention areas on S side of truck entrance and S side of parking lot.	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$23,000
CA9901	Larry Graves Park LID	Tripps Run	Construct bioretention areas in grass along Hillwood Ave. and replace inlet with tree box filter.	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$41,000

Table 6-3. (Continued)

Project ID	Project Name	Sub-watershed	Proposed Action	Benefit	Estimated Cost
CA9904	Devonshire Administration Center (School) LID	Tripps Run	Construct bioretention areas in traffic circle and in grass areas next to N and S parking lots; construct linear bioretention areas at edges of S lot; construct infiltration trenches and filter strips in N and rear lots; build detention micro-berm along tree line.	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$288,000
CA9911	Belvedere Elementary School LID	Holmes Run - Upper	Construct bioretention areas in bus loop island, traffic island, along back edge in side lot, and in landscape islands around bldg.; build detention micro-berm along north side of property; install linear bioretention area and infiltration trench in side parking lot; and convert concrete ditches to grass swales.	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$325,000
CA9914	Columbia Pines LID	Holmes Run - Upper	Construct off-line bioretention areas to capture end-of-pipe stormwater prior to entering the stream.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve stream stability, erosion, and instream habitat. Improve floodplain and nutrient cycling functions.	$ 96,000
CA9917	Beech Tree Elementary School LID	Holmes Run - Upper	Construct bioretention areas along Beechtree Ln. and in landscape islands around bldg. and trailers; install infiltration trenches in bus loop and drive; install two tree box filters at stormdrain inlets; install filter strip along Beechtree Ln.; build detention micro-berm along SW side of bldg.; convert playing fields to artificial turf with cistern.	Provide stormwater quality controls. Improve stormwater quantity controls. Improve community usage. Opportunity for public education.	$1,409,000
CA9921	Broyhill Crest Park LID	Holmes Run - Upper	Develop detention micro-berm along tree line to slow runoff and induce infiltration; construct bioretention areas with small cistern for watering community garden.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion. Improve community usage. Opportunity for public education.	$132,000
CA9922	Lacey Admin Center LID	Holmes Run - Upper	Develop playing field using artificial turf with underdrain/cistern system for use as soccer and football field; add bioretention areas and infiltration strips in parking lot islands and margins.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve community usage. Opportunity for public education.	$1,317,000
CA9925	Holmes Run Stream Valley Park LID	Holmes Run - Upper	Construct off-line bioretention areas (stepped) to capture end-of-pipe storm-water prior to entering the stream.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion. Improve floodplain and nutrient cycling functions.	$87,000

Table 6-3. (Continued)

Project ID	Project Name	Sub-watershed	Proposed Action	Benefit	Estimated Cost
CA9927	Round Tree Park LID - C	Holmes Run - Upper	Convert parking lot traffic islands to bioretention areas and re-route field and court drainage to bioretention areas; construct detention micro-berm in open area along stream.	Provide stormwater quality controls. Improve stormwater quantity controls. Opportunity for public education.	$195,000
CA9929	Round Tree Park LID - A	Holmes Run - Upper	Install off-line bioretention area to capture end of pipe stormwater prior to entering the stream.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion. Improve floodplain and nutrient cycling functions.	$52,000
CA9937	Walnut Hill Admin Center LID - B	Holmes Run - Upper	Construct linear bioretention strips along road, parking lots, and south side of playing fields; install infiltration trenches in front and rear lots; divert 12 roof drains and courts to bioretention areas; convert fields to artificial turf with underdrains; plantings in unused open space.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve community usage. Opportunity for public education.	$2,953,000
CA9941	Woodburn Elementary School LID	Holmes Run - Upper	Install bioretention areas in landscaped islands along Gallows Rd., Hemlock Dr., and bus loop; install infiltration trenches in front parking lot; install linear bioretention area along bldg. in downspout areas and ditch to N; install porous pavement in asphalt play area; convert soccer/football field from grass to artificial turf.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion. Improve community usage. Opportunity for public education.	$1,342,000
CA9942	Luria Park LID	Holmes Run - Upper	Install off-line bioretention areas at stormwater pipe outfalls and area bioretention areas at end of streets at Fallowfield Dr., Oak Run Ct., E end of Trail Run Rd., Crest Haven Ct., and W end of Camp Alger Av.	Provide stormwater quality controls. Improve stormwater quantity controls. Opportunity for public education.	$355,000
CA9946	Falls Church High School LID	Holmes Run - Upper	Construct bioretention areas in traffic islands along front of school, in landscape beds, and along side of E parking lot; install infiltration trench along E side of tennis courts, in NW parking lot, and in paved grandstand areas; create two multisport athletic fields with artificial turf; construct linear bioretention areas along S side of rear parking lot; build detention micro-berms around field margins and yard drain.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve community usage. Opportunity for public education.	$2,772,000
CA9947	Thomas Jefferson Library LID	Holmes Run - Upper	Construct bioretention areas in front of library for roof drainage, along row of head-on parking spaces, and at SW and SE corners of lot; install infiltration trench across entrance road.	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$179,000

Table 6-3. (Continued)

Project ID	Project Name	Sub-watershed	Proposed Action	Benefit	Estimated Cost
CA9949	Graham Road Elementary School LID	Holmes Run - Upper	Construct bioretention areas in traffic island for bus loop, between sidewalk and building in front, along Monticello Dr., and along north side of back lot; install porous pavement and infiltration trench in deteriorated asphalt play yard.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve community usage. Opportunity for public education.	$127,000
CA9950	Pine Spring Elementary School LID	Holmes Run - Upper	Construct detention micro-berm and bioretention areas along NW property line; construct bioretention areas in bus loop and parking lot islands, NW outfall, and trailers; construct linear bioretention along N parking lot, trailers, and in existing swale on S edge of property; construct off-line bioretention area at outfall S of rear parking lot.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve community usage. Opportunity for public education.	$576,000
CA9952	Timber Lane Elementary School LID	Holmes Run - Upper	Construct bioretention areas in lawn and traffic islands along West Street, in N parking lot, behind bldg., and next to fields; construct linear bioretention areas around building; install infiltration trench and tree box filter in N parking lot.	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$606,000
CA9953	Shrevewood Elementary School LID	Holmes Run - Upper	Construct bioretention areas in Shreve Rd. median islands, bus loop island, east side of parking lot, near playground, and at rear of bldg.; construct linear bioretention along NW corner of back field, next to asphalt courts, and in swale at NE corner along road.	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$359,000
CA9954	Jefferson District Park & Golf Course LID	Holmes Run - Upper	Install filter strips around SWM pond and 2 central water hazards; construct linear and area bioretention areas and infiltration trenches along parking lots and court surfaces; depress footpath to avoid directing flow from ponds to stream.	Improve stormwater quantity controls. Improve stormwater quality controls. Improve community usage. Opportunity for public education.	$236,000
CA9955	Dunn Loring Center (School) LID	Holmes Run - Upper	Disconnect downspouts and redirect to bioretention areas in landscape beds; construct linear bioretention areas around NW corner of bldg., above berm N of bldg., and at W end of fields; install infiltration trench in N parking lot; construct bioretention areas in traffic islands SW of bldg. and trailers.	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$722,000
CA9957	Fire Station - Company No. 13 LID	Holmes Run - Upper	Construct bioretention areas on W side of parking lot prior to inlets; provide rain barrels for downspouts from overhangs at front and rear entrances; install infiltration trenches along N side and in front of bldg.; install linear bioretention area in median along Gallows Rd.	Provide stormwater quantity controls. Provide stormwater quality controls.	$132,000

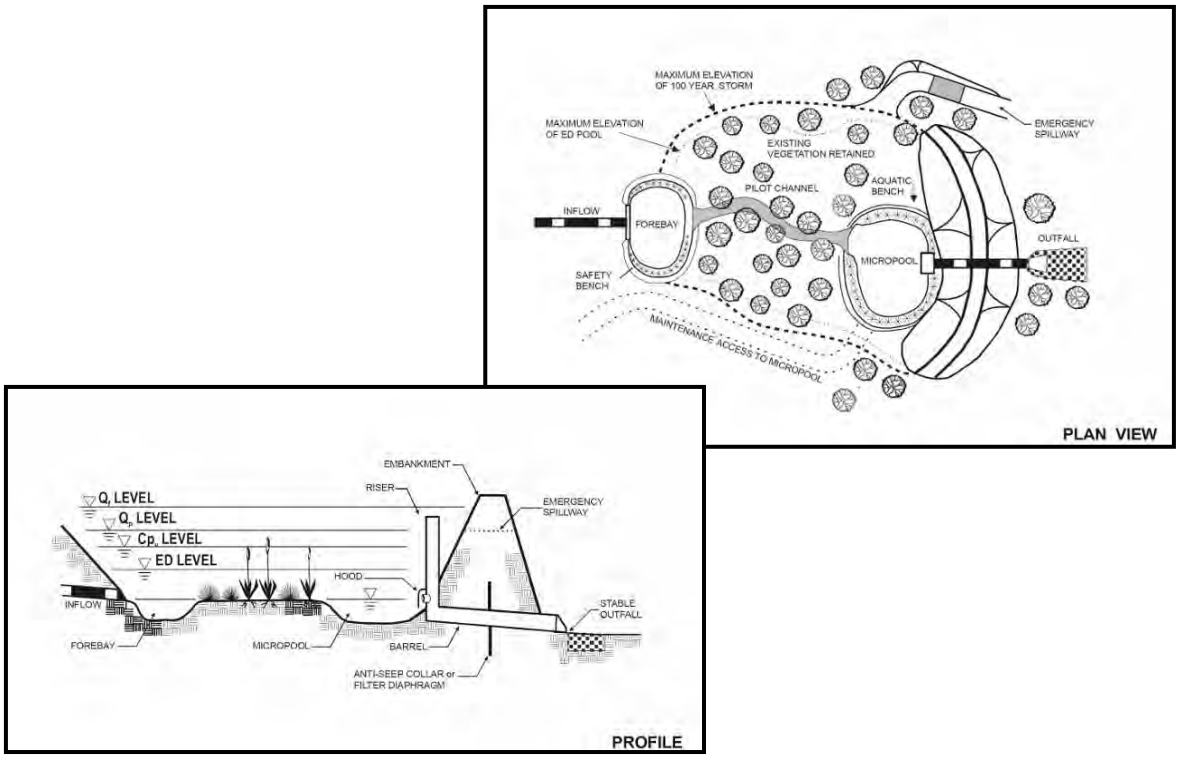
Table 6-3. (Continued)

Project ID	Project Name	Sub-watershed	Proposed Action	Benefit	Estimated Cost
CA9958	Lynbrook Subdivision LID - A	Backlick Run	Add 2 off-line bioretention areas below road to capture flow from two outfalls; repair concrete apron below road culvert.	Improve stormwater quantity controls. Improve stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion.	$89,000
CA9959	Anna Lee Heights LID	Tripps Run	Construct bioretention area within existing swale.	Improve stormwater quantity controls. Improve stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion.	$77,000
CA9960	Mason District Park LID	Turkeycock Run	Implement stormwater retrofits based on the Park Authority's existing LID retrofit concept plan.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion. Opportunity for public education.	$120,000
CA9962	Holmes Run Park LID	Holmes Run - Lower	Install linear and circular bioretention areas along road and detention micro-berms around two stormwater area drains in park.	Provide stormwater quantity controls. Provide stormwater quality controls. Opportunity for public education.	$158,000

6.4.3 New SWM Ponds

Description: SWM ponds are the traditional method of controlling stormwater flows. Create new SWM ponds to provide detention and water quality controls in areas where no ponds exist. Although sufficient space for this option may be difficult to obtain in built-out settings, the resulting benefits to flow volume and velocity control, and water quality improvement can be significant. Benefits may vary depending on the specific design features of the individual ponds.

Maintenance: The maintenance requirements of traditional stormwater ponds are well known. A typical pond is inspected by county personnel trained in dam safety and pond maintenance, looking at the dam, pipes, and riser structure to ensure they are functioning properly. Pretreatment facilities need to be inspected for clogging by sediments and large debris. If sediment or debris is evident, the area needs to be cleaned.



New SWM pond (micropool extended detention pond shown) (Source: MDE 2000a)

The new stormwater management pond project included in the plan is shown in Table 6-4.

Table 6-4. New stormwater management pond projects included in the plan

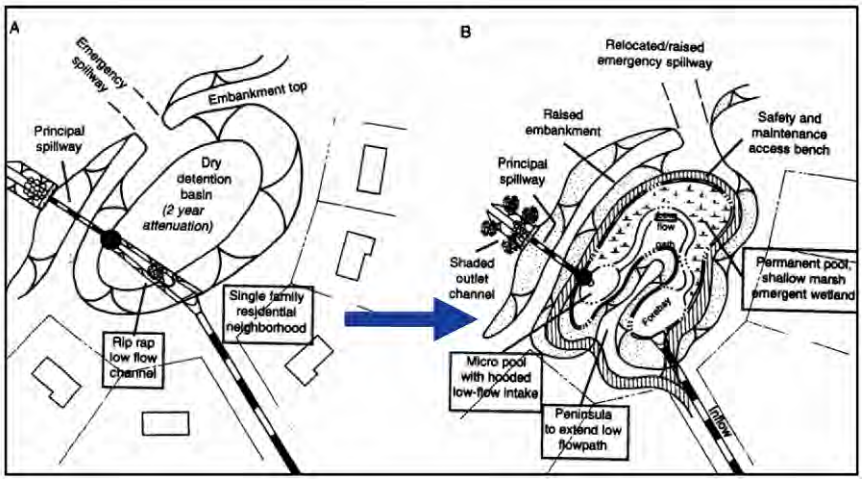
Project ID	Project Name	Sub-watershed	Proposed Action	Benefit	Estimated Cost
CA9102	Huntington Park SWM Pond	Tributaries to Cameron Run	Install SWM pond with micropool areas in pond bottom to provide water quality and extended detention controls. This project will be re-evaluated by the on-going flood damage reduction study for the Huntington community (Section 4.2.7.1) and recommendations from that study may supersede this project.	Improve stormwater quantity controls. Improve stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion.	$98,000

6.4.4 SWM Pond Retrofits

Description: Options for retrofitting existing SWM ponds (AMEC 2005) that may be suitable for implementation include the following:

1. Increasing detention storage by means of additional excavation and grading.
2. Providing water quality improvements at facilities that currently have only water quantity control. These facilities could be retrofitted to also provide water treatment by installing micropools, sediment forebays, or constructed stormwater wetlands or by increasing the surrounding riparian buffer.
3. Modifying or replacing the existing riser structure and outlet controls to further reduce the discharge rate from the stormwater management facility. A riser is a concrete structure with a metal grate on top, that controls the level of water in the stormwater pond.
4. Adding infiltration features such as sand filters or bioretention to promote greater peak flow reduction, increase groundwater recharge, and improve water quality treatment. A soil survey of the existing facility would be required to verify that this retrofit is suitable. Stormceptors or equivalent LID products could be installed in parking lots or other areas with a large percentage of impervious area. These devices are placed in the manhole and trap sediments and petroleum products before they flow into the pond.

Maintenance: The maintenance requirements of a retrofitted pond are not significantly greater than those for a traditional stormwater pond. A typical pond is inspected by county personnel trained in dam safety and pond maintenance who check the dam, pipes, and riser structure to ensure that they are functioning properly. Any pretreatment facilities need to be inspected for clogging by sediments and large debris items. If sediment or clogging is evident, the area needs to be cleaned. If manufactured LID devices are used, manufacturer's maintenance recommendations should be followed to ensure that devices function as designed.



Stormwater pond retrofit (A. pre-retrofit pond; B. retrofitted pond) (Source: Schueler et al. 2000)

The SWM pond retrofit projects included in the plan are shown in Table 6-5.

Table 6-5. Stormwater management pond retrofit projects included in the plan

Project ID	Project Name	Sub-watershed	Proposed Action	Benefit	Estimated Cost
CA9100	Farrington Park SWM Pond Retrofit	Tributaries to Cameron Run	Expand capacity of existing SWM wet pond and upgrade control structure. This project will be re-evaluated by the on-going flood damage reduction study for the Huntington community (Section 4.2.7.1) and recommendations from that study may supersede this project.	Improve stormwater quantity controls. Improve stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion.	$ 61,000
CA9103	Woodfield SWM Pond Retrofit	Backlick Run	Retrofit SWM pond control structure to improve detention control and add micropool areas in pond bottom to improve water quality.	Improve stormwater quantity controls. Improve stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion.	$276,000
CA9104	Thomas SWM Pond Retrofit	Backlick Run	Expand existing SWM pond control structure to provide additional storage capacity.	Provide stormwater quantity controls. Provide stormwater quality controls. Improve stormwater quality controls.	$148,000
CA9107	Jayhawk SWM Pond Retrofit	Backlick Run	Retrofit SWM pond control structure to improve detention control and add micropool areas in pond bottom to improve water quality.	Improve stormwater quantity controls. Improve stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion.	$236,000
CA9111	Beauregard SWM Pond Retrofit	Turkeycock Run	Retrofit SWM pond control structure to improve detention control and add micropool areas in pond bottom to improve water quality.	Improve stormwater quantity controls. Improve stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion.	$25,000
CA9112	Strawbridge Square SWM Pond Retrofit	Turkeycock Run	Retrofit SWM pond control structure to improve detention control and add micropool areas in pond bottom to improve water quality.	Improve stormwater quantity controls. Improve stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion.	$25,000
CA9115	Little River SWM Pond Retrofit	Turkeycock Run	Retrofit SWM pond control structure to improve detention control and add micropool areas in pond bottom to improve water quality.	Improve stormwater quantity controls. Improve stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion.	$33,000
CA9117	Braddock Place SWM Pond Retrofit	Turkeycock Run	Retrofit SWM pond control structure to improve detention control and add micropool areas in pond bottom to improve water quality.	Improve stormwater quantity controls. Improve stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion.	$49,000
CA9118	Pinecrest SWM Pond Retrofit	Turkeycock Run	Retrofit SWM pond control structure to improve detention control and add micropool areas in pond bottom to improve water quality.	Improve stormwater quantity controls. Improve stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion.	$69,000

Table 6-5. (Continued)

Project ID	Project Name	Sub-watershed	Proposed Action	Benefit	Estimated Cost
CA9126	Dominion SWM Pond Retrofit	Tripps Run	Retrofit SWM pond control structure to improve detention control and add micropool areas in pond bottom to improve water quality.	Improve stormwater quantity controls. Improve stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion.	$61,000
CA9128	Great Oak SWM Pond Retrofit	Tripps Run	Retrofit SWM pond control structure to improve detention control and add micropool areas in pond bottom to improve water quality.	Improve stormwater quantity controls. Improve stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion.	$89,000
CA9134	Columbia Pines SWM Pond Retrofit	Holmes Run - Upper	Retrofit SWM pond control structure to improve detention control and add micropool areas in pond bottom to improve water quality.	Improve stormwater quantity controls. Improve stormwater quality controls. Improve stream stability, erosion, and instream habitat. Improve floodplain and nutrient cycling functions.	$30,000
CA9138	Providence RECenter SWM Pond Retrofit	Holmes Run - Upper	Retrofit SWM pond control structure to improve detention control and add micropool areas in pond bottom to improve water quality; add bioretention areas in existing swale S of bldg.	Improve stormwater quantity controls. Improve stormwater quality controls. Opportunity for public education.	$102,000
CA9139	Kings Glen SWM Pond Retrofit	Holmes Run - Upper	Retrofit SWM pond with micro-pool micropool areas in pond bottom to provide water quality and extended detention controls; add detention micro-berm along contour and margin of mature woods in pond bottom	Improve stormwater quantity controls. Improve stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion.	$243,000
CA9142	Courts of Tyson SWM Pond Retrofit	Holmes Run - Upper	Retrofit SWM pond control structure to improve detention control and add micropool areas in pond bottom to improve water quality; install two bioretention areas at yard drains in Ch. 2 street (Kelleher Rd.).	Improve stormwater quantity controls. Improve stormwater quality controls. Improve stream stability and instream habitat. Reduce erosion.	$31,000

6.4.5 Stream Restoration/Bank Stabilization

Description: Streams damaged by erosive flows, excess sedimentation, and disruptive human activities are often not capable of re-establishing a stable form. Techniques to repair these damaged or degraded streams are now based on mimicking natural stream channels and the range of natural variability exhibited by nearby stable streams. Termed natural stream channel design, such repairs focus on establishing natural stream channel shape, size, and habitat features. Restoration can range from minor repairs to restore bank stability to complete reconstruction of the stream channel.

Maintenance: Maintenance of natural stream channel design projects includes periodic inspection and monitoring to ensure that conditions remain within the expected range of variability. Post-construction plantings need to be monitoring to ensure that they become well-established. In addition, periodic channel adjustments may be necessary after large flow events, especially while post-construction plantings become established.

A.

B.

Stream restoration (A. concrete lined urban channel; B. restored stream) (Photos by: A) M. Perot, Versar, Inc.; B) unknown)

The stream restoration/bank stabilization projects included in the plan are listed in Table 6-6.

Table 6-6. Stream Restoration/Bank Stabilization projects included in the plan

Project ID	Project Name	Sub-watershed	Proposed Action	Benefit	Estimated Cost
CA9207	Wilburdale Park Stream Restoration	Backlick Run	Notch two weirs and one concrete ford; redistribute large rocks in reach; control invasive vegetation; reforest buffer.	Improve stream stability and instream habitat. Reduce erosion. Improve floodplain and nutrient cycling functions. Opportunity for public education.	$320,000
CA9208	Wilburdale Park Bank Stabilization	Backlick Run	Remove check dam; enhance buffer through backyards; remove invasive bamboo and other species; implement backyard management program to reduce dumping of yard wastes/trash into streams.	Improve stream stability and instream habitat. Reduce erosion. Improve floodplain and nutrient cycling functions. Opportunity for public education. Improve community usage.	$169,000
CA9210	Brook Hill Stream Restoration	Backlick Run	Notch weirs in gabion lined channel; add rock vanes to straightened and overwidened middle section; cut log pour-overs/debris jams; add toe protection on steep berms in lower third; enhance buffer in localized areas; construct bioretention area at end of two roads; implement backyard management program to reduce dumping of yard wastes/ trash into streams.	Provide stormwater quantity controls. Improve floodplain and nutrient cycling functions. Opportunity for public education. Improve community usage. Greenway opportunity	$1,171,000
CA9216	Mason District Park Stream Restoration - A	Turkeycock Run	Implement Park Authority's stream restoration plans at this location.	Improve stream stability and instream habitat. Reduce erosion. Improve floodplain and nutrient cycling functions. Opportunity for public education. Improve community usage. Greenway opportunity	$996,000

6.4.6 Master Drainage Plan Projects

As discussed in Chapter 4, the county's Master Drainage Plan has identified 57 projects that have not yet been implemented in Cameron Run watershed. Upon review, 22 of the projects are recommended for "rollover" into the Cameron Run Watershed Management Plan (Table 6-7). Additional analysis of these opportunities and their priorities has placed these projects into the Tier 2 group of projects. Two residential flood relief projects are further evaluated in the following Drainage Complaint Projects section. The remaining 35 master drainage plan sites were not included in this plan because 1) more recent data from the SPA indicated that the severity of erosion was moderate or better; 2) county guidance noted that stream restoration potential was low, as indicated by "widening" or "incising" CEM stages; or 3) upstream candidate projects are anticipated to remove stressors from the project location.

Table 6-7. Master drainage plan projects (inactive) incorporated into the Cameron Run Watershed Management Plan

Segment	Tax Map	Type of Work	Old Project Name	Old Project Number	Comments
PIKE BRANCH	82-2, 83-1	STREAM RESTOR & STABIL		CA221	Incorporated with New Project CA9201
PIKE BRANCH	82-3	STREAMBANK STABIL		CA222	Incorporated with New Project CA9203
PIKE BRANCH	82-3	800' CHANN IMPROV	Franconia/Leewood	CA224	Not included in Plan
PIKE BRANCH	82-4	4000' STREAMBANK STABIL	Pike Branch Ph III	CA226	Not included in Plan
PIKE BRANCH	82-4	CHANNEL IMPROVEMENTS	Wilton Woods	CA227	Incorporated with New Project CA9203
CAMERON RUN	82-2	STREAM STABIL@ TELEGRAPH-BELTW		CA231	Incorporated with New Project CA9200
CAMERON RUN	82-2	600' INFRASTRUCTURE RPLMNT	Elmwood Drive	CA235	Not included in Plan
CAMERON RUN	82-2	STREAM STABILIZATION	Norton Villa	CA236	Not included in Plan
MILITARY	81-2	1800' STREAM STAB @ SOUTHERNRR		CA251	Incorporated with New Project CA9204
MILITARY	81-2	350' STREAM STAB SRR/S VAN DOR	Runnymede	CA252	Not included in Plan
MILITARY	81-4	1600' STORM SEWER	Old Rolling/Nedra	CA253	Not included in Plan
BACKLICK	81-1	STREAM STABIL & GABION @ RR		CA261	New Project CA9235
BACKLICK	80-2	STREAM @ SHIRLEY HWY		CA262	Not included in Plan
BACKLICK	80-2	STREAM STABIL D/S BACKLICK		CA263	Not included in Plan
WILBURDALE	71-3	1200' STORM SEWER	Leewood Subd	CA273	Not included in Plan
WILBURDALE	71-3	600' STORM SEWER, DITCH & BERM	Clemons Court	CA274	Incorporated with New Project CA9209
WILBURDALE	71-1	STUDY	Annandale Acres	CA276	Not included in Plan; area surveyed by SPA
INDIAN RUN	71-4	STREAMBANK STABIL		CA280	Not included in Plan
INDIAN RUN	72-3	800' STREAMBANK STABIL	Indian Run Ph III	CA281	Not included in Plan
INDIAN RUN	71-4	650' CHANNEL IMPROVEMENTS	Birch Lane	CA282	Not included in Plan
INDIAN RUN	71-4	400' STREAMBANK STABIL	Braddock Hills	CA283	Not included in Plan
INDIAN RUN	71-4	1000'STREAM REST @ SPRING VALL		CA284	Not included in Plan
INDIAN RUN	71-4	4000'STREAM ST U/S BRADDOCK RD	Willow Run Sub/Rndlp	CA285	Not included in Plan

Table 6-7. (Continued)

Segment	Tax Map	Type of Work	Old Project Name	Old Project Number	Comments
TURKEYCOCK	72-3	STREAM STAB @ EDSAL/SHIRLEY HW		CA291	Incorporated with New Project CA9211
TURKEYCOCK	72-3	1450'STREAM STAB @ CHOWEN AVE	Chowan Ave	CA292	Incorporated with New Project CA9212
TURKEYCOCK	72-3	60' STREAMBANK STABIL	Eighth St	CA293	Incorporated with New Project CA9212
TURKEYCOCK	72-1	STREAM STAB D/S BRADDOCK RD		CA295	Incorporated with New Project CA9213
TURKEYCOCK	72-1	STREAM STAB U/S BRADDOCK RD		CA296	Not included in Plan
TURKEYCOCK	72-1	650' STORM DRAIN IMP 250' RCBC	Holyoke-Piney Lane	CA298	Not included in Plan
PARKLAWN	72-2	800'STREAM ST @ ALEX CITY LINE		CA301	Not included in Plan
PARKLAWN	61-4	STREAM STABIL @ DRUMMOND DR		CA302	Incorporated with New Project CA9218
BARCROFT	60-4	STREAMBANK STABIL, ONE SIDE		CA312	Not included in Plan
BARCROFT	60-2	STREAM STABILIZATION	Crosswoods Dr.	CA314	Incorporated with New Project CA9228
BARCROFT	60-4	STREAM STABILIZATION	Juniper/Tripps	CA315	Incorporated with New Project CA9220
TRIPPS RUN	50-2	STREAMBANK STABIL		CA325	Incorporated with New Project CA9225
WEST FALLS CHUR	40-3	1000' STREAMBANK STABIL		CA331	Not included in Plan
HOLMES RUN	60-4	600' STREAM STABIL @ ROSE LANE	Holmes Run Ph II	CA342	Not included in Plan
HOLMES RUN	60-3	GABION @ BRADLEY CIRCLE		CA343	Not included in Plan
HOLMES RUN	60-3	200' STREAM BANK STABIL	Brookcrest Place	CA344	Not included in Plan
HOLMES RUN	60-1	STREAM STABIL @ ANNANDALE RD		CA345	Not included in Plan
HOLMES RUN	60-1	STREAM STABIL @ ARNOLD LANE		CA346	Not included in Plan
HOLMES RUN	60-1	90' STORM SEWER 370' SWALE	Locker Street	CA348	Not included in Plan
HOLMES RUN	60-4	200' STREAM BANK STABIL	Raleigh Road	CA349	Not included in Plan
HOLMES RUN	60-3	125' STREAM STABIL	Crest Drive	CA350	Not included in Plan
				CA353	Not included in Plan
MEMORIAL	39-4	150 L.F. STREAMBANK STABIL	Shadybrook	CA354	Incorporated with New Project CA9234
HOLMES RUN	60-3	100' STREAM STABIL / WALL	Raleigh Rd. Ph. II	CA361	Not included in Plan
INDIAN RUN	71-4	STREAM STABILIZATION	Fairland	CA381	Not included in Plan
INDIAN RUN	81-1	STREAM STABILIZATION	Bren Mar Ph II	CA382	Not included in Plan
TURKEYCOCK	72-1	ADD CULV @ BRADDOCK RD		CA491	New Project CA9236
TURKEYCOCK	72-1	ADD CULV @ OLD COLUMBIA PIKE		CA492	Not included in Plan
WEST FALLS CHUR	50-2	ADD CULV & STREAM STABIL		CA531	Incorporated with New Project CA9225
ALEXANDRIA	83-1	CONSTRUCT FLOODWALL ALONG CAME	Arlington Terrace	CA601	Additional evaluation underway by USACE study
BACKLICK	81-1	CONST EARTHEN BERM	Bren Mar Drive	CA661	Incorporated with New Project CA9205
INDIAN RUN	81-1	INSTALL RETAINING WALLS		CA681	Not included in Plan

Note: Master drainage plan projects not recommended for inclusion in this plan are shaded gray

6.4.7 Drainage Complaint Projects

Fairfax County's Maintenance and Stormwater Management Division (MSMD) maintains a database of storm drainage problems reported to the county. The county maintains the public storm drainage system contained within dedicated storm drainage easements, however, many of the drainage complaints received by the county are located outside these easements and cannot be addressed through existing maintenance programs. This watershed plan provides an alternate avenue for examining these citizen complaints and for developing recommendations to help alleviate problems in these areas.

Versar reviewed the county's drainage complaint database for flooding and erosion complaints, and found nearly 600 citizen complaints in Cameron Run watershed. Almost 75 percent of these complaints were related to house, yard, or road flooding issues, while the remaining complaints pertained to streambank and other erosion problems. Using the drainage complaints as an indicator of problem areas, Versar analyzed the location and nature of these complaints in combination with erosion and stream channel stability information from the SPA. As a result, Versar identified 57 locations that had a concentration of flooding complaints and 13 locations that had considerable erosion problems. Candidate projects were then developed for these identified problem areas (i.e., 70 candidate projects shown in Figure 6-2).

The county also maintains historical paper copy records on drainage complaints in the MSMD offices that date from the 1970s to the late 1990s, prior to creation of the electronic database. Versar reviewed these historical records for additional drainage complaint information on the 70 identified candidate projects.

Versar then applied a prioritization process similar to that described in Chapter 5.4 to help target restoration efforts to the biggest problem areas. Candidate drainage projects for flooding and erosion problems used different ranking criteria. Flooding project ranks were based on the size of the study area around the parcels with drainage complaints, the number of parcels with drainage complaints and the number of parcels with house flooding. Erosion project ranks were based on erosion site lengths, severity of erosion scores and CEM scores. Most criteria were converted to a 1 to 4 score with a 4 indicating the biggest problems. Erosion sites with a CEM score of 4 or 5 were assigned a score of 4; a score of 1 was assigned to the remaining sites. The 1 to 4 scores for each criterion were then summed within each flooding or erosion project.

The best opportunities to address drainage-related issues were chosen from the 70 candidate drainage complaint projects by selecting those that scored 8 or higher out of 12 on the selection criteria. This resulted in a list of 25 selected drainage complaint projects, including 21 flooding projects and four erosion projects (Figure 6-3 and Table 6-8). Project fact sheets for each of the selected project sites describe the recommended action to help alleviate drainage problems in these areas (Appendix A-4).

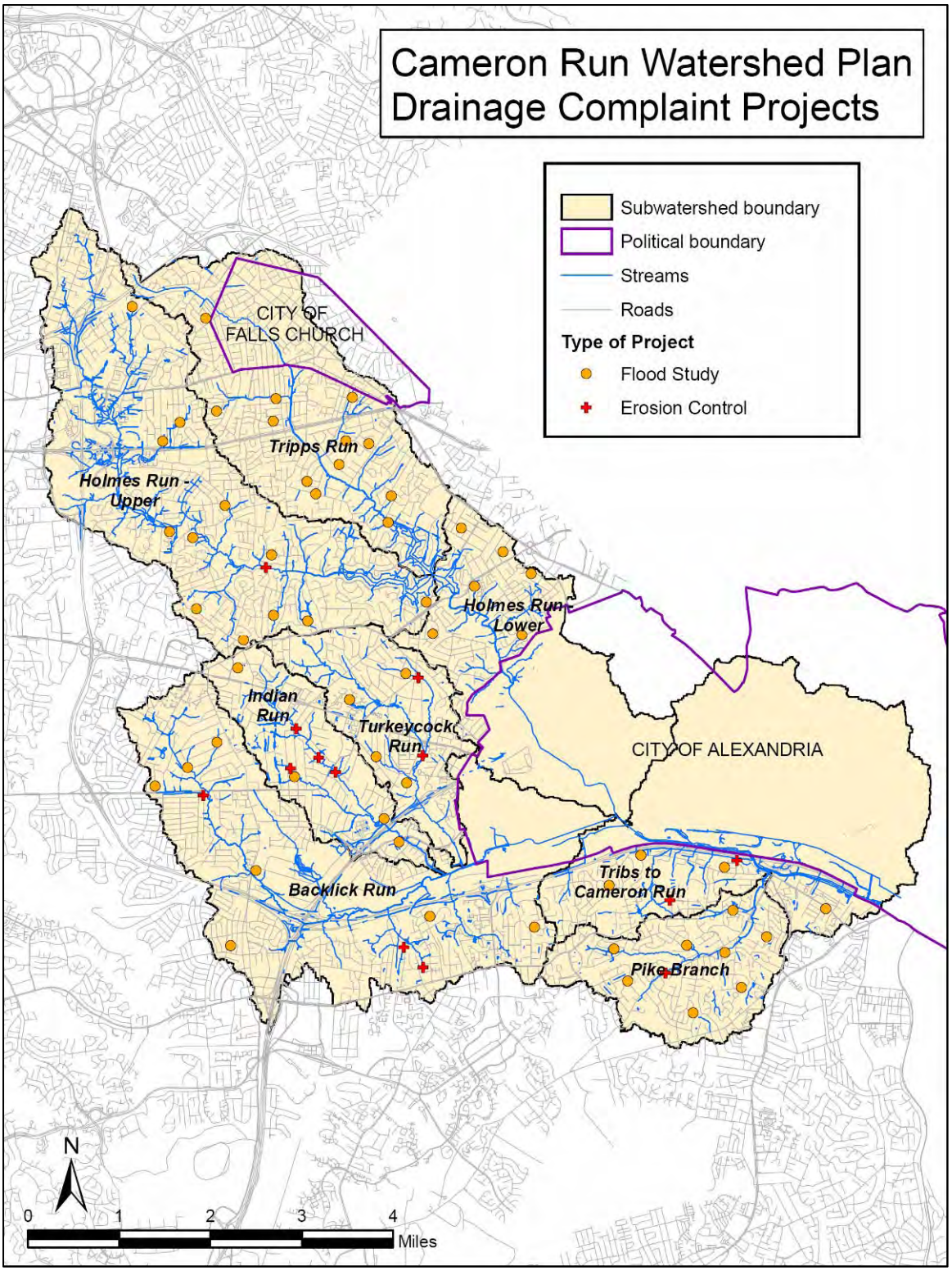


Figure 6-2. Location of candidate projects identified using the county's drainage complaint records

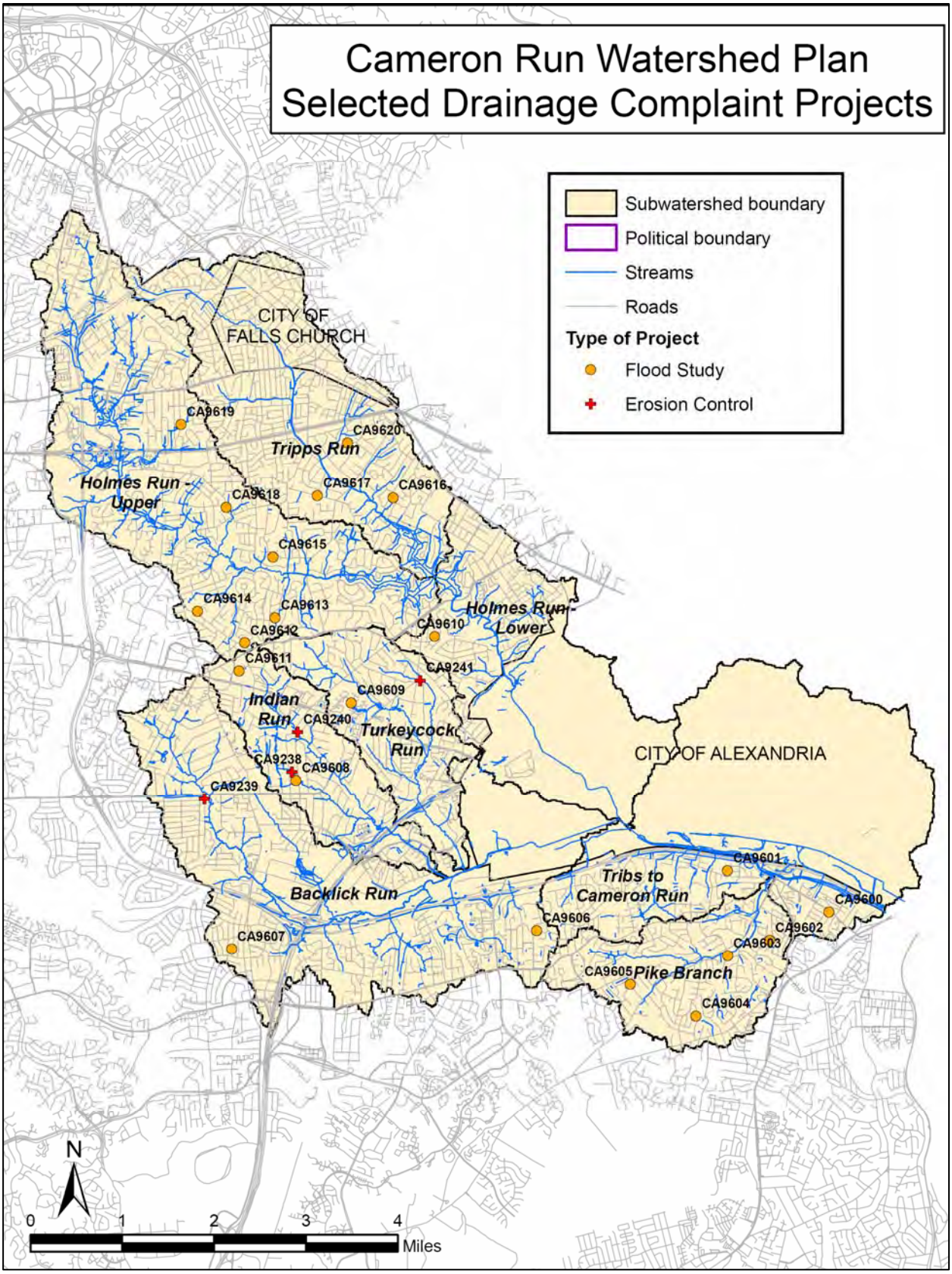


Figure 6-3. Selected project locations to address drainage related problems from the county's drainage complaint records

Table 6-8. Summary of selected projects to address drainage related problems from the county's drainage complaint records

Project ID	Project Name	Subwatershed	Proposed Action	Estimated Cost
CA9238	Indian Run Streambank Stabilization - B	Indian Run	Restore natural stream channel morphology, stabilize banks, and enhance riparian buffer.	$50,000
CA9239	Backlick Run Streambank Stabilization	Backlick Run	Restore natural stream channel morphology, stabilize banks, and enhance riparian buffer.	$69,000
CA9240	Indian Run Streambank Stabilization - A	Indian Run	Restore natural stream channel morphology, stabilize banks, and enhance riparian buffer.	$84,000
CA9241	Turkeycock Run Stream Stabilization	Turkeycock Run	Restore natural stream channel morphology, stabilize banks, and enhance riparian buffer.	$77,000
CA9600	Huntington Drainage Study	Tributaries to Cameron Run	Conduct a neighborhood drainage improvement study to investigate reported house and yard flooding problems in the area, and develop preliminary plans and cost estimates to provide improvements. This drainage study is being completed as part of an on-going flood damage reduction study for the Huntington community (Section 4.2.7.1).	$38,000
CA9601	Burgundy Village Drainage Study	Tributaries to Cameron Run	Conduct a neighborhood drainage improvement study to investigate reported house, yard, and road flooding problems in the area, and develop preliminary plans and cost estimates to provide improvements.	$38,000
CA9602	Jefferson Garden & Wilton Hall Drainage Study	Pike Branch	Conduct a neighborhood drainage improvement study to investigate reported house and yard flooding problems in the area, and develop preliminary plans and cost estimates to provide improvements. Improvements to the curb and gutter system have been initiated in this area since the analysis was performed, and evaluation of their effectiveness and the need for any additional improvements should be considered during the recommended drainage study.	$38,000
CA9603	Wilton Woods & Millwood Estates Drainage Study	Pike Branch	Conduct a neighborhood drainage improvement study to investigate reported house and yard flooding problems in the area, and develop preliminary plans and cost estimates to provide improvements.	$57,000
CA9604	Virginia Hills Drainage Study	Pike Branch	Conduct a neighborhood drainage improvement study to investigate reported house and yard flooding problems in the area, and develop preliminary plans and cost estimates to provide improvements.	$57,000
CA9605	Rose Hill Drainage Study	Pike Branch	Conduct a neighborhood drainage improvement study to investigate reported house and yard flooding problems in the area, and develop preliminary plans and cost estimates to provide improvements. Additional complaints about this area have been received since the analysis was performed, and all complaints will be considered during the detailed drainage study recommended for this area.	$38,000
CA9606	Brookland Estates Drainage Study	Backlick Run	Conduct a neighborhood drainage improvement study to investigate reported house and yard flooding problems in the area, and develop preliminary plans and cost estimates to provide improvements. Possible cross-connections between the storm drainage network and sanitary sewer system have also been reported for this area and should be investigated as part of the recommended drainage study.	$38,000
CA9607	Crestwood Drainage Study	Backlick Run	Conduct a neighborhood drainage improvement study to investigate reported house and yard flooding problems in the area, and develop preliminary plans and cost estimates to provide improvements.	$38,000
CA9608	Braddock Hills Drainage Study	Indian Run	Conduct a neighborhood drainage improvement study to investigate reported house, yard, and road flooding problems in the area, and develop preliminary plans and cost estimates to provide improvements.	$57,000
CA9609	Pinecrest Drainage Study	Turkeycock Run	Conduct a neighborhood drainage improvement study to investigate reported house, yard, and road flooding problems in the area, and develop preliminary plans and cost estimates to provide improvements.	$38,000
CA9610	Parklawn Drainage Study	Holmes Run - Lower	Conduct a neighborhood drainage improvement study to investigate reported house and yard flooding problems in the area, and develop preliminary plans and cost estimates to provide improvements.	$19,000
CA9611	Evergreen Heights Drainage Study	Indian Run	Conduct a neighborhood drainage improvement study to investigate reported house and yard flooding problems in the area, and develop preliminary plans and cost estimates to provide improvements.	$38,000
CA9612	Webbwood Drainage Study	Holmes Run - Upper	Conduct a neighborhood drainage improvement study to investigate reported house and yard flooding problems in the area, and develop preliminary plans and cost estimates to provide improvements.	$19,000

Table 6-8. (Continued)

Project ID	Project Name	Subwatershed	Proposed Action	Estimated Cost
CA9613	Sleepy Hollow Woods Drainage Study	Holmes Run - Upper	Conduct a neighborhood drainage improvement study to investigate reported house and yard flooding problems in the area, and develop preliminary plans and cost estimates to provide improvements.	$38,000
CA9614	Kenwood Drainage Study	Holmes Run - Upper	Conduct a neighborhood drainage improvement study to investigate reported house and yard flooding problems in the area, and develop preliminary plans and cost estimates to provide improvements.	$38,000
CA9615	Valley Brook Drainage Study	Holmes Run - Upper	Conduct a neighborhood drainage improvement study to investigate reported house and yard flooding problems in the area, and develop preliminary plans and cost estimates to provide improvements.	$19,000
CA9616	Ravenwood Drainage Study	Tripps Run	Conduct a neighborhood drainage improvement study to investigate reported house and yard flooding problems in the area, and develop preliminary plans and cost estimates to provide improvements.	$38,000
CA9617	Marlo Heights Drainage Study	Tripps Run	Conduct a neighborhood drainage improvement study to investigate reported house and yard flooding problems in the area, and develop preliminary plans and cost estimates to provide improvements.	$38,000
CA9618	Anna Lee Heights Drainage Study	Holmes Run - Upper	Conduct a neighborhood drainage improvement study to investigate reported house and yard flooding problems in the area, and develop preliminary plans and cost estimates to provide improvements.	$19,000
CA9619	Fenwick Park Drainage Study	Holmes Run - Upper	Conduct a neighborhood drainage improvement study to investigate reported house and yard flooding problems in the area, and develop preliminary plans and cost estimates to provide improvements.	$38,000
CA9620	Sleepy Hollow Drainage Study	Tripps Run	Conduct a neighborhood drainage improvement study to investigate reported house and yard flooding problems in the area, and develop preliminary plans and cost estimates to provide improvements.	$38,000

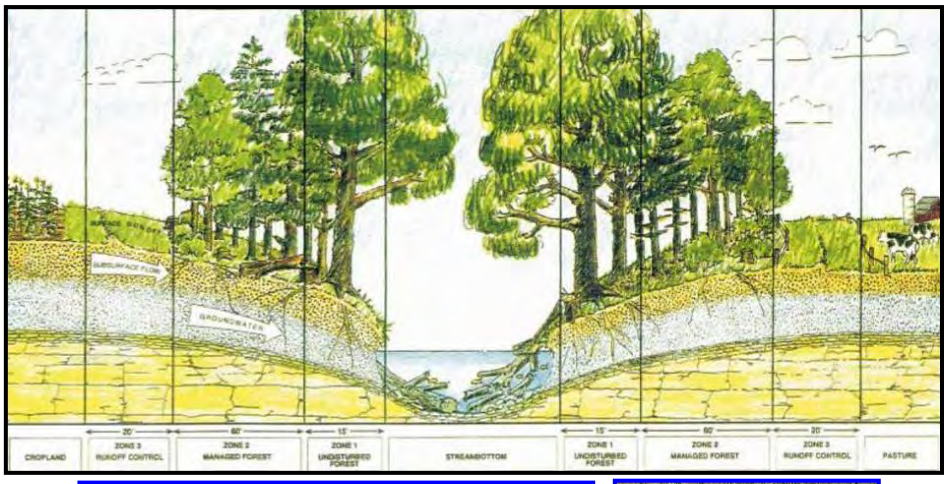
6.4.8 Other Opportunities

Planting riparian buffers is a high priority for the Cameron Run watershed, but this action will be addressed by the existing countywide riparian buffer planting program and is not included explicitly as a plan project. The concept and benefits of riparian buffer planting are described as below.

6.4.8.1 Riparian Buffer Enhancement

Description: Enhancing existing streamside vegetation by planting native varieties of trees, shrubs, and wildflowers restores many of the water quality, wildlife, and aesthetic benefits associated with riparian buffers. Vegetation filters sediments and other pollutants from storm-water runoff, moderates water temperatures in streams, improves aesthetics, and provides shelter and food to both terrestrial and stream organisms.

Maintenance: Maintenance of buffer enhancement projects includes periodic watering, removal of invasive species, and trash clean-up to ensure that plantings become well-established.



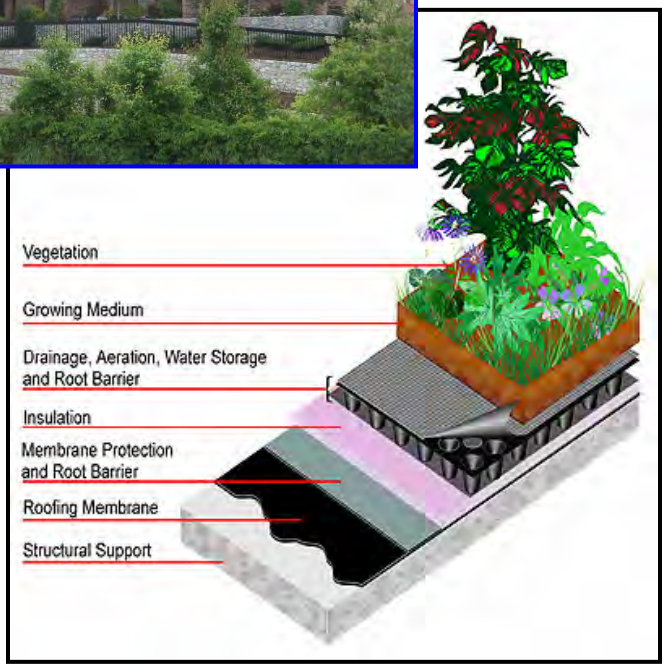
Buffer enhancement (Sources: Palone and Todd 1998; MDE 2000b; M. Southerland, Versar, Inc.)

6.4.8.2 Green Roof

Description: Green roof technology, which involves placing a layer of soil and vegetation on top of an impervious rooftop, can be applied to buildings to provide several benefits.

Economic Benefits –

- increases the life expectancy of rooftop and waterproofing (2-5 times) by providing protection against temperature extremes and ultraviolet light. The increased life span of the roof off-sets the somewhat higher up-front installation costs
- conserves energy by moderating building temperatures



Green roof construction

Ecological Benefits –

- reduces stormwater runoff (30% to 100% of annual rainfall can be stored, relieving stormdrains and feeder streams)
- reduces heat island effect (cooler air temperatures and higher humidity can be achieved through natural evaporation)
- improves air quality (up to 85% of dust particles can be filtered out of the air)
- provides new habitat for plants, insects, and birds

Amenities –

- reduces noise level by limiting reverberation and improving insulation
- improves the aesthetics of the landscape

Maintenance: Once a green roof is well-established, its maintenance requirements are usually minimal. Initial watering and occasional fertilization are required until the plants have fully established themselves, and periodically thereafter during drought conditions. Periodic trimming, weeding, inspection, and plant replacement is necessary.

Several county facilities present good opportunities for green roof technology (Figure 6-4, Table 6-9). Given the greater up-front expense of green roofs, it is recommended that the county consider this option on a case-by-case basis as each facility's roof approaches the end of its current life span. Scheduled roof replacement costs could substantially off-set the initial cost of a green roof, making this multipurpose roofing option more attractive.

Figure 6-4. Example of a county facility (Shrevewood Elementary School) that could present a good opportunity for a green roof

Table 6-9. County facilities that could be considered for a green roof during future renovation cycles

Project ID	Project Name	Subwatershed	Parcel ID No.
CA9805	Wilton Administration Center LID	Pike Branch	0824 01 0004A
CA9813	John Marshall Library LID	Pike Branch	0823 12 B
CA9822	Twain Middle School LID	Tributaries to Cameron Run	0823 01 0020
CA9823	Bush Hill Elementary School LID	Tributaries to Cameron Run	0823 01 0001
CA9830	Edsall Administration Center LID	Backlick Run	0714 01 0042
CA9835	Springfield Elementary School LID	Backlick Run	0813 01 0005B
CA9836	Lee High School LID	Backlick Run	0804 01 0037
CA9839	Key Middle School LID	Backlick Run	0813 01 0022B
CA9853	Annandale High School LID	Backlick Run	0711 01 0068
CA9854	Bren Mar Park Elementary School LID	Indian Run	0811 01 0006
CA9856	Holmes Middle School LID	Indian Run	0723 01 0014
CA9857	Weyanoke Elementary School LID	Indian Run	0721 01 0013
CA9858	Poe Middle School LID	Indian Run	0711 01 0131
CA9862	Columbia Elementary School LID	Indian Run	0712 05 0084A
CA9872	Mason Government Center LID	Turkeycock Run	0613 01 0003
CA9876	Glasgow Middle School LID	Holmes Run - Lower	0614 01 0151A
CA9879	Baileys Elementary School LID	Holmes Run - Lower	0612 01 0002
CA9882	JEB Stuart High School LID	Tripps Run	0611 01 0013
CA9892	Westlawn Elementary School LID	Tripps Run	0504 01 0002
CA9911	Belvedere Elementary School LID	Holmes Run - Upper	0604 01 0037
CA9917	Beech Tree Elementary School LID	Holmes Run - Upper	0602 38 A
CA9941	Woodburn Elementary School LID	Holmes Run - Upper	0592 01 0044
CA9946	Falls Church High School LID	Holmes Run - Upper	0503 01 0001A
CA9950	Pine Spring Elementary School LID	Holmes Run - Upper	0494 01 0060
CA9952	Timber Lane Elementary School LID	Holmes Run - Upper	0501 01 0044
CA9953	Shrevewood Elementary School LID	Holmes Run - Upper	0501 01 0002
CA9954	Jefferson District Park & Golf Course LID	Holmes Run - Upper	0492 01 0088

6.4.9 Watershed Projects By Subwatershed

The Cameron Run Watershed Plan Tier 1 candidate projects are shown in the following series of maps (Figs. 6-5 through 6-12) so that their location within each subwatershed can be readily determined. Detailed fact sheets for each Tier 1 candidate project are provided in Appendix A-1.

6.5 BENEFITS OF THE PLAN

As described in Chapter 5, estimating the benefits of the policy and project actions is critical to developing a plan that meets the county's and community's goals. The types of projects and their locations were selected to maximize benefits for stream protection and restoration. In the tables and fact sheets provided, we include estimates of benefits and costs.

6.5.1 Benefits of the Policy Recommendations

The policy recommendations will provide a range of benefits to the Cameron Run watershed. Policies that are implemented countywide in conjunction with other watershed management plans will be most efficient and should result in improved environmental conditions throughout Fairfax County and the surrounding region. Because these policy recommendations are non-structural, it is difficult to quantify the benefits to the watershed. Generally, the policy recommendations will help to improve the enforcement of existing regulations and laws and provide additional protection for areas that are environmentally valuable, but not necessarily located within an RPA. Institution of programmatic solutions is one of the best ways to deal with adverse cumulative effects from distributed sources such as stormwater.

6.5.2 Benefits of the Project Actions

Cameron Run is the most heavily urbanized watershed in the county, with impervious surface in each subwatershed exceeding the 10% to 15% threshold considered the minimum for good stream conditions. Most of the development in the watershed occurred before stormwater controls were required; therefore, reducing the effects of excessive runoff of stormwater is the most important benefit that can be achieved through project actions. Each stormwater-control project included in the plan has been scored based on the area of impervious surface controlled and the effectiveness of the recommended practice to help prioritize projects. Both water quantity improvement (i.e., reduction in average peak flows) and water quality improvement (i.e., reduction in pollutant loading) are included. More precise estimates of project benefits have been modeled (Appendix B). These model-based estimates can be used to evaluate the Plan's contributions to meeting water quality standards (e.g., TMDL implementation) and Chesapeake Bay Tributary goals.

Future conditions with proposed BMP projects were modeled to compare the condition of the watershed as development continues and when projects identified above are completed. The proposed actions in the Cameron Run Watershed Management Plan will reduce pollutant loadings throughout the county portion of the watershed. The model of future conditions with proposed projects shows a 4.9% decrease in total suspended solids, a 3.8% decrease in total phosphorus, and a 3.6% decrease in total nitrogen pollutant loads for the entire Cameron Run watershed. It is important to note that the model shows only small decreases in pollutant loading

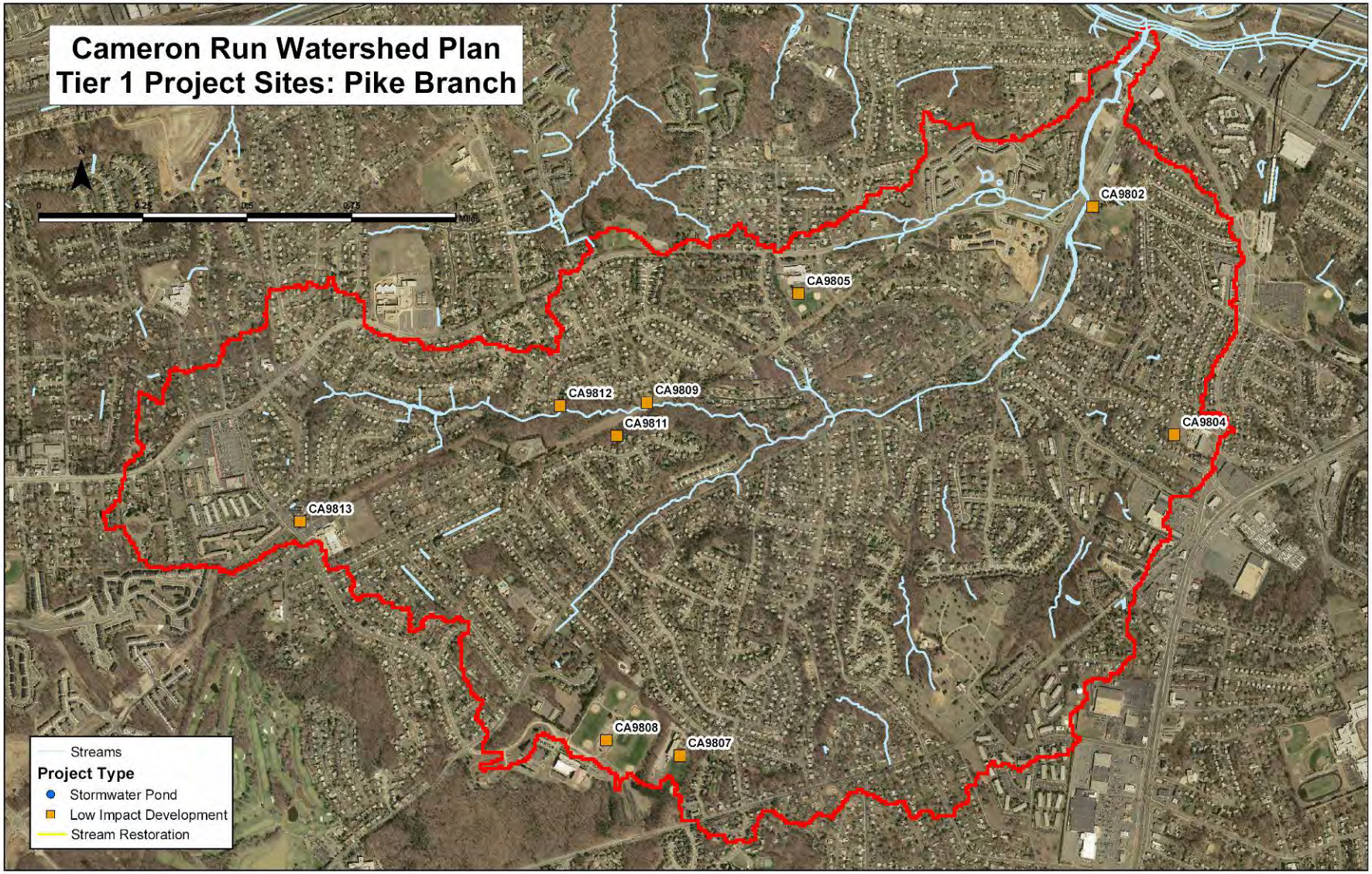


Figure 6-5. Pike Branch – Tier 1 candidate restoration sites

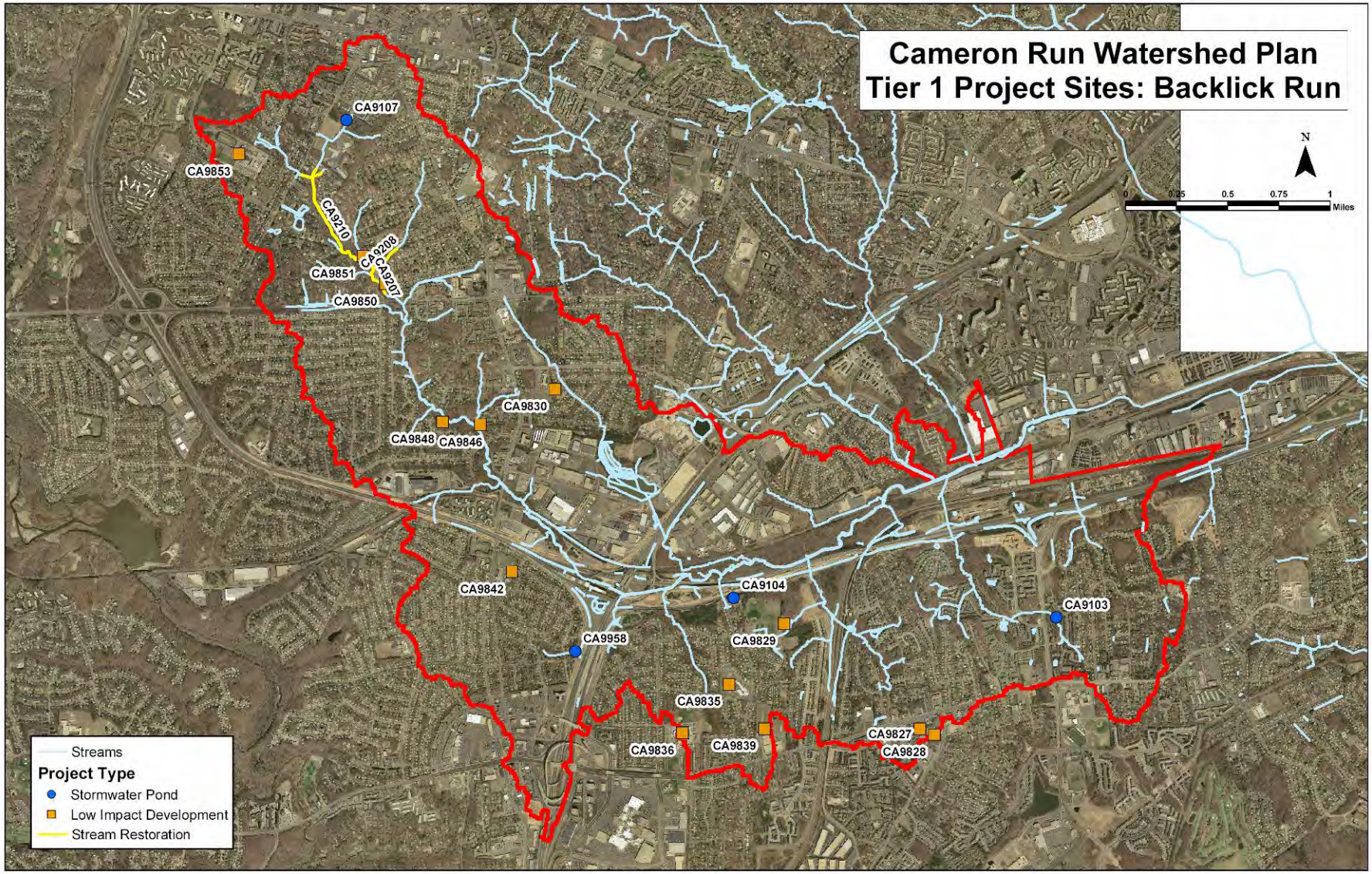


Figure 6-6. Backlick Run – Tier 1 candidate restoration sites

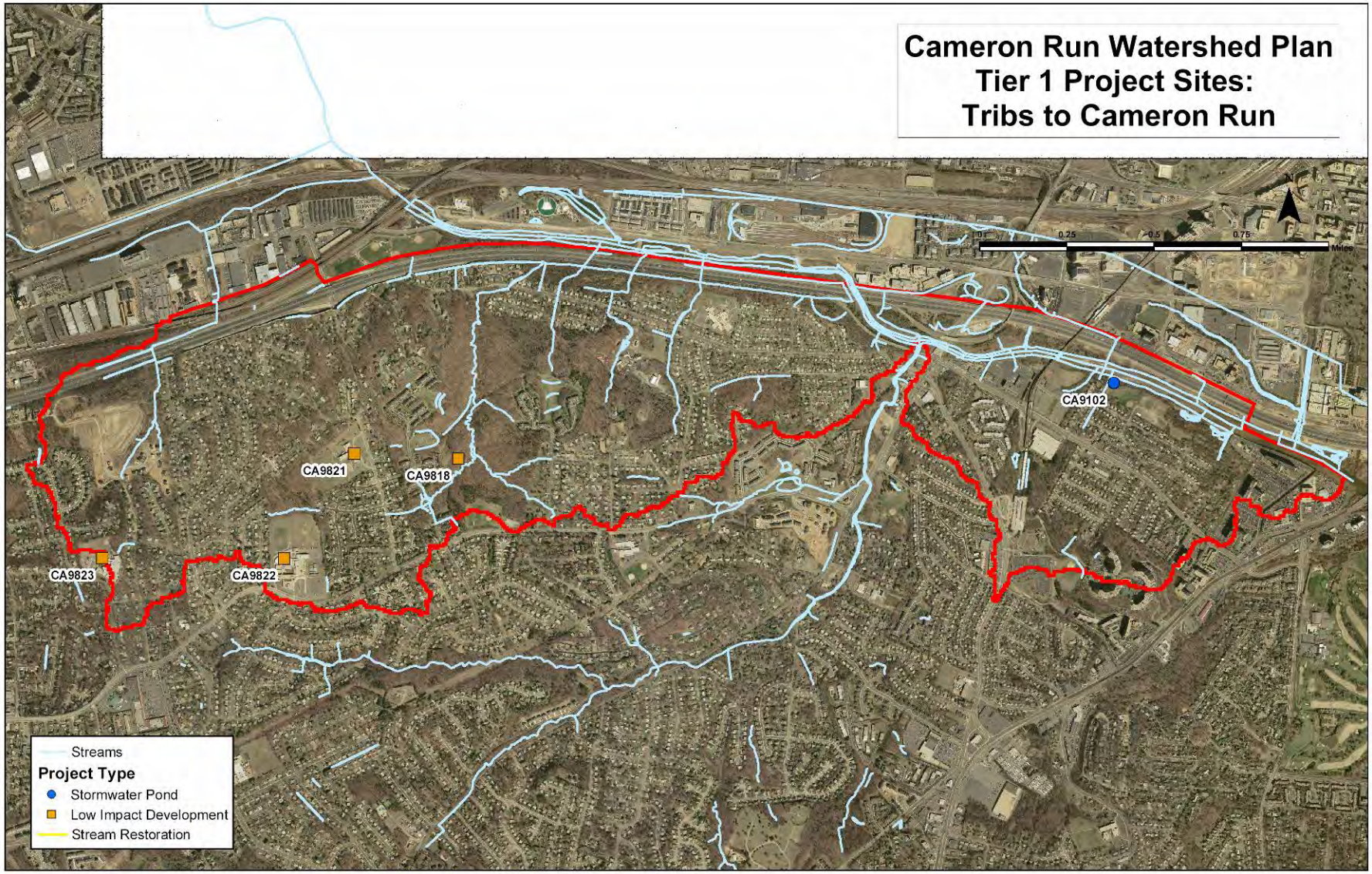


Figure 6-7. Tributaries to Cameron Run – Tier 1 candidate restoration sites

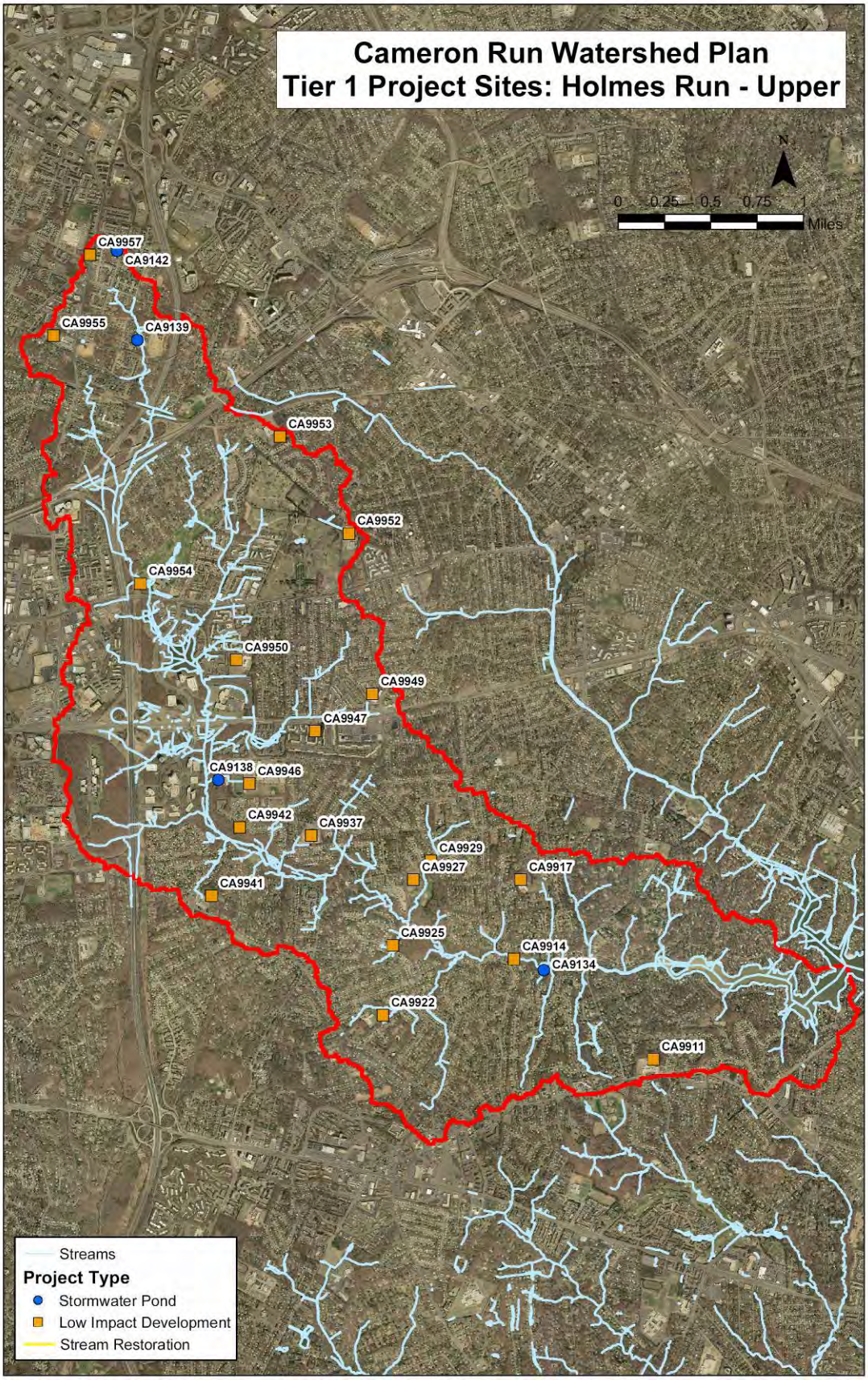


Figure 6-8. Holmes Run (Upper) – Tier 1 candidate restoration sites

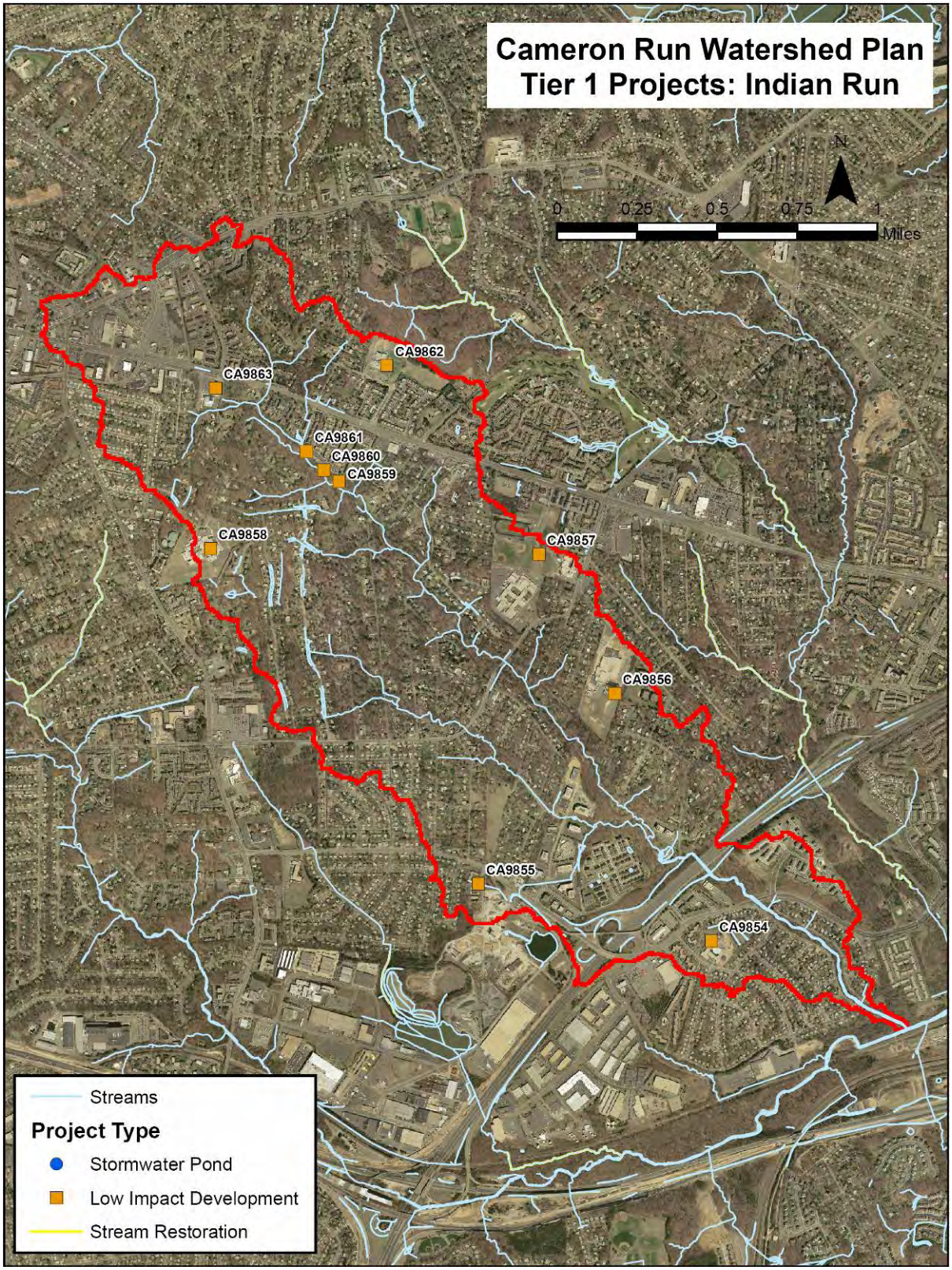


Figure 6-9. Indian Run – Tier 1 candidate restoration sites

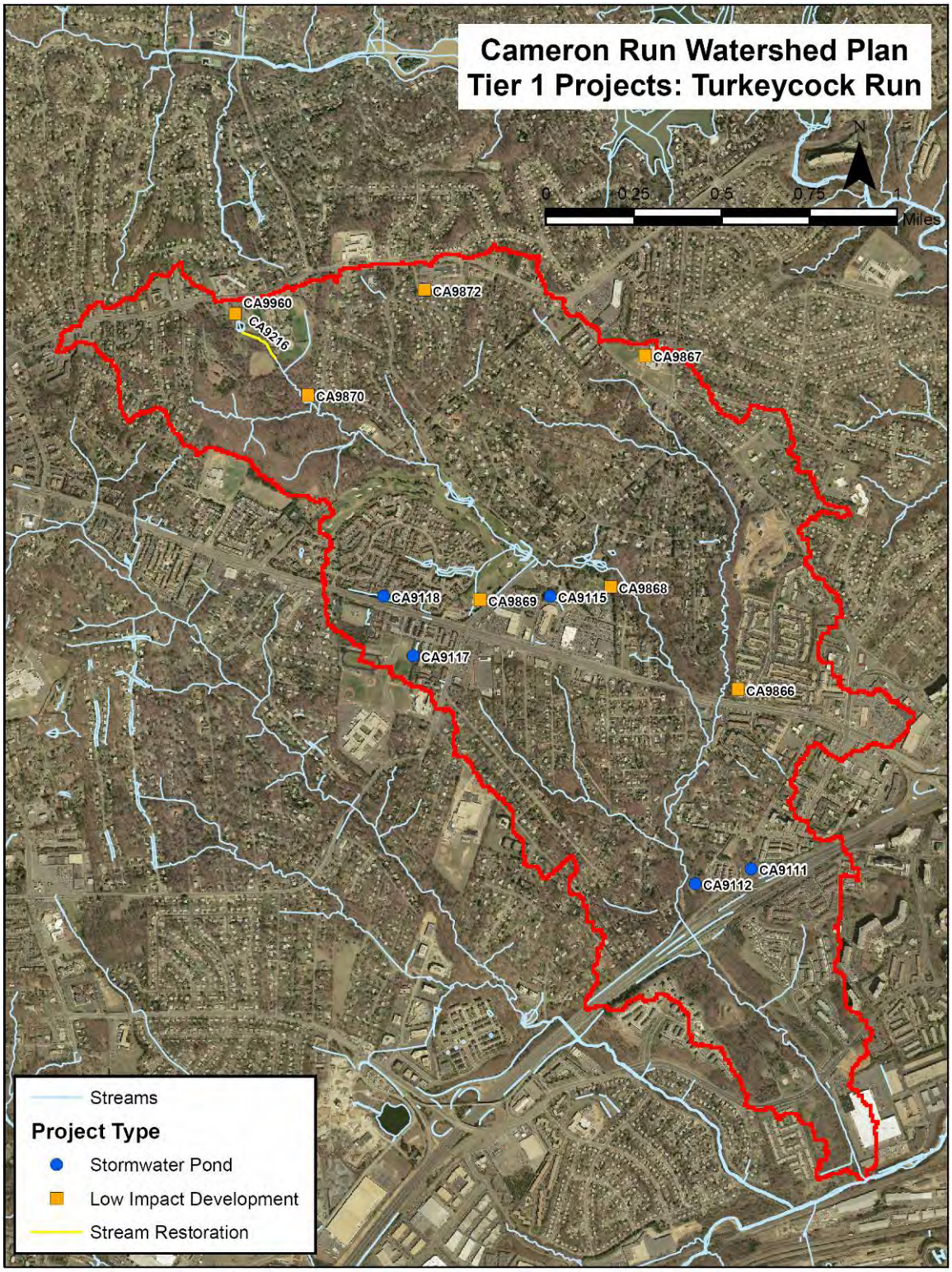


Figure 6-10. Turkeycock Run – Tier 1 candidate restoration sites

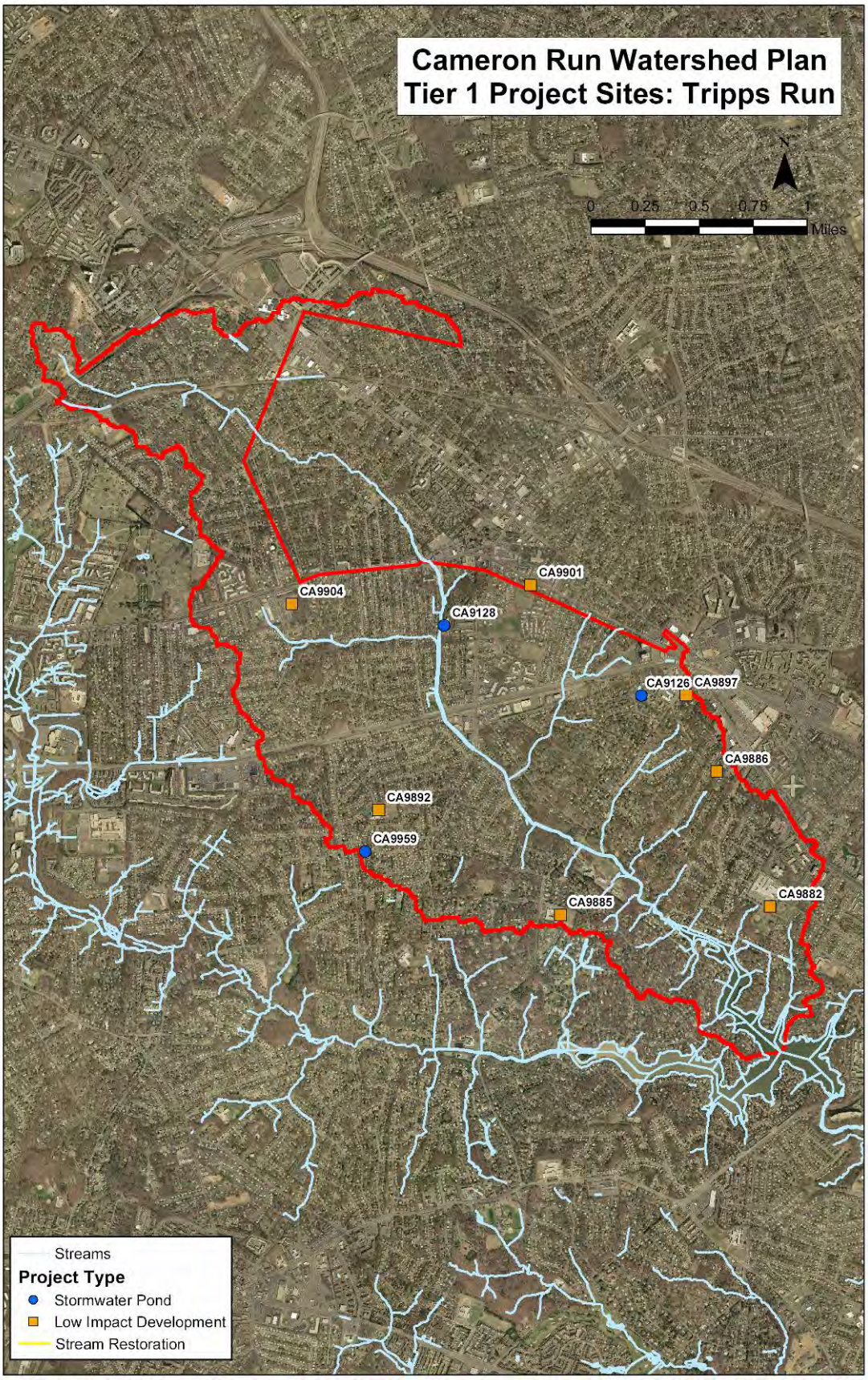


Figure 6-11. Tripps Run – Tier 1 candidate restoration sites

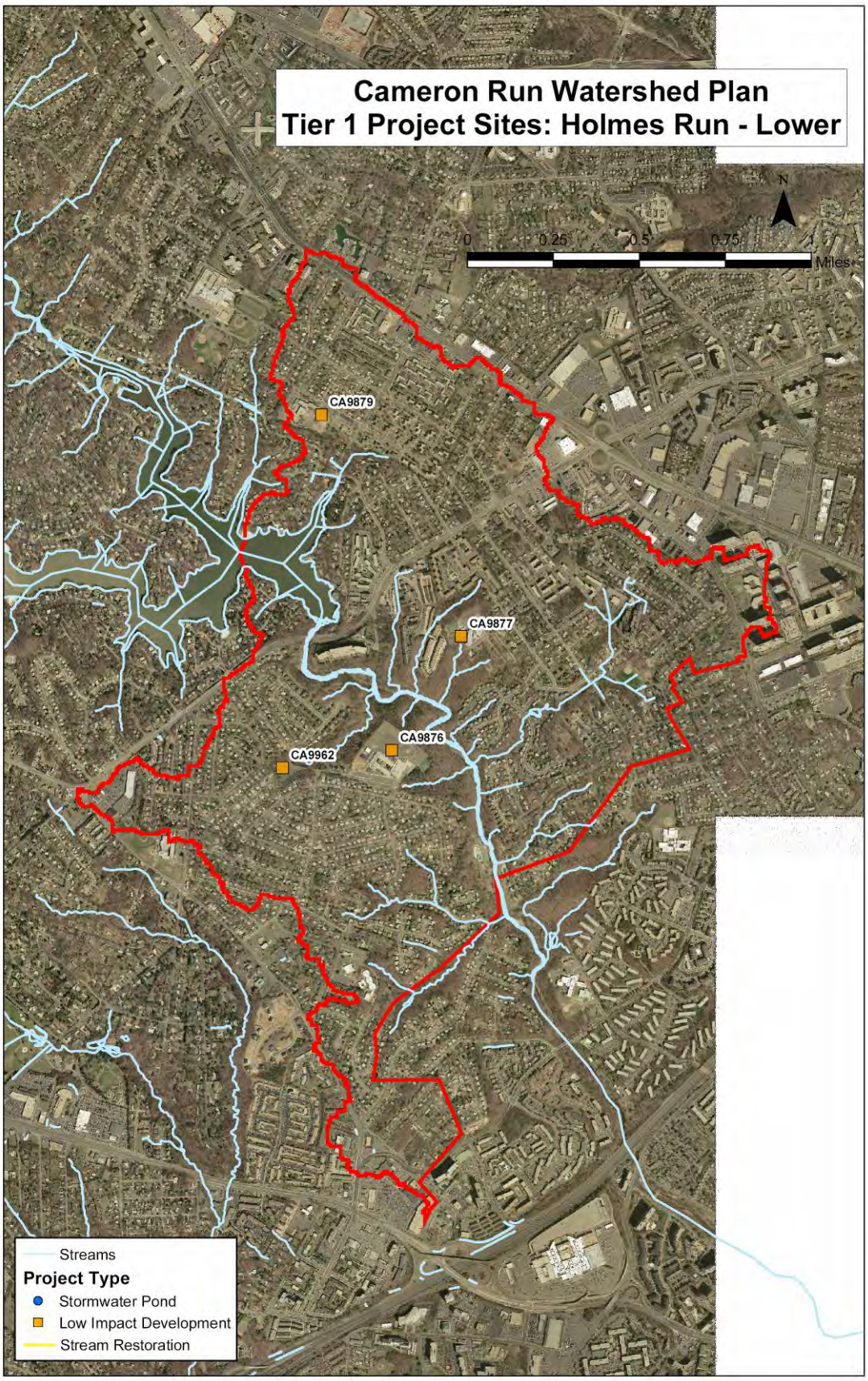


Figure 6-12. Holmes Run (Lower) – Tier 1 candidate restoration sites

because the Cameron Run watershed is highly developed; therefore, opportunities for BMPs are limited in many areas. Table 6-10 shows pollutant reductions by subwatershed if the proposed BMP projects are all implemented.

The selected stream restoration projects are expected to improve stream habitat and water quality. To quantify the benefits of the proposed stream restoration projects, the county's stream condition index (SCI) rating (modified from USACE and VDEQ 2003) was applied to determine the increase in stream habitat and reduction in erosion and sediment loss (Table 6-11). Briefly, the SCI is determined by looking at five variables within the stream and rating them from 1.0 (worst) to 5.0 (best). Each stream restoration project will gain a certain number of habitat units per the SCI index. In addition, the stream restoration projects in the plan will improve a certain number of stream miles from one condition class to another (e.g., very poor habitat to fair habitat), with assumed increases in the abundance and diversity of stream life. The county's application of the SCI index was based on stream condition data gathered during the 2002 SPA. Although the stream in Mason District Park (Project ID CA9216) was not surveyed during the SPA and sufficient data were not available to calculate the SCI for this project, similar improvements of stream condition as a result of the restoration project are anticipated.

6.6 IMPLEMENTATION OF THE PLAN

The policy recommendations and project actions will be implemented over the 25-year life of the Cameron Run Watershed Plan. This plan should serve as guidance for all county agencies and officials to protect and maintain the health of the Cameron Run watershed. The plan should be considered as an active, or "living," document that is revisited every five years. Most of the selected projects are on property owned by Fairfax County. This facilitates the coordination needed for implementation. Selected projects that would require access to privately owned property will be coordinated with landowners to obtain their approval early in the design phase.

6.6.1 Policy Recommendations

Fairfax County will review the policy recommendations described in Section 6.3 to evaluate countywide implications and to compare them with similar recommendations provided in other watershed management plans for the county. If ordinance amendments are needed, they will be developed to include other county initiatives and address the common ground that can be established between the various policy recommendations.

The first step in developing an implementation schedule was to prioritize the recommendations and evaluate how well they meet the goals of the plan. A weighted set of five criteria was used to prioritize each recommendation. The following criteria were used: Board Adopted Stormwater Control Project Prioritization Categories (40%); Direct Regulatory Contribution (10%); Effectiveness/Location (25%); and Ease of Implementation (15%). The recommendations in the plan were scored on a scale of 1 (worst) to 5 (best) for each of the criteria. The recommendations were ranked according to their total score, from highest to lowest. Table 6-12 shows the resulting priority of policy recommendations.

Table 6-10. Pollutant loading by subwatershed in Cameron Run

Subwatershed	Total Suspended Solids				Total Phosphorus				Total Nitrogen			
	Future (lb/ac/yr)	Future with Proposed BMPs (lb/ac/yr)	Reduction (lb/ac/yr)	% Decrease	Future (lb/ac/yr)	Future with Proposed BMPs (lb/ac/yr)	Reduction (lb/ac/yr)	% Decrease	Future (lb/ac/yr)	Future with Proposed BMPs (lb/ac/yr)	Reduction (lb/ac/yr)	% Decrease
Backlick Run	265	253	13	4.7	1.25	1.21	0.04	3.2	11.1	10.8	0.3	2.7
Holmes Run Lower	215	209	6	2.6	1.16	1.13	0.03	2.3	9.8	9.6	0.2	2.3
Holmes Run Upper	247	231	16	6.3	1.23	1.16	0.07	5.3	10.6	10.0	0.6	5.3
Indian Run	234	220	15	6.2	1.23	1.17	0.06	5.1	10.5	10.0	0.5	5.2
Pike Branch	240	235	5	2.0	1.32	1.29	0.02	1.8	11.2	11.0	0.2	1.8
Tributaries to CR	254	247	7	2.6	1.33	1.31	0.02	1.4	11.4	11.2	0.1	1.3
Tripps Run	233	223	10	4.3	1.29	1.25	0.04	2.8	10.8	10.5	0.3	2.7
Turkeycock Run	203	186	17	8.3	1.13	1.06	0.07	6.5	9.6	9.0	0.6	6.3
Cameron Run Weighted Average	243	231	12	4.9	1.24	1.20	0.05	3.8	10.7	10.3	0.4	3.6

Table 6-11. Stream Condition Index scores

Project ID	Project Name	Existing SCI	Proposed SCI	Increase in SCI
CA9210	Brook Hill Stream Restoration	2.98	3.35	11%
CA9208	Wilburdale Park Bank Stabilization	2.65	3.20	17%
CA9207	Wilburdale Park Stream Restoration	2.95	3.35	12%
CA9216	Mason District Park Stream Restoration - A	*	*	*

* Insufficient data to calculate SCI

Table 6-12. Priority of policy recommendations

Recommen-dation ID	Project Name	Board Adopted Categories (40%)	Direct Regulatory Contribution (10%)	Public Support (10%)	Effectiveness/ Location Rating (25%)	Ease of Implementa-tion Rating (15%)	Total Score
A2.1	Encourage approval of LID facilities as acceptable SWM; adopt policy preferring LID projects	3	4	4	4	5	3.75
A1.5	Retrofit and upgrade SWM facilities and BMPs; construct new BMPs including LID practices	3	4	4	4	3	3.45
A3.3	Provide incentives to developers, builders, etc. to reduce runoff by using conservation design/LID	3	4	4	4	3	3.45
A4.1	Facilitate construction and use of LID practices, initially targeting areas near headwaters	3	4	4	4	3	3.45
A1.4	Evaluate current list of recommended BMPs; add some newer practices (LID)	3	4	4	3	4	3.35
A1.8	Increase fines for noncompliance with BMP or LID requirements	3	4	4	3	4	3.35
A3.1	Amend ordinances to require that redevelopment demonstrate 10% net decrease in runoff	3	4	4	4	2	3.3
A3.2	Amend zoning regulations to encourage better design of new development to reduce runoff	3	4	4	4	2	3.3
A1.6	Enact new policy to require on-site water retention in all land disturbance projects	3	4	4	3	3	3.2
A1.9	Coordinate SWM activities with neighboring jurisdictions, including annual reviews	3	4	4	3	3	3.2
A3.5	Conduct frequent inspections to ensure compliance with permit conditions concerning landscaping	3	4	4	3	3	3.2
D2.3	Evaluate, through a literature review or formal study, the effectiveness of public education programs for watershed stewardship.	2	4	4	4	4	3.2
A1.1	Inspect BMPs and perform assessments every 5 years (county and VDOT)	3	4	4	4	1	3.15

Table 6-12. (Continued)

Recommen-dation ID	Project Name	Board Adopted Categories (40%)	Direct Regulatory Contribution (10%)	Public Support (10%)	Effectiveness/ Location Rating (25%)	Ease of Implementation Rating (15%)	Total Score
B1.3	Require restoration of buffer for RPA development; mandate native vegetation mixes	2	2	4	4	5	3.15
A1.2	Provide additional staff/resources to county for BMP review and inspection	3	4	4	2	4	3.1
A1.3	Increase frequency of inspection of BMPs to annually; provide maintenance education	3	4	4	2	4	3.1
A1.7	Do not grant waivers of water quality controls for nonbonded lots with > 18% imperviousness	3	4	4	2	4	3.1
A4.2	Involve the public in early stages of planning of watershed projects; maintain communication	3	4	4	2	4	3.1
A5.1	Require road widening projects to control runoff from existing paved areas w/o SWM controls	3	4	4	3	2	3.05
C1.1	Provide additional staff/resources to inspect development projects for erosion/ sediment controls	2	3	3	4	4	3
B1.1	Plant buffers using native vegetation and trees; monitor buffers for 5 years	2	2	4	4	4	3
B1.2	Provide additional staff/resources for buffer protection in RPAs; ensure adequate training	2	2	4	4	4	3
B2.3	Implement natural and water conserving landscaping at county facilities	2	2	4	4	4	3
C1.3	Reduce the amount of de-icing chemicals and sand entering surface waters of watershed	2	3	3	3	4	2.75
C2.2	Perform additional water quality monitoring including macroinvertebrate/aquatic plant surveys	2	3	3	3	4	2.75
C2.3	Identify, investigate, and prosecute illicit discharges from commercial and residential activities	2	3	3	3	4	2.75
A3.4	Limit removal of mature trees and native vegetation in any development or renovation	2	2	4	3	4	2.75
B1.4	Provide educational assistance regarding buffers to property owners with tidal shorelines or streams	2	2	4	3	4	2.75

Table 6-12. (Continued)

Recommen-dation ID	Project Name	Board Adopted Categories (40%)	Direct Regulatory Contribution (10%)	Public Support (10%)	Effectiveness/ Location Rating (25%)	Ease of Implementation Rating (15%)	Total Score
B2.1	Monitor and report on stream condition by performing stream physical assessments	2	2	4	3	4	2.75
B2.2	Facilitate acquisition/donation of easements to community groups for buffer/stream protection	2	2	4	3	4	2.75
B3.1	Perform wetlands functions-and-values survey to identify characteristics of existing wetlands	2	2	4	3	4	2.75
C3.3	Place containers at public facilities for recycling and install signs requesting sorting, fines for littering	2	2	4	3	4	2.75
B3.3	Purchase, designate, acquire land for conservation of critical wetland habitat areas	2	2	4	4	2	2.7
C2.1	Identify sources of fecal coliform in watershed; prepare action plan to reduce it	2	3	3	3	3	2.6
C2.5	Encourage all lawn management companies to participate in VA Water Quality Improvement Program; create a “green label” program for lawn/landscaping companies	2	3	3	3	3	2.6
A5.2	Replace grasses on medians and sides of roadway with native trees and vegetation where possible	2	2	4	3	3	2.6
B1.5	Amend ordinance to expand woodlands; survey existing trees and builder requirements	2	2	4	3	3	2.6
B1.6	Determine current level of mature tree canopy; establish a reforestation goal	2	2	4	3	3	2.6
B3.2	Construct and restore wetlands at suitable locations as identified in wetland survey	2	2	4	3	3	2.6
A3.6	Allocate sufficient funding for county inspection and enforcement of landscaping regulations	2	2	4	2	4	2.5
B2.4	Notify property owners on steps for improving water quality in their streams	2	3	3	2	4	2.5
B3.4	Provide outreach materials for value/benefit of wetlands, permits required for wetland activities	2	2	4	2	4	2.5
B3.5	Discourage further development in native wetlands; require mitigation when impacts are unavoidable	2	2	4	2	4	2.5

Table 6-12. (Continued)

Recommen-dation ID	Project Name	Board Adopted Categories (40%)	Direct Regulatory Contribution (10%)	Public Support (10%)	Effectiveness/ Location Rating (25%)	Ease of Implementation Rating (15%)	Total Score
C1.2	Encourage application of bioengineering to stabilize streambanks and improve habitat	2	3	3	2	4	2.5
C2.4	Educate public on ways to reduce pollutants in stormwater runoff	2	3	3	2	4	2.5
C2.6	Strengthen enforcement of "pooper scooper" regulation; institute $100 fine for violators	2	3	3	2	4	2.5
C3.1	Partner to clean up trash, woody debris, dumpsites throughout watershed	2	2	4	2	4	2.5
C3.2	Conduct vigorous public info campaign to deter littering and trash dumping	2	2	4	2	4	2.5
C3.4	Enforce solid waste and ESC ordinances against illegal dumping; impose fines/require restoration	2	3	3	2	4	2.5
D2.1	Post signage publicizing existence and importance of RPAs for stream protection and recreation	2	2	2	2	4	2.3
D2.2	Install signage at public facilities explaining benefits of LID; identify sources for further information	2	2	2	2	4	2.3
D1.2	Develop master plan for environmentally friendly recreation opportunities in Cameron Run	1	1	2	3	4	2.05
D1.1	Identify stream corridors for purchase for public access and environmentally friendly recreation	1	1	2	2	4	1.8

6.6.2 Project Actions

As described in Section 5.4.3, the county's stormwater project prioritization guidance, in conjunction with a cost-benefit analysis, was used to select and rank the Tier 1 candidate projects. Projects are listed by subwatershed, with those having a better cost-benefit ratio listed first (Table 6-13). Drainage complaint projects are not included in this table because they were prioritized using a separate process (see Section 6.4.7).

Table 6-13. Priority of proposed projects

Project ID	Project Name	Board Adopted Categories (40%)	Direct Regulatory Contribution (10%)	Public Support (10%)	Effectiveness/ Location Rating (25%)	Ease of Implementation Rating (15%)	Total Score	Acres Treated	Site Footprint (Acres)	Estimated Cost	Cost (Normalized)/ Benefit Ratio
Watershed-wide											
CA9700	Instream Debris Jam Evaluation and Removal	4	2	3	3	2	3.15	28,400		$286,000	3
CA9702	Small Watershed Grant Program	4.5	5	5	4	3	4.25	28,400		$1,094,000	9
CA9701	Community Watershed Restoration Support	4.5	5	5	4	3	4.25	28,400		$1,407,000	12
Pike Branch											
CA9802	Jefferson Manor Park Bioretention	4.5	4	5	4	5	4.45	9.2		$ 73,000	1,783
CA9809	Ridgeview Park LID – A	4.5	4	3	4	4	4.1	2.9		$ 59,000	4,962
CA9804	Mount Eagle Elementary School LID	4.5	5	3	5	5	4.6	5.9		$210,000	7,738
CA9808	Lee District Park LID	4.5	5	3	5	5	4.6	43.4		$1,589,000	7,959
CA9810	Ridgeview Park LID - B	4.5	4	3	5	4	4.35	7.6		$414,000	12,523
CA9805	Wilton Administration Center LID	4.5	5	3	5	5	4.6	6.6		$460,000	15,152
CA9807	Virginia Hills Administration Center (School) LID	4.5	5	3	5	5	4.6	4.8		$352,000	15,942
CA9811	Redwood Lane - LID	4.5	4	3	4	4	4.1	2.9		$211,000	17,746
CA9812	Ridge View Drive - LID	4.5	4	3	5	5	4.5	3.1		$249,000	17,849
CA9813	John Marshall Library LID	4.5	5	3	5	5	4.6	1.8		$246,000	29,710
Backlick Run											
CA9848	Leewood Park LID - B	4.5	4	3	3	4	3.85	6.6		$ 13,000	512
CA9103	Woodfield SWM Pond Retrofit	4.5	4	3	4	4	4.1	102.1		$276,000	659
CA9104	Thomas SWM Pond Retrofit	4.5	5	3	4	5	4.35	39.3		$148,000	866
CA9846	Leewood Park LID - A	4.5	4	3	3	4	3.85	11.4		$ 39,000	889
CA9107	Jayhawk SWM Pond Retrofit	4.5	5	3	4	5	4.35	46.3		$236,000	1,172
CA9850	Wilburdale Park LID - A	4.5	4	5	5	5	4.7	25.6		$156,000	1,297
CA9958	Lynbrook Subdivision LID - A	4.5	4	3	4	5	4.25	14.7		$ 89,000	1,425
CA9829	Franconia Park LID	4.5	5	3	4	5	4.35	12.8		$126,000	2,263
CA9851	Wilburdale Park LID - B	4.5	4	3	4	5	4.25	6.0		$ 97,000	3,804
CA9853	Annandale High School LID	4.5	5	3	5	5	4.6	17.7		$420,000	5,158
CA9842	Lynbrook Elementary School LID	4.5	5	3	4	5	4.35	11.0		$254,000	5,308
CA9828	Fire Station - Company No. 5 LID	4.5	4	3	4	5	4.25	2.6		$ 71,000	6,425
CA9830	Edsall Administration Center LID	4.5	5	3	5	5	4.6	4.5		$139,000	6,715
CA9827	Lee District Government Center LID	4.5	5	3	5	5	4.6	3.1		$209,000	14,656
CA9208	Wilburdale Park Bank Stabilization	4	5	3	3	4	3.75	-	2.8	$169,000	16,359
CA9836	Lee High School LID	4.5	5	3	5	5	4.6	42.1		$3,421,000	17,665
CA9207	Wilburdale Park Stream Restoration	4	5	3	3	4	3.75	-	3.6	$320,000	23,556
CA9210	Brook Hill Stream Restoration	3	5	5	4	3	3.65	-	12.6	$1,171,000	25,530

Table 6-13. (Continued)

Project ID	Project Name	Board Adopted Categories (40%)	Direct Regulatory Contribution (10%)	Public Support (10%)	Effectiveness/ Location Rating (25%)	Ease of Implementation Rating (15%)	Total Score	Acres Treated	Site Footprint (Acres)	Estimated Cost	Cost (Normalized)/ Benefit Ratio
Backlick Run (Continued)											
CA9839	Key Middle School LID	4.5	5	3	5	5	4.6	21.3		$2,745,000	28,016
CA9835	Springfield Elementary School LID	4.5	5	3	5	5	4.6	10.2		$1,356,000	28,900
Tributaries to Cameron Run											
CA9100	Farrington Park SWM Pond Retrofit	4.5	5	3	4	5	4.35	13.8		$ 61,000	1,016
CA9102	Huntington Park SWM Pond	4.5	5	3	4	5	4.35	16.7		$ 98,000	1,349
CA9823	Bush Hill Elementary School LID	4.5	5	3	5	5	4.6	9.6		$183,000	4,144
CA9821	Clermont Elementary School LID	4.5	5	3	5	5	4.6	12.4		$308,000	5,400
CA9818	Clermont School Site Park LID	4.5	4	3	3	4	3.85	1.1		$ 49,000	11,570
CA9822	Twain Middle School LID	4.5	5	3	5	5	4.6	9.6		$660,000	14,946
Holmes Run - Upper											
CA9139	Kings Glen SWM Pond Retrofit	4.5	5	3	4	4	4.2	81.8		$243,000	707
CA9929	Round Tree Park LID - A	4.5	4	3	5	4	4.35	16.0		$ 52,000	747
CA9914	Columbia Pines LID	4.5	4	3	5	4	4.35	28.1		$ 96,000	785
CA9954	Jefferson District Park & Golf Course LID	4.5	5	5	4	5	4.55	59.7		$236,000	869
CA9134	Columbia Pines SWM Pond Retrofit	4.5	5	3	4	4	4.2	7.7		$ 30,000	928
CA9142	Courts of Tyson SWM Pond Retrofit	4.5	5	3	4	4	4.2	6.5		$ 31,000	1,136
CA9942	Luria Park LID	4.5	4	3	5	5	4.5	57.1		$355,000	1,382
CA9138	Providence RECenter SWM Pond Retrofit	4.5	5	5	4	5	4.55	4.5		$102,000	4,982
CA9949	Graham Road Elementary School LID	4.5	5	3	5	5	4.6	4.7		$127,000	5,874
CA9953	Shrevewood Elementary School LID	4.5	5	3	5	5	4.6	11.8		$359,000	6,614
CA9927	Round Tree Park LID - C	4.5	4	3	4	5	4.25	6.8		$195,000	6,747
CA9911	Belvedere Elementary School LID	4.5	5	3	5	5	4.6	9.9		$325,000	7,137
CA9950	Pine Spring Elementary School LID	4.5	5	3	5	5	4.6	11.1		$576,000	11,281
CA9921	Broyhill Crest Park LID	4.5	4	3	4	5	4.25	2.4		$132,000	12,941
CA9952	Timber Lane Elementary School LID	4.5	5	3	5	5	4.6	9.7		$606,000	13,581
CA9946	Falls Church High School LID	4.5	5	3	5	5	4.6	38.1		$2,772,000	15,817
CA9955	Dunn Loring Center (School) LID	4.5	5	3	5	5	4.6	9.1		$722,000	17,248
CA9947	Thomas Jefferson Library LID	4.5	5	3	5	5	4.6	2.2		$179,000	17,688
CA9957	Fire Station - Company No. 13 LID	4.5	4	3	5	5	4.5	1.5		$132,000	19,556
CA9925	Holmes Run Stream Valley Park LID	4.5	4	3	4	5	4.25	0.9		$ 87,000	22,745
CA9917	Beech Tree Elementary School LID	4.5	5	3	5	5	4.6	7.8		$1,409,000	39,270
CA9922	Lacey Admin Center LID	4.5	5	3	5	5	4.6	6.7		$1,317,000	42,732
CA9941	Woodburn Elementary School LID	4.5	5	3	5	5	4.6	6.1		$1,342,000	47,826

Table 6-13. (Continued)

Project ID	Project Name	Board Adopted Categories (40%)	Direct Regulatory Contribution (10%)	Public Support (10%)	Effectiveness/ Location Rating (25%)	Ease of Implementation Rating (15%)	Total Score	Acres Treated	Site Footprint (Acres)	Estimated Cost	Cost (Normalized)/ Benefit Ratio
Holmes Run – Upper (Continued)											
CA9937	Walnut Hill Admin Center LID - B	4.5	5	3	5	5	4.6	8.7		$2,953,000	73,788
Indian Run											
CA9857	Weyanoke Elementary School LID	4.5	5	3	5	5	4.6	5.9		$124,000	4,569
CA9862	Columbia Elementary School LID	4.5	5	3	5	5	4.6	5.5		$134,000	5,296
CA9858	Poe Middle School LID	4.5	5	3	5	5	4.6	9.6		$248,000	5,616
CA9860	Indian Run Stream Valley Park LID - A	4.5	4	3	4	5	4.25	9.9		$334,000	7,938
CA9854	Bren Mar Park Elementary School LID	4.5	5	3	4	5	4.35	5.5		$230,000	9,613
CA9855	Fire Station - Company No. 26 LID	4.5	4	3	5	5	4.5	1.8		$131,000	16,173
CA9863	George Mason Regional Library LID	4.5	5	3	5	5	4.6	5.1		$403,000	17,178
CA9856	Holmes Middle School LID	4.5	5	3	5	5	4.6	17.5		$1,593,000	19,789
CA9859	Indian Run Stream Valley Park LID - C	4.5	4	3	4	5	4.25	3.9		$516,000	31,131
CA9861	Indian Run Stream Valley Park LID - B	4.5	4	3	4	5	4.25	3.6		$543,000	35,490
Turkeycock Run											
CA9118	Pinecrest SWM Pond Retrofit	4.5	5	3	4	5	4.35	13.3		$ 69,000	1,193
CA9866	Turkeycock Run Stream Valley Park LID	4.5	4	3	4	4	4.1	34.4		$198,000	1,404
CA9117	Braddock Place SWM Pond Retrofit	4.5	5	3	4	5	4.35	7.4		$ 49,000	1,522
CA9111	Beauregard SWM Pond Retrofit	4.5	5	3	3	4	3.95	3.5		$ 25,000	1,808
CA9115	Little River SWM Pond Retrofit	4.5	5	3	4	5	4.35	3.9		$ 33,000	1,945
CA9112	Strawbridge Square SWM Pond Retrofit	4.5	5	3	3	5	4.1	2.0		$ 25,000	3,049
CA9867	Parklawn Elementary School LID	4.5	5	3	5	5	4.6	11.1		$168,000	3,290
CA9960	Mason District Park LID	4.5	4	3	5	5	4.5	5.1		$120,000	5,229
CA9872	Mason Government Center LID	4.5	5	3	5	5	4.6	6.6		$220,000	7,246
CA9870	Wolftree Lane LID	4.5	4	3	5	5	4.5	8.6		$286,000	7,390
CA9869	Pinecrest Golf Course LID	4.5	4	3	4	4	4.1	1.9		$ 78,000	10,013
CA9868	Green Spring Gardens LID	4.5	4	3	3	5	4	1.1		$ 99,000	22,500
CA9216	Mason District Park Stream Restoration - A	3	5	5	5	5	4.2	-	4.8	$996,000	49,378
Tripps Run											
CA9959	Anna Lee Heights LID	4.5	4	3	5	4	4.35	16.8		$ 77,000	1,054
CA9128	Great Oak SWM Pond Retrofit	4.5	5	3	4	5	4.35	18.9		$ 89,000	1,083
CA9126	Dominion SWM Pond Retrofit	4.5	5	5	4	4	4.4	8.3		$ 61,000	1,670
CA9892	Westlawn Elementary School LID	4.5	5	3	5	5	4.6	8.0		$117,000	3,179
CA9901	Larry Graves Park LID	4.5	5	3	4	5	4.35	1.2		$ 41,000	7,854
CA9886	Nicholson St - Ch. 2 Street LID	4.5	4	5	4	5	4.45	2.4		$100,000	9,363

Table 6-13. (Continued)

Project ID	Project Name	Board Adopted Categories (40%)	Direct Regulatory Contribution (10%)	Public Support (10%)	Effectiveness/ Location Rating (25%)	Ease of Implementation Rating (15%)	Total Score	Acres Treated	Site Footprint (Acres)	Estimated Cost	Cost (Normalized)/ Benefit Ratio
Tripps Run (Continued)											
CA9897	Fire Station - Company No. 28 LID	4.5	5	3	5	5	4.6	0.5		$ 23,000	10,000
CA9885	Sleepy Hollow Elementary School LID	4.5	5	3	5	5	4.6	9.2		$455,000	10,751
CA9904	Devonshire Administration Center (School) LID	4.5	5	3	5	5	4.6	5.3		$288,000	11,813
CA9882	JEB Stuart High School LID	4.5	5	5	5	5	4.8	23.6		$1,881,000	16,605
Holmes Run - Lower											
CA9962	Holmes Run Park LID	4.5	4	3	5	5	4.5	8.0		$158,000	4,389
CA9876	Glasgow Middle School LID	4.5	5	3	5	5	4.6	22.6		$703,000	6,762
CA9877	Baileys Community Center LID	4.5	5	3	5	5	4.6	6.9		$351,000	11,059
CA9879	Baileys Elementary School LID	4.5	5	3	5	5	4.6	9.6		$1,535,000	34,760

The 25-year implementation plan for structural and nonstructural projects is shown in Table 6-14. Projects have been placed into one of five implementation groups, based on relative priority. The five-year implementation groups are listed below:

Group A:	Fiscal Year 2007 – 2011
Group B:	Fiscal Year 2012 – 2016
Group C:	Fiscal Year 2017 – 2021
Group D:	Fiscal Year 2022 – 2026
Group E:	Fiscal Year 2027 – 2031

The dates for implementation are target dates, beginning with Board approval of the plan, and subject to County funding approval and ongoing updates to the plan. Implementation groupings for projects with specific locations are shown in Figures 6-13 through 6-17. Although not included in the following table or figures, implementation of the separate drainage complaint projects is targeted for the initial five-year period,

Some of the actions in the implementation plan were scheduled with the assistance of the Advisory Committee according to the following important factors in addition to the priority ratings:

- high visibility and opportunity for public education at a variety of kinds of facilities
- logical progression of actions, such as starting upstream flow-reduction actions before downstream restoration actions
- spreading of actions throughout the watershed during the plan period, not concentrating early actions in one area
- spreading costs out throughout the plan period

Table 6-14. Implementation of proposed projects

Project ID	Project Name	Implementation Timeframe	Estimated Cost
Watershed-wide			
CA9700	Instream Debris Jam Evaluation and Removal	A	$286,000
CA9702	Small Watershed Grant Program	A	$1,094,000
CA9701	Community Watershed Restoration Support	A	$1,407,000
Pike Branch			
CA9802	Jefferson Manor Park Bioretention	B	$73,000
CA9809	Ridgeview Park LID - A	B	$59,000
CA9804	Mount Eagle Elementary School LID	B	$210,000
CA9808	Lee District Park LID	A	$1,589,000
CA9810	Ridgeview Park LID - B	C	$414,000
CA9805	Wilton Administration Center LID	A	$460,000
CA9807	Virginia Hills Administration Center (School) LID	A	$352,000
CA9811	Redwood Lane - LID	D	$211,000
CA9812	Ridge View Drive - LID	D	$249,000
CA9813	John Marshall Library LID	A	$246,000

Table 6-14. (Continued)

Project ID	Project Name	Implementation Timeframe	Estimated Cost
Backlick Run			
CA9848	Leewood Park LID - B	A	$13,000
CA9103	Woodfield SWM Pond Retrofit	A	$276,000
CA9104	Thomas SWM Pond Retrofit	A	$148,000
CA9846	Leewood Park LID - A	A	$39,000
CA9107	Jayhawk SWM Pond Retrofit	A	$236,000
CA9850	Wilburdale Park LID - A	A	$156,000
CA9958	Lynbrook Subdivision LID - A	B	$89,000
CA9829	Franconia Park LID	B	$126,000
CA9851	Wilburdale Park LID - B	B	$97,000
CA9853	Annandale High School LID	B	$420,000
CA9842	Lynbrook Elementary School LID	B	$254,000
CA9828	Fire Station - Company No. 5 LID	B	$71,000
CA9830	Edsall Administration Center LID	A	$139,000
CA9827	Lee District Government Center LID	A	$209,000
CA9208	Wilburdale Park Bank Stabilization	C	$169,000
CA9836	Lee High School LID	D	$3,421,000
CA9207	Wilburdale Park Stream Restoration	D	$320,000
CA9210	Brook Hill Stream Restoration	D	$1,171,000
CA9839	Key Middle School LID	D	$2,745,000
CA9835	Springfield Elementary School LID	E	$1,356,000
Tributaries to Cameron Run			
CA9100	Farrington Park SWM Pond Retrofit	A	$61,000
CA9102	Huntington Park SWM Pond	A	$98,000
CA9823	Bush Hill Elementary School LID	B	$183,000
CA9821	Clermont Elementary School LID	B	$308,000
CA9818	Clermont School Site Park LID	C	$49,000
CA9822	Twain Middle School LID	C	$660,000
Holmes Run - Upper			
CA9139	Kings Glen SWM Pond Retrofit	B	$243,000
CA9929	Round Tree Park LID - A	A	$52,000
CA9914	Columbia Pines LID	A	$96,000
CA9954	Jefferson District Park & Golf Course LID	A	$236,000
CA9134	Columbia Pines SWM Pond Retrofit	A	$30,000
CA9142	Courts of Tyson SWM Pond Retrofit	C	$31,000
CA9942	Luria Park LID	B	$355,000
CA9138	Providence RECenter SWM Pond Retrofit	B	$102,000
CA9949	Graham Road Elementary School LID	C	$127,000
CA9953	Shrevewood Elementary School LID	B	$359,000
CA9927	Round Tree Park LID - C	B	$195,000
CA9911	Belvedere Elementary School LID	B	$325,000
CA9950	Pine Spring Elementary School LID	C	$576,000
CA9921	Broyhill Crest Park LID	E	$132,000
CA9952	Timber Lane Elementary School LID	C	$606,000
CA9946	Falls Church High School LID	C	$2,772,000
CA9955	Dunn Loring Center (School) LID	A	$722,000
CA9947	Thomas Jefferson Library LID	A	$179,000

Table 6-14. (Continued)

Project ID	Project Name	Implementation Timeframe	Estimated Cost
Holmes Run – Upper (Continued)			
CA9957	Fire Station - Company No. 13 LID	D	$132,000
CA9925	Holmes Run Stream Valley Park LID	D	$87,000
CA9917	Beech Tree Elementary School LID	E	$1,409,000
CA9922	Lacey Admin Center LID	A	$1,317,000
CA9941	Woodburn Elementary School LID	E	$1,342,000
CA9937	Walnut Hill Admin Center LID - B	B	$2,953,000
Indian Run			
CA9857	Weyanoke Elementary School LID	B	$124,000
CA9862	Columbia Elementary School LID	B	$134,000
CA9858	Poe Middle School LID	B	$248,000
CA9860	Indian Run Stream Valley Park LID - A	B	$334,000
CA9854	Bren Mar Park Elementary School LID	C	$230,000
CA9855	Fire Station - Company No. 26 LID	C	$131,000
CA9863	George Mason Regional Library LID	A	$403,000
CA9856	Holmes Middle School LID	D	$1,593,000
CA9859	Indian Run Stream Valley Park LID - C	E	$516,000
CA9861	Indian Run Stream Valley Park LID - B	E	$543,000
Turkeycock Run			
CA9118	Pinecrest SWM Pond Retrofit	B	$69,000
CA9866	Turkeycock Run Stream Valley Park LID	B	$198,000
CA9117	Braddock Place SWM Pond Retrofit	C	$49,000
CA9111	Beauregard SWM Pond Retrofit	B	$25,000
CA9115	Little River SWM Pond Retrofit	B	$33,000
CA9112	Strawbridge Square SWM Pond Retrofit	B	$25,000
CA9867	Parklawn Elementary School LID	B	$168,000
CA9960	Mason District Park LID	A	$120,000
CA9872	Mason Government Center LID	A	$220,000
CA9870	Wolftree Lane LID	B	$286,000
CA9869	Pinecrest Golf Course LID	C	$78,000
CA9868	Green Spring Gardens LID	D	$99,000
CA9216	Mason District Park Stream Restoration - A	A	$996,000
Tripps Run			
CA9959	Anna Lee Heights LID	C	$77,000
CA9128	Great Oak SWM Pond Retrofit	B	$89,000
CA9126	Dominion SWM Pond Retrofit	C	$61,000
CA9892	Westlawn Elementary School LID	B	$117,000
CA9901	Larry Graves Park LID	B	$41,000
CA9886	Nicholson St - Ch. 2 Street LID	C	$100,000
CA9897	Fire Station - Company No. 28 LID	C	$23,000
CA9885	Sleepy Hollow Elementary School LID	C	$455,000
CA9904	Devonshire Administration Center (School) LID	A	$288,000
CA9882	JEB Stuart High School LID	C	$1,881,000
Holmes Run - Lower			
CA9962	Holmes Run Park LID	B	$158,000
CA9876	Glasgow Middle School LID	B	$703,000
CA9877	Baileys Community Center LID	C	$351,000
CA9879	Baileys Elementary School LID	E	$1,535,000

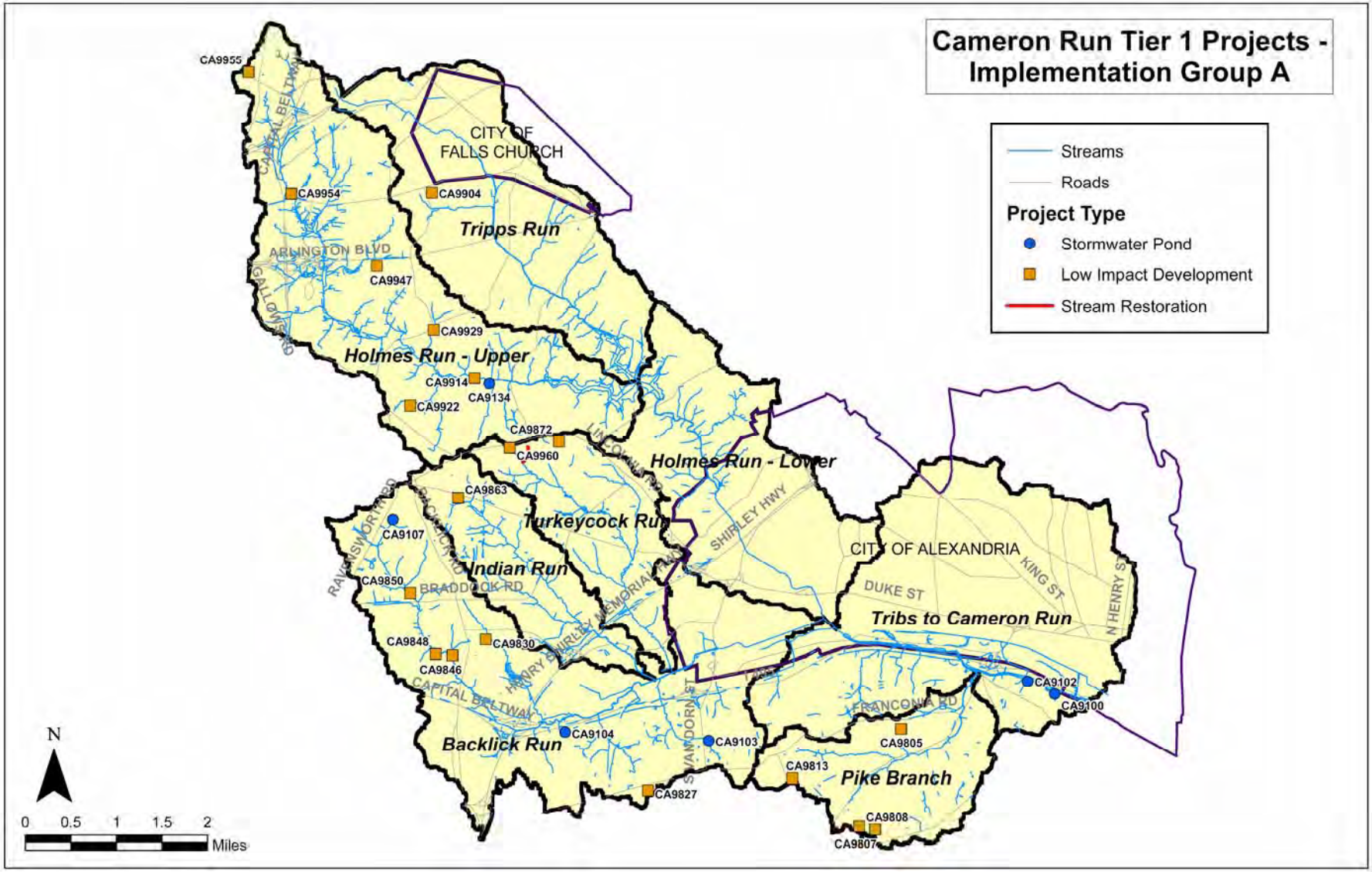


Figure 6-13. Implementation Group A (2007 – 2011)

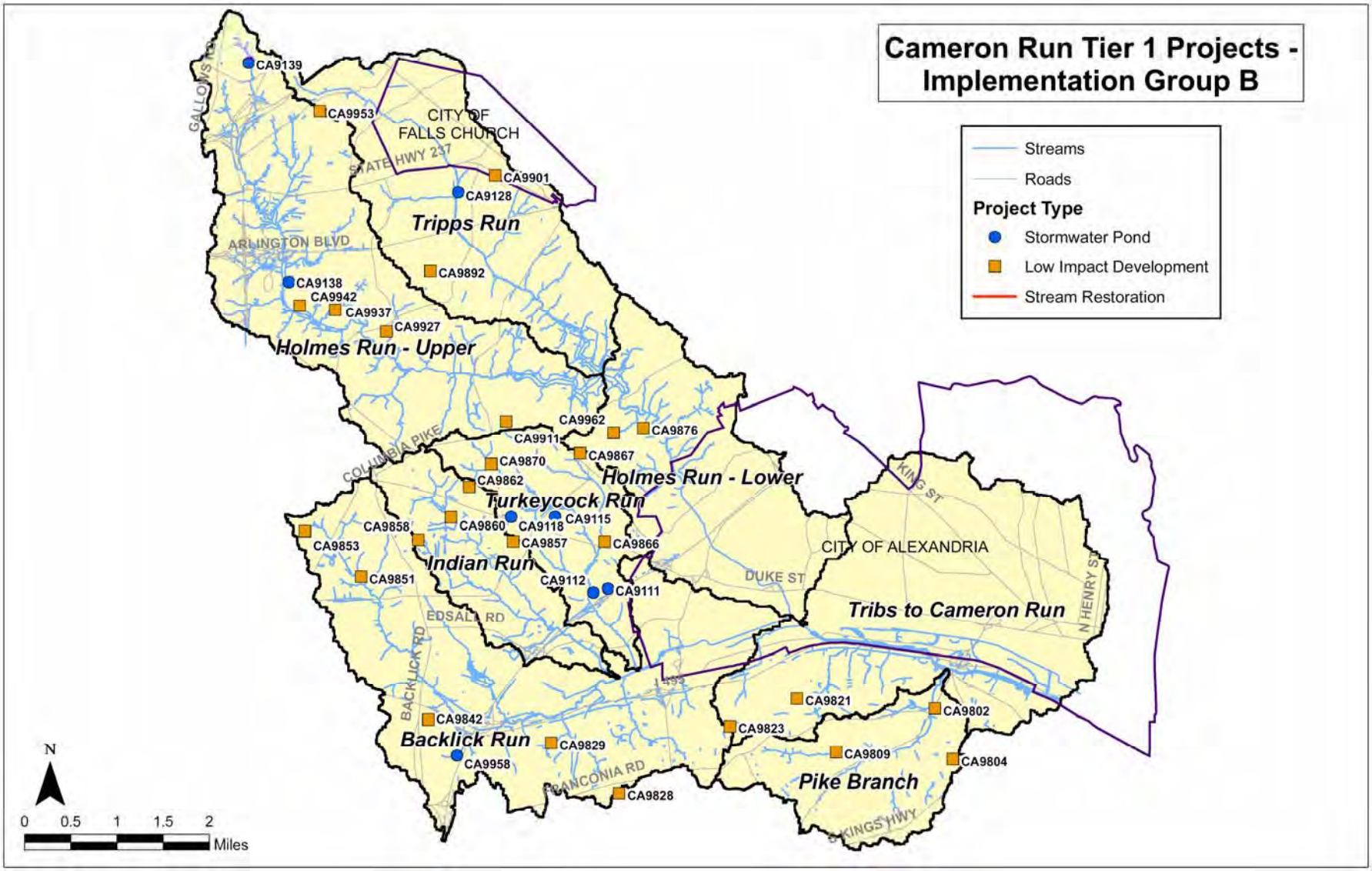


Figure 6-14. Implementation Group B (2012 – 2016)

Figure 6-15. Implementation Group C (2017 – 2021)

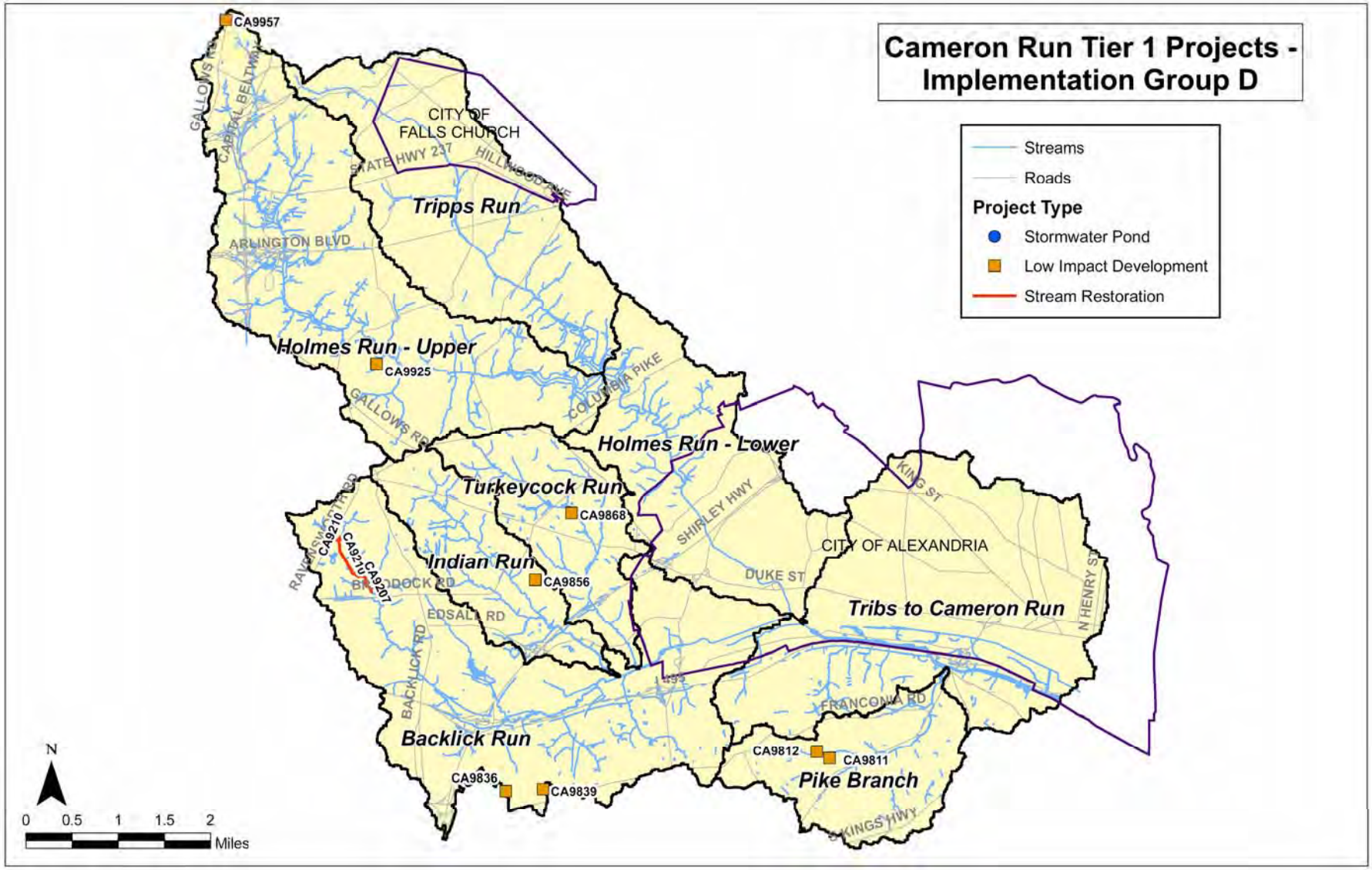


Figure 6-16. Implementation Group D (2022 – 2026)

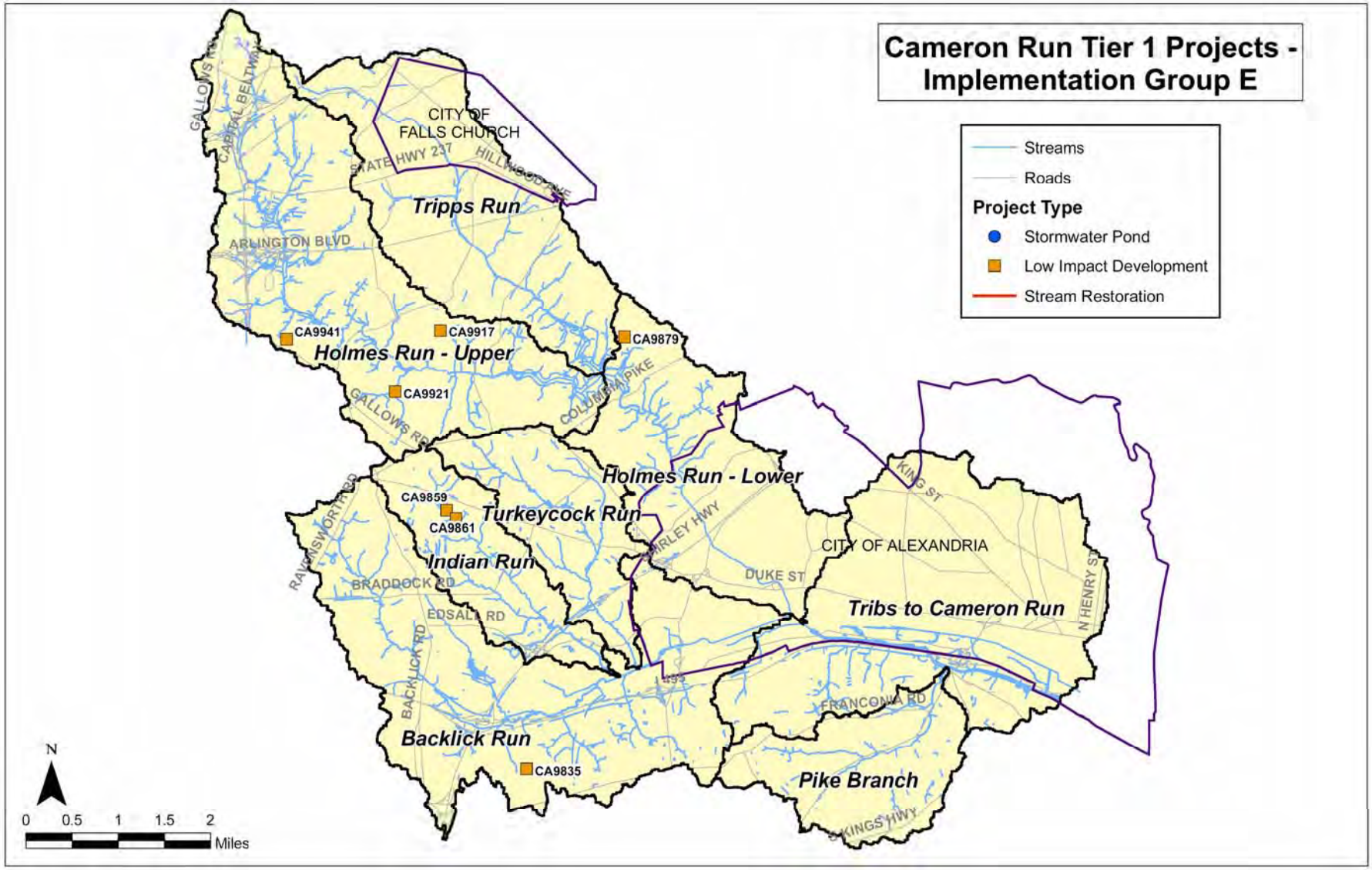


Figure 6-17. Implementation Group E (2027 – 2031)

The 25-year estimated funding requirements for all the structural and nonstructural recommended actions is $47.4 million. The breakdown of funding requirements for each five-year period of the plan is shown in Table 6-15. Estimated costs included in this plan represent actual costs that, in many cases, can be off-set or eliminated through the use of existing staff resources, in-kind services, cost-share programs, donated materials, volunteers, and other means.

Table 6-15. Funding requirements

Implementation Period	Estimated Funding Requirements
Group A: Fiscal Year 2007 – 2011	$11,468,000
Group B: Fiscal Year 2012 – 2016	$9,174,000
Group C: Fiscal Year 2017 – 2021	$8,840,000
Group D: Fiscal Year 2022 – 2026	$10,028,000
Group E: Fiscal Year 2027 – 2031	$6,833,000
Drainage Complaint Projects: Fiscal Year 2007 – 2011	$1,059,000
Total	$47,402,000

During the process of reviewing of the plan, members of the public frequently asked how the plan will be funded. Possible funding sources for the proposed actions in this plan include the general fund, a bond referendum, grants, cost sharing, and a stormwater environmental utility fee. Annual allocations of the general fund for controlling stormwater have ranged from $760,000 to $2.2 million over the past three years. The last stormwater bond referendum to be approved was in 1988 in the amount of $12 million subject to cash flow restrictions. As part of the county Board of Supervisors Environmental Agenda, an additional $17.9 million has been allocated in Fiscal Year 2006 for stormwater program implementation. The county has also signed a memorandum of agreement with the U.S. Army Corps of Engineers to share the cost of restoration projects in the watershed.

6.7 MONITORING PLAN

Monitoring the progress of implementation and the results of individual projects is critical to determining the success or failure of future structural and nonstructural projects and the overall success of the watershed management plan. Evaluation of project actions can also help to determine if the plan should be modified because of a low success rate or as watershed conditions change. As such, the plan should be reviewed annually to evaluate the progress of initiated projects, the overall implementation schedule, funding and staff availability, and future funding needs, using this information to revise the plan as needed.

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Glossary

Abatement: Reducing the degree or intensity of, or eliminating, pollution, as in a water pollution abatement program.

Annual Flood Series: A list of annual floods for a given period of time.

Annual Low-Flow: The lowest flow occurring each year, usually the lowest average flow for periods of perhaps 3, 7, 15, 30, 60, 120, or 180 consecutive days.

Annual Runoff: The total quantity of water in runoff for a drainage area for the year. Data reports may use any of the following units of measurement in presenting annual runoff data: (1) acre-feet (AC-FT, acre-ft, af)– the quantity of water required to cover 1 acre to a depth of 1 foot and is equal to 43,560 cubic feet, 325,851 gallons, or 1,234 cubic meters; (2) cubic feet per second per square mile (CFSM, $(ft^3/s)\ mi^2$) – the average number of cubic feet of water flowing per second from each square mile of area drained, assuming the runoff is distributed uniformly in time and area; (3) inch (In., in.) – the depth to which a drainage area would be covered with water if all the runoff for a given time period was uniformly distributed on it.

Aqueduct: (1) A pipe, conduit, or channel designed to transport water from a remote source, usually by gravity. (2) A bridge-like structure supporting a conduit or canal passing over a river or low ground.

Bacteria: Single celled organisms that can cause diseases.

Berm: (1) A narrow ledge or path as at the top or bottom of a slope, stream bank, or along a beach. (2) (Dam) A horizontal step or bench in the upstream or downstream face of an *Embankment Da*m.

Best Management Practice (BMP): A structural or nonstructural practice that is designed to prevent or reduce the discharge of pollutants to waterbodies and to minimize the impacts of changes in land use on surface and groundwater systems. Structural best management practices refer to basins or facilities engineered for the purpose of reducing the pollutant load in stormwater runoff, such as bioretention, constructed stormwater wetlands, etc. Nonstructural best management practices refer to land use or development practices that are determined to be effective in minimizing the impact on receiving stream systems such as the preservation of open space and stream buffers, disconnection of impervious surfaces, etc. BMPs also include treatment requirements, operating procedures, and practice to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

Bioretention Basin: A water quality best management practice engineered to filter the water quality volume through an engineered planting bed, consisting of a vegetated surface layer (vegetation, mulch, ground cover), planting soil, and sand bed (optional), and into the in-situ material. Also called rain gardens.

Bioretention Filter: A bioretention basin with the addition of a sand layer and collector pipe system beneath the planting bed.

Buffer: An area of natural or established vegetation managed to protect other components of a resource protection area and save waters from significant degradation due to land disturbances, also a R*iparian Buffer*.

Chesapeake Bay Preservation Areas: Any land designated by the County pursuant to Part III of the Chesapeake Bay Preservation Area Designation and Management Regulations and Code of Virginia, Section 10.1-2107. A Chesapeake Bay Preservation Area shall consist of a resource protection area and a resource management area.

Capacity: The amount of water that a channel can accommodate up to its bank full condition, which is dependent on its slope, roughness characteristics, and geometric shape.

Channel: A natural or manmade waterway.

Confluence: The joining point where two or more streams create a combined, larger stream.

Constructed Stormwater Wetlands: Areas intentionally designed and created to emulate the water quality improvement function of wetlands for the primary purpose of removing pollutants from stormwater.

Detention Basin: A stormwater management facility that temporarily impounds runoff and discharges it through a hydraulic outlet structure to a downstream conveyance system. While a certain amount of overflow may also occur via infiltration through the surrounding soil, such amounts are negligible when compared to the outlet structure discharge rates, and therefore, are not considered in the facility's design. Since a detention basin impounds runoff only temporarily, it is normally dry during periods of no rainfall.

Easement: A legal instrument enabling the giving, selling, of taking or certain land or water rights without transfer of title, such as for the passage of utility lines. An affirmative easement gives the owner of the easement the right to use the land for a stated purpose. A negative easement is an agreement with a private property owner to limit the development of his land in specific ways.

Ecosystem: All of the component organisms of a community and their environment that together form an interacting system.

Embeddedness: The extent to which the spaces between particles on the streambed are filled with sediment.

Environmental Quality Corridor (ECQ): A county policy that aims to protect sensitive areas in stream valleys during the rezoning process. It was the precursor to Resource Protection Areas and is still applied when possible. The EQC policy does not directly address stormwater discharges; however, it is particularly relevant to the County's overall water quality management

program as it serves to identify, protect, and, in some cases, restore environmentally-sensitive resources. Specifically, the EQC policy recommends the preservation and restoration of areas including floodplains, steep slopes (slope gradients of 15% or greater) adjacent to streams or floodplains, wetlands connected to stream valleys, minimum stream buffers (variable in width depending on topography), and sensitive habitat areas. While there is no County regulation requiring EQC protection (Resource Protection Area and floodplain provisions in the County Code protect many, but not all, EQC areas), the application of the EQC policy during the zoning process has been effective in protecting, and in some cases restoring, environmentally-sensitive areas.

Erosion: (1) Detachment of soil particles under the influence of water and/or wind. (2) The wearing away and removal of materials of the earth's crust by natural means. (3) The process by which flood waters lower the ground surface in an area by removing upper layers of soil. As usually employed, the term includes weathering, solution, corrosion, and transportation. The agents that accomplish the transportation and cause most of the wear are running water, waves, moving ice, and wind currents. Most writers include under the term all the mechanical and chemical agents of weathering that loosen rock fragments before they are acted on by the transportation agents; a few authorities prefer to include only the destructive effects of the transporting agents. Various types of water erosion include:

- ***Accelerated*** – Erosion much more rapid than normal, natural, or geologic erosion, primarily as a result of the influence of the activities of man or, in some cases, of other animals or natural catastrophes that expose bare surfaces, for example, forest fires;
- ***Geological*** – The normal or natural erosion caused by geological processes acting over long geologic periods and resulting in the wearing away of mountains, the building up of floodplains, coastal plains, etc., and also referred to as natural erosion;
- ***Gross*** – A measure of the potential for soil to be dislodged and moved from its place of origin, not necessarily the amount of soil that actually reaches a stream or lake, but the amount of soil that can be calculated from water and wind equations;
- ***Gully*** – The erosion process whereby water accumulates in narrow channels and, over short periods of time, removes soil from this narrow area to considerable depths, ranging from 1–2 feet (0.3–0.6 meters) to as much as 75–100 feet (23–31 meters);
- ***Natural*** – The wearing away of the earth's surface by water, ice, or other natural agents under natural environmental conditions of climate, vegetation, etc., undisturbed by man, and also referred to as geological erosion;
- ***Normal*** – The gradual erosion of land used by man that does not greatly exceed natural erosion;
- ***Rill*** – An erosion process in which numerous small channels only several inches deep are formed; occurs mainly on recently cultivated soils and/or recent cuts and fills;
- ***Sheet*** – The removal of a thin, fairly uniform layer of soil from the land surface by runoff waters;
- ***Shore*** – Removal of soil, sand, or rock from the land adjacent to a body of water due to wave action;
- ***Splash*** – The spattering of small soil particles caused by the impact of raindrops on wet soils. The loosened and spattered particles may or may not be subsequently removed by surface runoff;

- ***Streambank*** – Scouring of material and the cutting of channel banks by running water;
- ***Streambed*** – Scouring of material and cutting of channel beds by running water;
- ***Undercutting*** – Removal of material at the base of a steep slope or cliff by falling water, a stream, wind erosion, or wave action; the removal steepens the slope or produces an overhanging cliff.

Eutrophication: The process by which a body of water becomes enriched in dissolved nutrients (as phosphates) that stimulate the growth of aquatic plant life usually resulting in the depletion of dissolved oxygen.

Exceedance: (Water Quality) The violation of the pollutant levels permitted by environmental protection standards.

Fecal Coliform Bacteria: A group of organisms common to the intestinal tracts of humans and animals. The presence of fecal coliform bacteria in water is an indicator of pollution and of potentially dangerous bacterial contamination.

First Flush: The first portion of runoff considered to contain the highest pollutant concentration resulting from a rainfall event.

Floodplain: Those land areas in and adjacent to streams and watercourses subject to continuous or periodic inundation from flood events.

Geographic Information System (GIS): A method of overlaying spatial land and land use data of different kinds. The data are referenced to a set of geographical coordinates and encoded in a computer software system. GIS is used by many localities to map utilities and sewer lines and to delineate zoning areas.

Grassed Swale: An earthen conveyance system that is broad and shallow with check dams and vegetated with erosion-resistant and flood-tolerant grasses, engineered to remove pollutants from stormwater runoff by filtration through grass and infiltration into the soil.

Headwater: The source of a stream or watershed.

Hydrology: A science dealing with the properties, distribution, and circulation of water on and below the earth's surface and in the atmosphere.

Imperviousness or Impervious Cover: A surface composed of any material that significantly impedes or prevents natural infiltration of water into soil. Impervious surfaces include, but are not limited to, roofs, buildings, streets, parking areas, and any concrete, asphalt, or compacted gravel surface.

Infill: A residential development that has occurred proximate to, or within, an already established neighborhood.

Low-Impact Development (LID): Integrated hydrologically functional site design with pollution prevention measures to compensate for land development impacts on hydrology and water quality. The primary goal of Low Impact Development methods is to mimic the predevelopment site hydrology.

Major Floodplain: Those land areas in and adjacent to streams and watercourses subject to continuous or periodic inundation from flood events with a 1% chance of occurrence in any given year (i.e., the 100-year flood frequency event) and having a drainage area equal to or greater than 360 acres.

Marsh: A wet area, periodically inundated.

Mitigation: To make a scenario less harmful in the original condition; or to provide a habitat in another more conducive, larger, or better-suited area, typically in a different location from the original. Mitigation may result due to constructability, cost, or other site restriction issues.

Modeling: The application of a mathematical process or simulation framework, to describe various phenomenon and analyze the effects of changes in independent (i.e., explanatory) variables on dependent variables.

Nonpoint Source Pollution: Contaminants such as sediment, nitrogen, phosphorous, hydrocarbons, heavy metals, and toxics whose sources cannot be pinpointed but rather are washed from the land surface in a diffused manner by stormwater runoff.

Peak Flows: The maximum instantaneous discharge of a stream or river at a given location. It usually occurs at or near the time of maximum stage.

Peak Discharge: The maximum rate of flow at an associated point within a given rainfall event or channel condition.

Pervious Cover: Any ground cover material that allows water to penetrate to the soil below.

Point Source: Any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural storm water runoff.

Post-Development: Refers to conditions that reasonably may be expected or anticipated to exist after completion of the land development activity on a specific site or tract of land.

Pre-Development: Refers to the conditions that exist at the time that plans for the land development of a tract of land are approved by the plan approval authority. Where phased development or plan approval occurs (preliminary grading, road, and utilities, etc.), the existing conditions at the time prior to the first item being approved or permitted establishes the pre-development conditions.

Redevelopment: The substantial alteration, rehabilitation, or rebuilding of a property for residential, commercial, industrial, or other purposes.

Resource Protection Area (RPA): RPAs are the corridors of environmentally sensitive land that lie alongside or near the shorelines of streams, rivers and other waterways. In their natural condition, RPAs protect water quality by filtering pollutants out of stormwater runoff, reducing the volume of stormwater runoff, preventing erosion and performing other important biological and ecological functions. State Regulations and county ordinances allow certain limited activities within areas mapped as RPA, however, larger land disturbing activities are prohibited unless a special exception is granted.

Retention: The permanent storage of stormwater.

Riparian Area: Land adjacent to a stream that is saturated by ground water or intermittently inundated by surface water at a frequency and duration sufficient to support the prevalence of vegetation typically adapted for life in saturated soil. It is the transition area between the aquatic ecosystem and the nearby, upland terrestrial ecosystem. Zones are identified by soil characteristics and/or plant communities and include the wet areas in and near streams, ponds, lakes, springs and other surface waters.

Riparian Buffer: Strips of grass, shrubs, and/or trees along the banks of rivers and streams filter polluted runoff and provide a transition zone between water and human land use. Buffers are also complex ecosystems that provide habitat and improve the stream communities they shelter.

Rip Rap: A layer rock or stone randomly placed on banks and swales that is used to prevent erosion. Rocks size is chosen to withstand erosive forces, with larger sizes used in areas subjected to higher energies.

Runoff: The portion of precipitation that flows across the land surface that ultimately reaches streams often with dissolved or suspended material.

Sediment: Material, both mineral and organic, that is in suspension, is being transported, or has been moved from its original site of origin by water or wind. Sediment piles up in reservoirs, rivers and harbors, reducing channel depth, impeding navigability, destroying wildlife habitat and clouding water so that sunlight cannot reach aquatic plants.

Sedimentation (Settling): A pollutant removal method to treat stormwater runoff in which gravity is utilized to remove particulate pollutants. Pollutants are removed from the stormwater as sediment settles or falls out of the water column.

Stakeholder: Stakeholders include a range of groups within the watershed (residents, industry, local government, agencies, community groups, etc.), as well as those whose livelihoods take them into the watershed.

Stormwater: Stormwater discharges are generated by runoff from land and impervious areas such as paved streets, parking lots, and building rooftops during rainfall and snow events that often contain pollutants in quantities that could adversely affect water quality.

Stormwater Management Facility: A device that controls stormwater runoff and changes the characteristics of that runoff including, but not limited to, the quantity and quality, the period of release or the velocity of flow.

Subwatershed: A smaller subsection of a larger watershed, which may have been delineated to describe a particular land use, function, or hydrologic condition.

Total Maximum Daily Load (TMDL): A TMDL is a tool used to improve the water quality of water bodies that do not meet water quality standards. These water bodies are listed in Section 303(d) of the Clean Water Act as Impaired Water Bodies. The tool limits the pollutant loads allowable from each pollutant contributor in the watershed to levels that will ensure that the water quality standard is achieved.

Urbanization: The process of changing the landscape from one dominated by natural, undeveloped areas to developed areas with less natural area and more paved surfaces.

Water Quality Standard (WQS): A law or regulation that consists of the beneficial use or uses of a waterbody, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular waterbody, and an antidegradation statement.

Watershed: The area of land that catches rain and snow and drains or seeps into a marsh, stream, river, lake or groundwater.

Wetlands: Areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

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