2005 Annual Report on Fairfax County's Streams

November 2005

Prepared by:

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Department of Public Works and Environmental Services

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Executive Summary

Fairfax County's Stream Protection Strategy Baseline Study report documented conditions in the county's streams based on biological communities observed at 114 targeted monitoring sites. The abundance and diversity of fish and benthic macroinvertebrates (aquatic bugs) provides an indicator of the overall health of streams and a way to evaluate the effectiveness of measures to protect and restore this natural resource. The results of the baseline study suggested that three-quarters of the county's streams were in "fair" to "very poor" condition and that approximately 70 percent of streams needed some degree of restoration.

The baseline study set the foundation for implementing a watershed management program to protect and restore streams, the riparian corridors (stream valleys) and associated resources such as the county's drinking water supply and to help reverse impaired conditions of the Chesapeake Bay. Currently, watershed plans have been initiated or completed for approximately 50 percent (200 square miles) of the county. The development of watershed management plans are scheduled for completion by 2009.

In 2004 the county's biological sampling strategy was re-evaluated and long-term goals established. It was determined that annual countywide conditions and trends were best determined from a probability-based sampling procedure, rather than the targeted sampling approach employed in the baseline study. Various volunteer biological monitoring activities were identified as valuable data sources for site-specific trend evaluations. In addition, the bacteria monitoring program previously administered by the Health Department for over 30 years was integrated into the biological monitoring program to provide a more comprehensive report on water quality from both a biological and human health perspective.

This annual report documents the results from a probability-based sampling procedure conducted in 2004. It includes several new items that were not part of the original baseline study including:

- the findings of volunteer monitors that routinely monitor streams through the Northern Virginia Soil and Water Conservation District and Audubon Naturalist Society volunteer monitoring programs,
- the results and analysis of the bacteria monitoring that was formally conducted by the Health Department,
- a Fish Index of Biotic Integrity, a multimetric index for fish community analysis,
- a countywide stream quality index that will be calculated annually to report the overall condition of streams, and to help determine the progress of future restoration efforts.

The biological monitoring program is intended to serve many needs including requirements under the Virginia Pollution Discharge Elimination System (VPDES) or Municipal Separate Storm Sewer System (MS4) stormwater permit issued by the state.

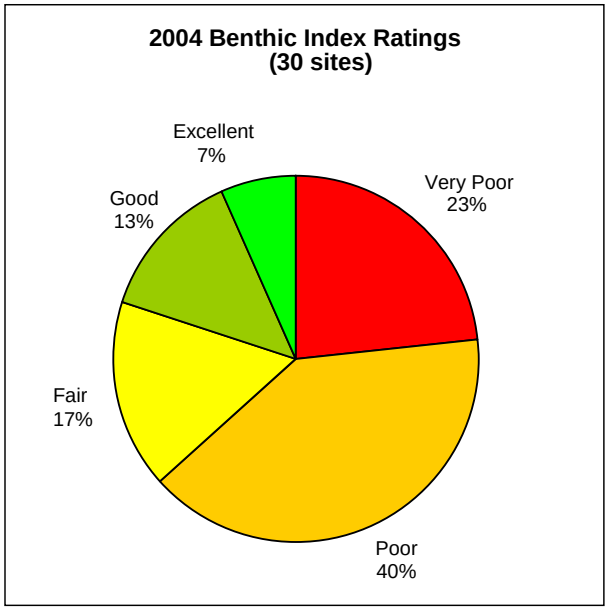


Figure E1. Ratings of 2004 biomonitoring sites based on benthic macroinvertebrate data.

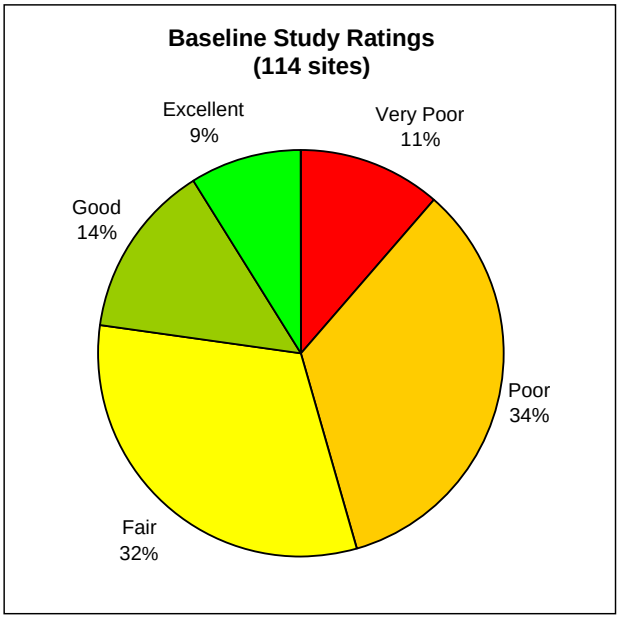


Figure E2. Ratings of benthic macroinvertebrate data from the baseline study. Data was collected in 1999 and the baseline report was published in 2001.

Results

Biological Monitoring: The results of the 2004 benthic macroinvertebrate monitoring are simliar to the results of the baseline study (Figures E1 and E2). The 2004 data suggest that more than 60 percent of the county's streams are in "poor" to "very poor" condition and 80 percent are now "fair" to "very poor" based on a five category rating scale (Figures E1). The five category scale is: excellent; good; fair; poor; and very poor. Forty-five percent were in "poor" to "very poor" condition based on the baseline study (Figures E2). The benthic macroinvertebrate community lacks enough sensitive species that are indictors of good water quality and is dominated by tolerant species that are characteristic of degraded streams. According to fish index all sites received a rating of less than "good" (Figure E3). The fish community is dominated by habitat generalists, omnivores, and non-native species.

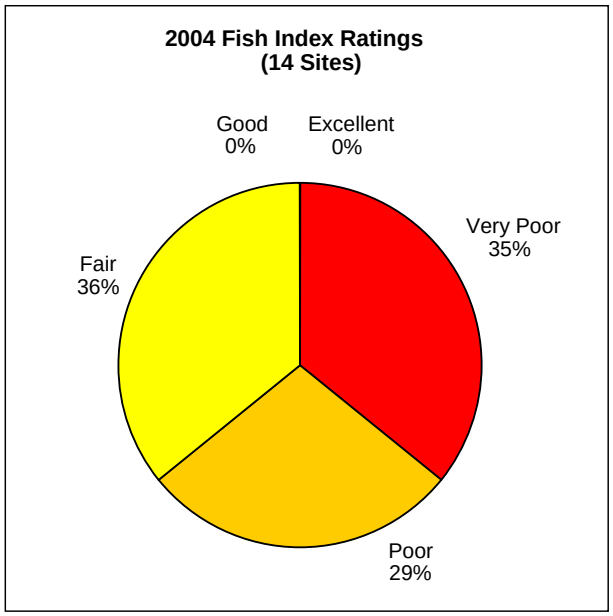


Figure E3. Ratings of 2004 biomonitoring based on fish data.

Volunteer monitoring programs such as those conducted by the Northern Virginia Soil and Water Conservation District and the Audubon Naturalist Society also show similar signs of poor water quality. For example, 81 percent of Northern Virginia Soil and Water Conservation District sites reported "unacceptable" conditions.

Bacteria Monitoring: All sites sampled in 2004 for bacteria violated the state's water quality standard for fecal coliform bacteria (400 f.c./100 ml) on at least one occasion. Of the 67 sites that were sampled four times (seasonally) during 2004, 20 percent of the sites exceeded the water quality standard for bacteria levels on all sampling occasions (Figure E4).

Based on historical bacteria monitoring data, the Fairfax County Health Department issued the following statement related to the use of streams for contact recreation:

> *"In summary, any open, unprotected body of water is subject to pollution from indiscriminate dumping of litter and waste products, sewer line breaks and contamination from runoff pesticides, herbicides, and waste from domestic and wildlife animals. Therefore, the use of streams for contact recreational purposes, such as swimming, wading, etc., which could cause ingestion of stream water or possible contamination of an open wound by stream water, should be avoided."*

Additional information related to use of streams for contact recreation is available on the Health Department's web site at:

http://www.fairfaxcounty.gov/service/hd/resourcewater.htm

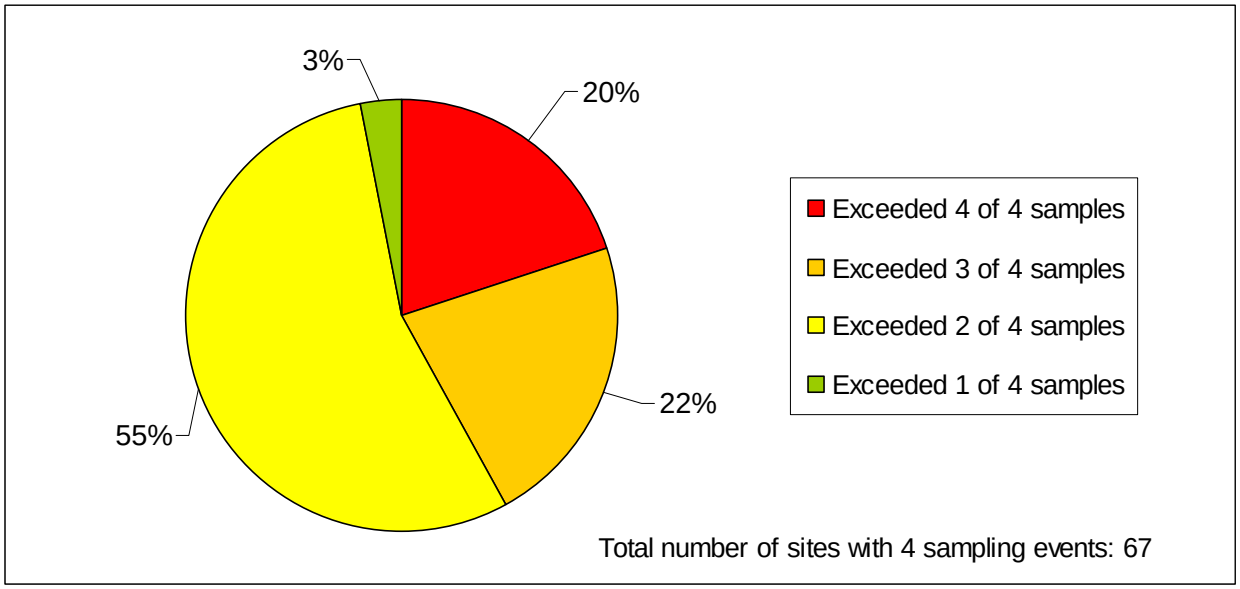


Figure E4. Percentage of sites with exceedences of the state's water quality standard (400 f.c./100ml) for fecal coliform bacteria.

Countywide Stream Quality Index: A stream quality index was developed to establish a performance measure for a key natural resource (streams) which are visible and of great interest to the public. The index which is based on benthic macroinvertebrate data suggests a small decline in overall stream quality from data collected in 2004 compared to data collected for the baseline study (from 2.76 to 2.41, over a possible range or scale of 1 to 5). However, it is difficult to make any broad statements about trends based on data from two sampling years. This index will be reported annually to evaluate trends in the overall health of streams countywide.

1. Introduction

Fairfax County is located in the northeastern part of the state of Virginia, bordering the Potomac River. The county is bordered by Arlington County, and the Cities of Falls Church and Alexandria to the east. The Potomac River borders the county to the northeast and southeast. The land border with Loudon County lies to the north, and the Bull Run/Occoquan rivers form the southern border with Prince William County. Within the borders of Fairfax County are three incorporated towns (Vienna, Herndon, and Clifton) and one city (Fairfax City).

Fairfax County today is highly urbanized and approaching ultimate build-out conditions, as envisioned in the county's Comprehensive Plan. The total land area of Fairfax County, including incorporated towns is 395 mi^2. It is the most populous jurisdiction in Virginia as well the Washington D.C. metropolitan area, with the 2005 population estimated to be 1,047,500 with 387,700 households. Most land in the county is devoted to residential, commercial, recreational, and open-land uses, with heavy industry essentially nonexistent.

1.1 Watersheds and Physiographic Setting

There are approximately 850 miles of stream channels (with perennial streamflow) draining 30 designated major watersheds (drainage basins) in the county, with 23 watersheds falling entirely within the county's borders (Figure 1). The 30 watersheds drain either to the north and east to the Potomac River, or to the south into the Bull Run/Occoquan rivers (which eventually outlets into the Potomac). The 30 major watersheds within the county range in size from the two square mile Turkey Run drainage to the 58 square mile Difficult Run basin. The mouths of the streams draining the far southeastern portion of the county are influenced by the tidal rhythm of the Lower Potomac. The major lakes throughout the county are all man-made impoundments and were designed primarily for stormwater control, recreational, or aesthetic purposes. The Occoquan River is impounded just upstream of where it passes under Route 123. The reservoir was created when the river was dammed in 1950, and then enlarged in 1957 by the county to provide a source of drinking water for residents within the region. In July 1982, the Fairfax County Board of Supervisors voted to restrict development on 41,000 of the 64,500 acres within Fairfax County draining to the reservoir. The resultant "down-zoning" limited the number of residences to one home per five acres in an effort to improve the quality of stream water draining into the drinking water reservoir.

Fairfax County lies within two major physiographic provinces, the Coastal Plain and Piedmont (Figure 1). Physiographic provinces are areas that have common geology, surface processes, and landscape history having characteristic landforms and environments. Each province comprises areas with similar terrestrial and aquatic floral and faunal ecosystems, including certain communities which may be unique to those provinces. These provinces are the basic landscape units by which biological communities can be evaluated and compared. The Piedmont province covers 60% of the county (243 mi^2) and is typified by gently rolling landscapes, deeply weathered bedrock/soils and a relatively low occurrence of solid outcrop. The Triassic basin occupying the far western portion of Fairfax County is a subset of the larger Piedmont province, and covers 17% of the county (69 mi^2). The Triassic basin is actually the remains of a huge prehistoric lake bottom that covered portions of western Northern Virginia

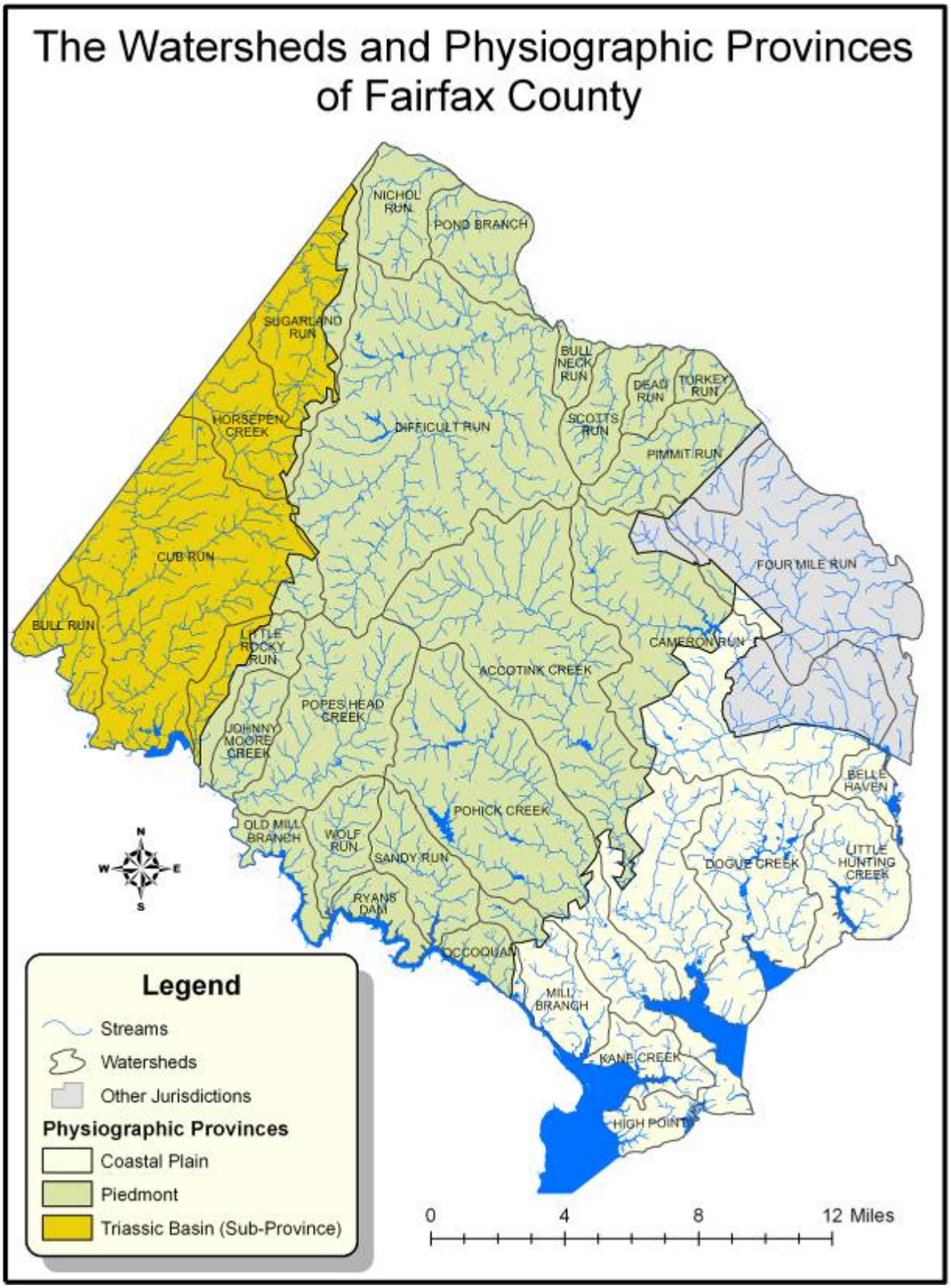


Figure 1: The 30 watersheds and two physiographic provinces and sub-province in Fairfax County, Virginia.

and Maryland. It is typically much flatter and has unique lake sediment-type soils as compared to the encompassing Piedmont province. The Coastal Plain province spans the eastern portion of the county and bounds the Piedmont along the fall line. The fall line is a low east-facing cliff paralleling the Atlantic coastline from New Jersey to the Carolinas. It marks the boundary between the hard Paleozoic metamorphic rocks of the Piedmont (to the West) from the softer, flatter Mesozoic and Tertiary sedimentary rocks of the Coastal Plain. To the west of this line, the streams are typified by greater-sloping channel bottoms and the resultant higher velocity riffle-run habitats. East of this line, in the Coastal Plain, the stream channels (and landscapes), have much gentler slopes, and as a result much more flat water areas dominated more by lower velocity pool and glide habitats. Historically, this fall line presented an obstacle to further upstream navigation to early European settlers in boats and thus is the location of many major mid-Atlantic cities such as Philadelphia, Baltimore, Washington DC, and Richmond. Interstate 95 generally traverses this geologic feature through Northern Virginia.

1.2 Monitoring Efforts

1.2.1 Stream Protection Strategy

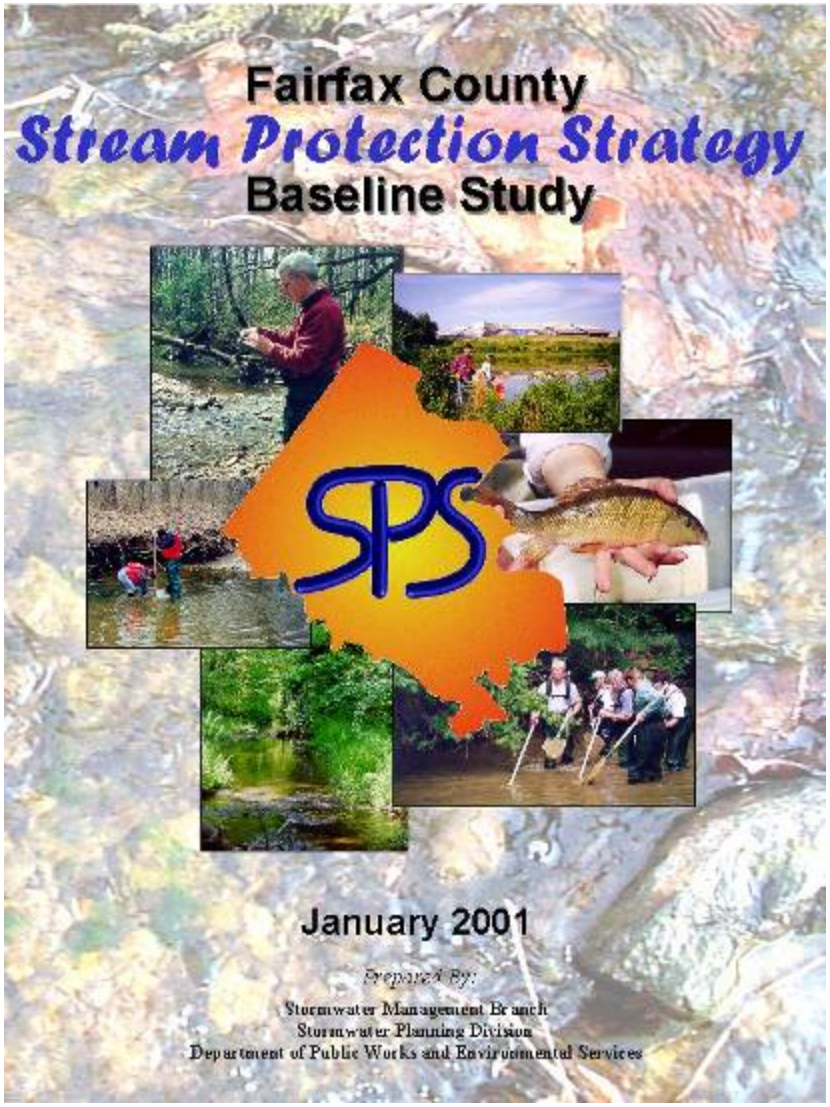
The Stream Protection Strategy Baseline Study on the biological condition of Fairfax County's streams was published in January 2001. This study evaluated the physical, chemical, and biological conditions of 114 sites located along the major streams and tributaries in each of the county's 30 watersheds based on data collected in 1999. Modified versions of the Environmental Protection Agency's (EPA) Rapid Bioassessment Protocol (RBP) were applied along with a Quality Assurance/Quality Control (QA/QC) methodology. Eleven reference sites, located in the Prince William Forest National Park, were used for comparison.

The results of the baseline study were used to identify, rank, and prioritize county streams and create broad management categories and strategies for future restoration and/or preservation efforts on a sub-watershed basis. The baseline study set the framework for developing comprehensive management programs for the county's watersheds.

Major recommendations from the baseline study and their status are summarized below:

Recommendations	Status
Continue a five-year rotational sampling scheme for the county's streams.	A probability-based sampling scheme has been developed. This report summarizes the methodology and results of monitoring during 2004.
Complete a countywide stream physical assessment survey on ALL streams	A Countywide Stream Physical Assessment was completed in 2003
Develop and implement a countywide watershed management program.	Currently, watershed plans have been initiated or completed for over 50 percent (200 square miles) of the county. All watershed management plans are scheduled to be completed by 2009. These plans will be updated periodically.
Pursue a dedicated source of funding for implementing the proposed improvements in county streams and the stormwater infrastructure system.	A Stormwater Needs Assessment Program was completed in 2005 that identified program needs and alternative funding sources. Approximately $18 million in new funds was dedicated from tax revenues in the fiscal year 2006 budget to supplement funds for the stormwater program.
Encourage the use of Best Management Practices (BMP) and Low Impact Development (LID) techniques in all new construction and retrofit activities.	In 2001, a letter to industry (#01-11) was published to facilitate the use of innovative Best Management Practices (BMP). Currently, DPWES is working on amendments to the Public Facilities Manual (PFM) to include additional Best Management Practices (BMP) and Low Impact Development (LID).

The data and the report are being used as part of a long-term database, as well as to guide future activities as they relate to the development and implementation of Watershed Management Plans.



http://www.fairfaxcounty.gov/dpwes/environmental/sps_main.htm

1.2.2 Post-Baseline Study Sampling

Under the original recommendation of the baseline study, trend data was to be collected at each of the 114 sites on a five year rotational basis, where 20 percent of the total sites would be collected annually. Staff began this process in the spring of 2001. Biological and habitat data was collected at approximately 20 percent of the original monitoring locations. Specifically, assessments were made at 23 sites, randomly selected from the original site list, and at the 11 reference locations within Prince William Forest Park. An additional seven sites were established on streams whose watersheds were designated as Priority Assessment Areas in the baseline study.

Unlike the monitoring conducted in 1999, the 2001 effort also included an additional fish sampling event in the spring. This was done in an effort to understand possible seasonal variations in fish distribution patterns and overall abundance, and their subsequent influence on metric development and scoring. Specifically, large numbers of young-of-year fish were collected and enumerated in the original assessments—which may have led to inflated population measures relative to habitat quality—and it was hoped that early season sampling, prior to emergence and development of fry, would eliminate this potential problem.

Results from the 2001 sampling event may be found in Appendix A.

1999 – Monitoring efforts initiated in the county as part of the Stream Protection Strategy Baseline Study. One hundred and fourteen sites were established and sampled in the county for benthic macroinvertebrates and fish.

2000 – Sampling continued in support of the baseline study. A portion of the sites were resurveyed for fish, under relatively normal drought conditions.

2001 – Baseline study was released in January. As recommended, 20 percent of the original 114 sites were resurveyed for the benthic macroinvertebrate and fish community composition. Seven additional sites were established in Priority Assessment Areas. A spring fish sampling event occurred, to understand any possible seasonal variations in distribution and abundance.

2002 – 2003 – Fieldwork conducted as part of the Perennial Streams Identification and Mapping project.

2004 – Biological monitoring sites were randomly selected based on stream order. Benthic macroinvertebrates were collected and identified from all sites. Fish were collected at higher order sites (greater than 2nd order).

Fieldwork for the Perennial Stream Identification and Mapping project initiated with a pilot study in October-December 2001. Formal field identifications commenced in March 2002 and continued through October 2003. The 2003 RPA maps were adopted by the Fairfax County Board of Supervisors on November 18, 2003. This fieldwork was rechecked and validated with a 10 percent quality control re-survey in the spring and summer of 2004. Following data analysis, map production, and Planning Commission hearings, the final Chesapeake Bay Preservation Area (RPA) maps were adopted by the Board of Supervisors on July 11, 2005. Further information can be found at www.fairfaxcounty.gov/dpwes/stormwater.

1.2.3 Bacteria Monitoring

The bacteria monitoring program was initiated in 1969 by the Department of Health's Division of Environmental Health to generate a baseline for bacterial levels in the waterways of Fairfax County. This bacteria baseline allowed the Health Department to monitor the water quality of the streams by establishing a "normal" level of bacteria for different sections of our waterways. By establishing a baseline, it enabled the Health Department to determine when a spike in the bacteria concentration occurred for a particular waterway and facilitated staff to locate pollution sources and to initiate corrective action or refer to the appropriate agency for corrective action. Fecal coliform has been used as an indicator of possible bacteria contamination because it is commonly found in human and animal feces. Although fecal coliform is generally not harmful itself, the occurrence indicates the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans which are correlated with swimming-associated gastroenteritis. In 2003, the Fairfax County Health Department transferred the bacteria monitoring program to the county's Stormwater Planning Division in an effort to consolidate all stream monitoring functions in the county. At the time of transfer, 80 sites were divided into nine zones and were visited at a frequency of once to twice per month by the Health Department. The monitoring program has been modified by Stormwater Planning Division, the routine sampling was reduced to visiting each zone four times per year. The Stormwater Planning Division has continued this monitoring effort and took over 300 samples from 25 watersheds in 2004.

1.2.4 Volunteer Biomonitoring

Data that is generated by volunteer stream monitors supplement the county program by providing greater coverage of the county's streams and information on general trends. Audubon Naturalist Society monitors six sites in Fairfax County. Northern Virginia Soil and Water Conservation District has several years' worth of data for 35 sites in the county, and sometimes monitors as many as 50 sites in a given year. In working together with these volunteer monitoring organizations, the county effectively doubles the number of sites visited in a particular year.

In addition to learning about stream monitoring, many volunteers also become involved in watershed groups, clean-up programs, and educational programs. Newsletters and calendars are sent to about 700 people and forwarded to hundreds more, a very effective way to reach large numbers of existing and potential monitors.

Several newsletters and other information can be found on the NVSWCD monitoring Web site at www.fairfaxcounty.gov/nvswcd/monitoring.htm or by contacting Joanna Cornell, NVSWCD Watershed Specialist, at jcornell@gmu.edu or 703-324-1425.

1.2.5 Other Monitoring Efforts

There are many agencies and groups that regularly monitoring water quality in the county. A listing of these can be found in Appendix G.

1.3 Goals

The goal of this report is to present the results of Fairfax County's annual surface water quality monitoring efforts. The results are used to help determine the county's Stream Quality Index as an indicator of the overall condition of Fairfax County's waterways. It is envisaged that

future reports will serve as a clearinghouse for information and data related to the biological, chemical and physical conditions of the county's waterways, collected through various county agencies and local organizations.

The long-term biological and bacteriological monitoring program supports the Board of Supervisor's Environmental Excellence for Fairfax County, a 20-year Vision by providing a comprehensive analysis of stream conditions throughout the county, while simultaneously meeting the requirements set forth in local, state, and federal regulations, including:

- Chesapeake Bay Act;
- Municipal Separate Storm Sewer System (MS4) Permit;
- Virginia Pollutant Discharge Elimination System (VPDES); and
- Clean Water Act.

While supporting these requirements, the program will also develop a substantial dataset, which over time will provide essential data to determine the overall rate of change or trends in the conditions of Fairfax County's streams and provide a basis for prioritization of watershed implementation measures to restore watersheds.

2. Methods

Fairfax County uses various methods to collect data for surface water quality monitoring and analyze it for useable results. The monitoring and analysis methods of the county and volunteer organizations are described below in detail.

2.1 History

In the Stream Protection Strategy Baseline Study, a targeted site selection method was employed. The basic goal was to locate sites that (incrementally) drained two to five square miles and were distributed relatively evenly within the county's watersheds. Most sites were located on second and third order streams (determined from 1:24,000 scale USGS topographic maps).

Fairfax County staff collect aquatic insects in Pohick Creek in March 2004. The samples are used to determine the health of the watershed.

It had been the original intent to continue sampling 20 percent of the targeted sites from the baseline study on an annual, rotating basis, so that an assessment of countywide conditions could be performed after five years. This was initiated in 2001 with a resample of 23 of the baseline study sampling locations (Appendix A). The 2001 sampling also included seven new sites to fill in data gaps identified in the baseline study.

In 2004, the county's biological sampling strategy was re-evaluated and long-term goals established. To meet the long-term goals, it was felt that rather than the 20 percent annual resampling of the baseline study monitoring sites on a rotating basis, it would be more meaningful to infer annual countywide conditions and trends from a probability-based sampling procedure. In addition, various volunteer biological monitoring activities were identified as valuable data sources for site-specific trend evaluations (see Section IV and Appendix B).

2.2 Probability-Based Site Selection

Sampling based on probability survey designs are generally acknowledged to be the best way of obtaining statistically defensible estimates of a variable of interest when a full census is impractical or cost prohibitive. The basic disadvantage with targeted sampling approaches is that it is essentially impossible to establish that the sites targeted are representative of the target population of interest. In probability-based sampling, because sites are randomly selected, every possible sampling unit has a non-zero probability of being selected. This eliminates any site selection bias and provides the basis for making statistical inferences about characteristics of the target population being sampled.

Probability sampling can be implemented in a number of ways, including simple random sampling and stratified random sampling. While simple random sampling is straightforward to implement and results can be easily analyzed, it does not incorporate any information about the target population that could potentially provide more precise results, and it does not allow inferences to be made about any sub-populations of interest. Stratified random sampling,

which is probably the most common probability sampling technique in aquatic resource surveys, overcomes the disadvantages of simple random sampling. In stratified random sampling, the target population is divided into a number of mutually exclusive subgroups, called strata, based on some characteristic that results in less variability within each subgroup than the overall variability. Each stratum is then sampled by simple random sampling, and the results from different strata may be combined to give more precise results than if the population had not been stratified.

A key task in developing a probability-based sampling methodology is to establish the sampling frame, which refers to the collection of all possible sampling locations. It is also necessary to uniquely identify every sampling location, and incorporate these locations into a randomization scheme to allow probability-based selection of sampling locations. Additionally, for stratified random sampling, the sampling frame must clearly demarcate the different strata.

A high-resolution Digital Elevation Model of the county, created from over 1.1 million spot elevations, was used to create a synthetic stream network at a threshold of 50 acres[*]. All stream segments were assigned a Strahler stream order. The synthetic stream network was utilized as the basic sampling frame. A stratified random sampling procedure was employed based on Strahler stream order, with samples allocated in a proportional manner according to the total stream length in each stratum (Table 1).

A two-stage procedure was employed to determine sampling locations. Within each stratum, a stream segment was first selected at random. A sampling location was then randomly selected within each segment. The final sampling locations used for the 2004 monitoring campaign for all strata are shown in Figure 2. (for more information see Appendix G)

An example of a first order stream in Occoquan.

Table 1. Number of sampling sites per stream order.

Stream Order	Total length (mi)	Percentage of total (%)	Number of sampling locations
1	526.5	52.9	16
2	221.8	22.3	7
3	144.1	14.5	4
4	85.4	8.6	2
5	17.0	1.7	1

[*] The 'threshold' refers to the drainage area that must be equaled or exceeded to initiate a starting point of the synthetic stream network.

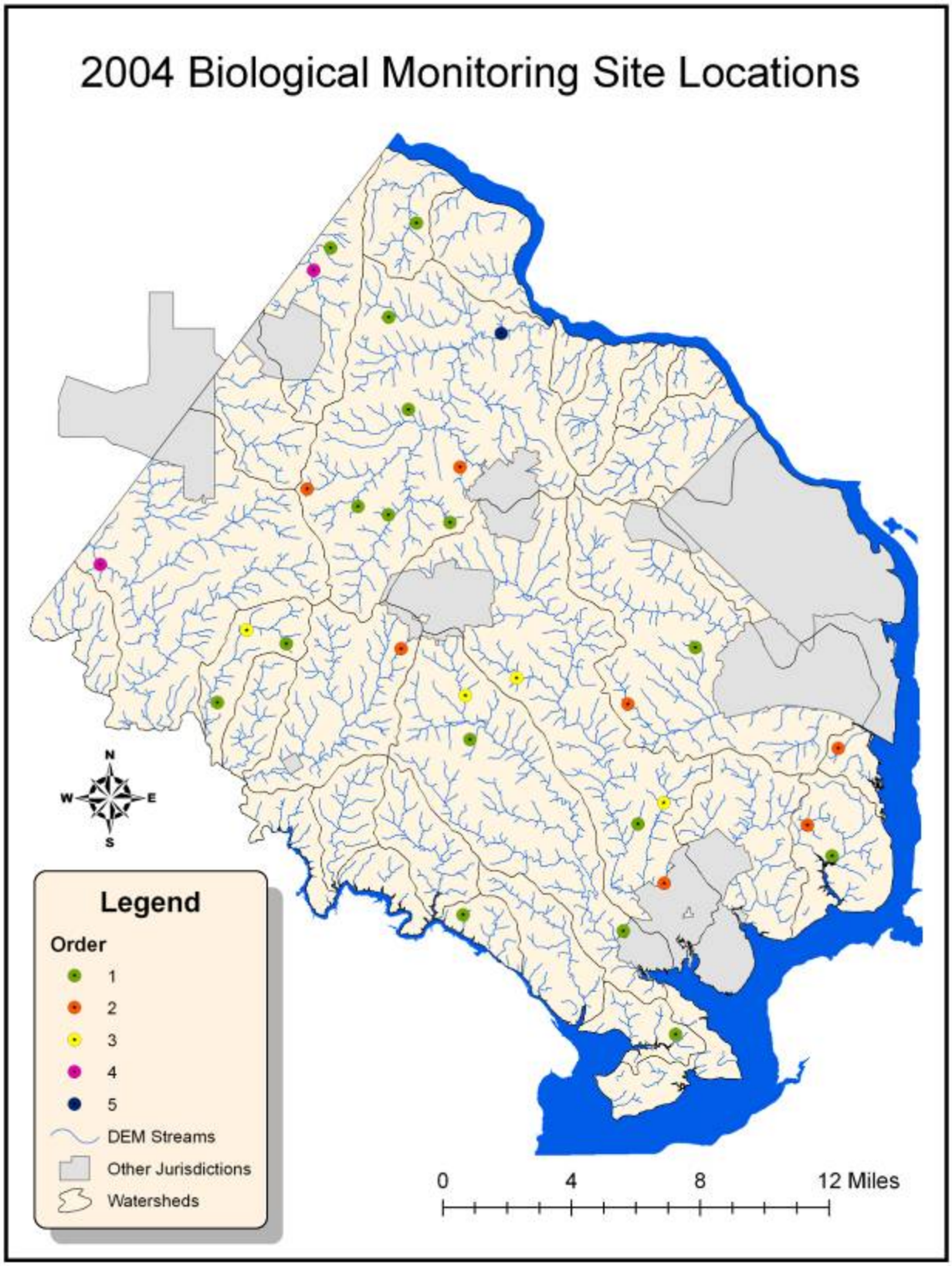


Figure 2: Location of 2004 biological sampling sites.

2.3 Bacteria

Fairfax County conducts bacteria sampling throughout the county to determine the concentration of fecal coliform and *E. coli* in the streams which can be harmful to humans.

The first full year that the Stormwater Planning Division assumed bacteria monitoring activities from the Health Department was 2004. The 80 original sampling sites were sectioned into nine separate zones (Figure 3). Each zone was sampled four times in 2004, for a total of more than 300 bacteria samples.

2.3.1 Procedures

Bacteria sampling involved taking grab samples from the stream to determine the concentration of fecal coliform and *E. coli* in the water. In addition to the assessment of bacteria, sterile bottles were used to collect samples to assess Nitrate (NO_3^-) and Phosphate (PO_4^{-3}) as a secondary test for possible human inputs. Finally, chemical parameters, such as pH, water temperature, dissolved oxygen, and specific conductance were recorded during bacteria sampling using a combination of YSI 85, YSI 556, and Accument Portable pH meters. The sampling techniques, the sample site locations, the parameters sampled for, as well as the chemical data collected for each site was identical to the previous Health Department monitoring program (Appendix D).

Fairfax County staff collecting a bacteria sample in February 2004. Results from the samples indicate that Fairfax County streams are not safe for recreational contact.

2.3.2 Analysis

Beginning in May of 2004, the concentration of *E. coli* in water samples was determined in addition to fecal coliform concentrations. This was in response to the EPA recommendation to use concentrations of *E. coli* and enterococci rather than concentrations of fecal coliform to better determine possible health issues associated with surface waters. Virginia's Department of Environmental Quality has also adopted new *E. coli* standards for water quality.

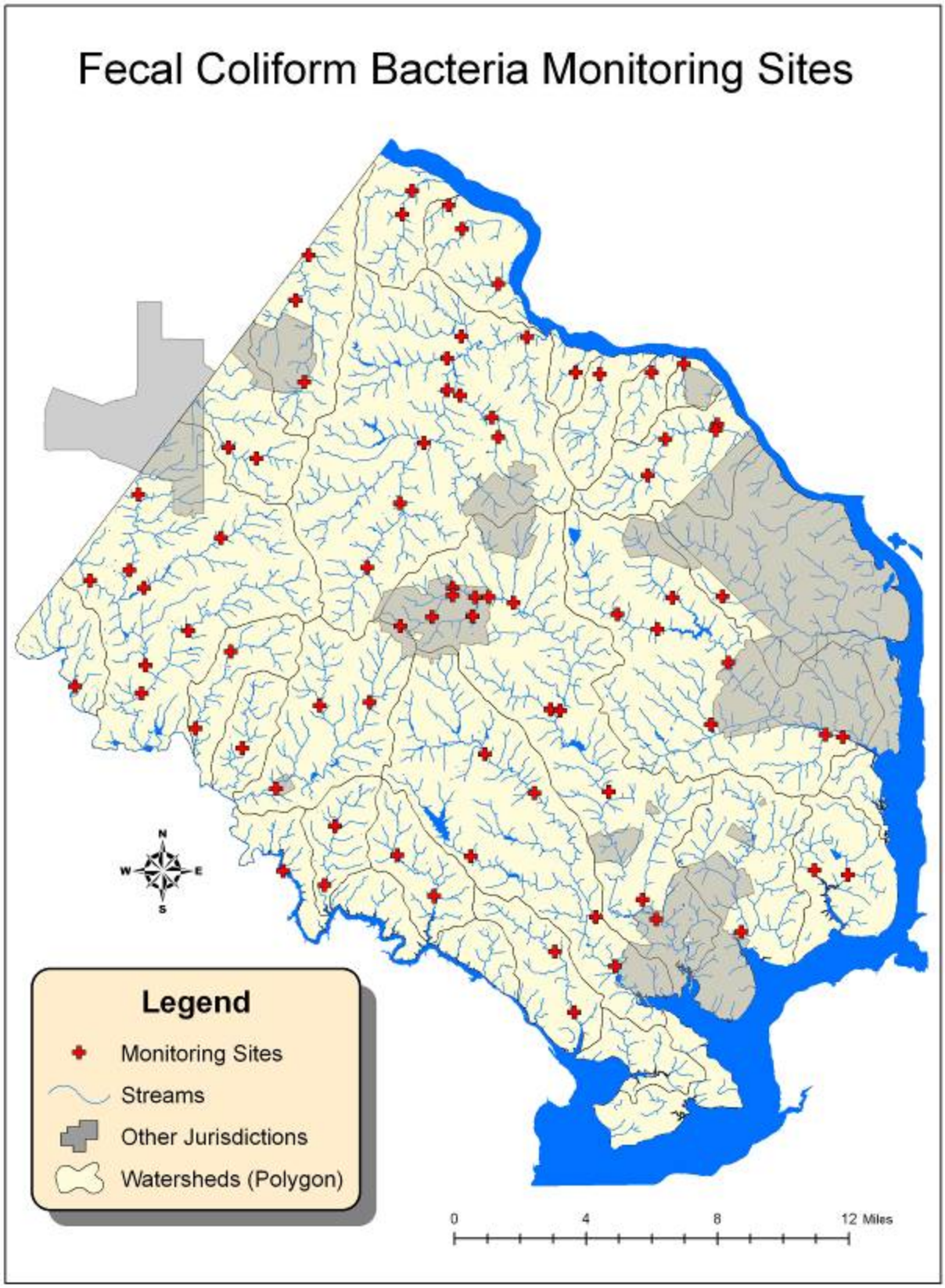


Figure 3: Locations of bacteria monitoring sites.

2.4 Fish

Fish sampling is done by the county because a collection of fish represents the apex of most stream communities. Fish typically are at the top of the food web and are sensitive to both natural and anthropogenic changes within a given system and are, therefore, useful indicators of stream ecosystem health.

Fairfax County staff sampling fish in Pohick Creek in August 2004. Samples are taken to determine stream ecosystem health.

2.4.1 Sampling

Fairfax County conducts fish sampling every summer using the U.S. Environmental Protection Agency's (EPA) Rapid Bioassessment Protocol (RBP) for Use in Wadeable Streams and Rivers (Barbour et al. 1999) to determine stream ecosystem health. Samples were collected in the field using electrofishing equipment that temporarily stuns fish, allowing them to be netted with relative ease. The fish were then identified and released back into the stream. See Appendix C for more detailed information on sampling and laboratory methods.

2.4.2 Analysis

In the baseline study an attempt was made to quantify the health of each of the 30 watersheds using an index based on the fish community data. The data collected at that time was not used to create a Fish Index of Biotic Integrity (F-IBI), similar to index that was developed for the benthic macroinvertebrate data, which is described later in this document. The development of a fish index is an additional useful tool because fish communities are sensitive to different stressors, such as blockages, compared with benthic macroinvertebrates.

Fairfax County staff evaluated an extensive suite of candidate metrics and each metric was evaluated based on trophic characteristics, tolerance, and community structure. The county assessed each metric for its usefulness in developing a fish index. Metrics tested were similar to those tested by Dr. Billy Teels whose work was completed in the Occoquan watershed in 2001. Metrics used by the statewide Maryland Biological Stream Survey (MBSS) were also tested. Metrics were chosen on their ability to correlate with imperviousness, ability to distinguish most disturbed sites from least disturbed sites and frequency of appearance in literature (Table 2).

Fairfax County staff identifying fish species in a sample in August 2004. The number and type of species are used to determine a Fish Index of Biotic Integrity (F-IBI).

There are two physiographic provinces in the county, Coastal Plain and Piedmont. Studies have shown

that there is a significant difference in fish communities in the Coastal Plain versus the Piedmont (Smogor 1999, Roth et. al 2005). A small portion of Fairfax County is in the Coastal Plain, but there are few reference areas available in this small portion. The fish index for the Coastal Plain will be based on metrics and scoring criteria used by Roth et al. in Maryland Coastal Plain streams. Metrics used for Piedmont streams are similar to those used by Teels. Metrics for the Piedmont were chosen based on their ability to correlate with imperviousness and ability to distinguish most disturbed sites from least disturbed sites. Scoring criteria was determined using the tri-sectioning method as detailed by Fausch et al. (1984) and Karr (1986) and results are similar to Teels. Further refinement of the metrics and/or scoring criteria could occur in the future as more data is collected, particularly for the Coastal Plain.

Table 2: Metrics chosen for the Piedmont Fish Index of Biotic Integrity.

METRIC	DESCRIPTION
1. Number of Native Species	Number of species in sample that are native to the Potomac Drainage.
2. Number of Darter Species	Number of species in sample that are darters.
3. Percent Tolerant	Percent of individuals in the sample that are classified as being tolerant.
4. Number of Intolerant Species	Number of species in sample that are classified as being intolerant.
5. Percent Omnivores	Percent of individuals whose functional feeding group is omnivores.
6. Percent Benthic Invertivores	Percent of individuals whose primary functional feeding group is benthic invertivores.
7. Percent Carnivores	Percent of individuals whose primary functional feeding group is carnivores.
8. Percent Lithophils	Percent of individuals that spawn on clean gravel.
9. Percent Anomalies	Percent of individuals in the sample that have wounds, diseases, or parasites.

Table 3: Metrics chosen for the Coastal Plain Fish Index of Biotic Integrity.

METRIC	DESCRIPTION
1. Percent Tolerant	Percent of individuals in the sample that are classified as being tolerant.
2. Percent Omnivores and Invertivores	Number of species whose functional feeding group is omnivores and/or invertivores.
3. Percent Non-tolerant Suckers	Percent of individuals in that sample that are suckers not classified as tolerant.
4. Percent Dominance	Percent of sample that is the most abundant species.

Measures of fish community richness typically increase with increasing stream discharge or order, and the values were adjusted accordingly to generate an ultimate rating of: excellent; good; fair; poor; and very poor (Table 4).

Table 4: Classification rating for the Fish Index of Biotic Integrity.

Fish Index Score		RATING
Piedmont	Coastal Plain	
> 34	-	Excellent
30 to 34	>17	Good
25 to 29	14 – 17	Fair
20 to 24	10 - 13	Poor
< 20	< 10	Very Poor

See Appendix C for a more in-depth explanation on the creation and use of the fish index.

2.5 Benthic Macroinvertebrates

Benthic macroinvertebrate samples are collected by county ecologists to help determine the water quality of streams. Benthic macroinvertebrates are important indicators of water quality of their varying tolerances to chemical, nutrient, and sediment pollution in waterbodies. Benthics are also an important link in any aquatic food web by forming the core diet of many stream fishes.

2.5.1 Sampling

The county conducts benthic macroinvertebrate sampling at all sites in late winter to early spring using the 20 jab multi-habitat sampling protocol of the U.S. Environmental Protection Agency's (EPA) Rapid Bioassessment Protocol (RBP) for Use in Wadeable Streams and Rivers (Barbour et al. 1999). The "20 jab" method involves taking 20 separate "jabs" or collections from representative habitat types in the reach including undercut banks, aquatic vegetation, riffles and snags. The benthics that are collected are brought back a county lab where they are subsampled which means that 200 individual benthic macroinvertebrates (plus/minus 20 percent) are picked. The subsample is then identified to the

Fairfax County staff sampling benthic macroinvertebrates in Kane Creek in April 2004. Samples are taken to determine the stream ecosystem health based on an Index of Biotic Integrity (IBI).

genus level where possible with all others categorized at a higher taxonomic level due to time constraints. See Appendix B for more detailed information on sampling and laboratory methods.

2.5.2 Analysis

The data obtained from the identification of the benthic macroinvertebrate samples was then used within a framework of pre-established metrics. Each metric is a numerical valuation reflecting the tolerance or trophic structure variables of the benthic macroinvertebrate community. The metrics are combined into a Benthic Index of Biotic Integrity. A metric set that was developed for use within the Northern Virginia Piedmont areas (Jones 2000, personal communication) was used for sites located within the Piedmont physiographic region of Fairfax County (Table 5). The metrics used in the benthic index for sites in the Coastal Plain region were based on a metric set (Table 6) created by Maxted et al. (1999).

Table 5: Metrics for the Piedmont Benthic Index of Biotic Integrity.

METRIC	DESCRIPTION
1. Taxa Richness	Number of different taxa at a site.
2. EPT Taxa	Number of Mayfly, Stonefly, and Caddisfly taxa at a site.
3. Percent EPT	Percent of Mayfly, Stonefly, and Caddisfly taxa at a site excluding the Net-Spinning Caddisfly (Hydropsychidae).
4. Percent Trichoptera without Hydropsychidae	Percent of sample that are Caddisflies excluding the tolerant Net-Spinning Caddisflies (Hydropsychidae).
5. Percent Coleoptera	Percent of sample that are beetles.
6. Family Biotic Index (FBI)	General tolerance/intolerance of the sample.
7. Percent Dominance	Percent of sample that is the most abundant taxa.
8. Percent Clingers + Percent Plecoptera	Percent of individuals whose habitat type is clingers plus percent of sample that are stoneflies but are not clingers.
9. Percent Shredders	Percent of individuals whose primary functional feeding group is shredders.
10. Percent Predators	Percent of individuals whose primary functional feeding group is predators.

Table 6: Metrics for the Coastal Plain Benthic Index of Biotic Integrity.

METRIC	DESCRIPTION
1. Taxa Richness	Number of different taxa at a site
2. EPT Taxa	Number of Mayfly, Stonefly and Caddisfly taxa at a site
3. Percent Ephemeroptera	Percent of sample that are Mayflies
4. Hilsenhoff Biotic Index (HBI)	General tolerance/intolerance of the sample
5. Percent Clingers	Percent of individuals whose habitat type is clingers.

For each individual metric, sites were scored on a scale of 0 (low correspondence) to 10 (high correspondence) relative to the reference condition. For Piedmont sites, comparisons were made to reference sites sampled in Prince William Forest Park, while Coastal Plain sites where compared to Kane Creek in southeastern Fairfax County based on the use of least impaired sites approach recommended by Karr et al. (1986). Values from each suite of metrics (10 for the Piedmont region and 5 for the Coastal Plain region) were then added together to develop a single benthic index measured on a 0 to 100 scale. In the Coastal Plain, values were doubled to produce a comparable 0 to 100 scale. Based on this value, individual sites were given a qualitative rating within one of the following five categories: excellent; good; fair; poor; and very poor (Table 7).

Table 7: Benthic Index of Biotic Integrity scoring and equivalent rating system.

BENTHIC INDEX SCORE	RATING	DESCRIPTION
80 to 100	Excellent	Equivalent to reference conditions; high biodiversity and balanced community.
60 to 80	Good	Increased number of intolerant species; balanced community
40 to 60	Fair	Marked decrease in intolerant species; shift to an unbalanced community.
20 to 40	Poor	Intolerant species rare or absent, decreased diversity.
0 to 20	Very Poor	Degraded site dominated by a small number of tolerant species.

See Appendix B for a more in-depth explanation on the creation and use of the benthic index.

2.6 Volunteer Monitoring

2.6.1 Audubon Naturalist Society

The Audubon Naturalist Society water quality monitoring program recruits, trains, equips, and organizes volunteers to assess the health of streams throughout the Washington, D.C., region. The program uses a modified version of the EPA's Rapid Bioassessment Protocols (RBP) to perform habitat assessments and benthic macroinvertebrate surveys (see Appendix E). All monitoring equipment is provided. There are six permanent sites within Fairfax County that are covered by 20 to 30 volunteers each year (Figure 5). The data collected by the society volunteers are currently shared with the Department of Environmental Quality, Prince William County, Fairfax County, National Park Service, and Department of Game and Inland Fisheries.

Volunteers assess habitat conditions and macroinvertebrate community composition (usually to family level) at specific points throughout the year (May, July, and September, with an optional winter sample). Macroinvertebrates are collected using a "hand-scrubbing" sampling technique whereby the volunteers pick up rocks from the stream and rub them in a bucket filled with stream water to detach any macroinvertebrates on the rocks. All benthics that are collected using this method are visually identified to the family taxonomic level where possible. Multiple samples are collected from riffle and pool areas.

Monitors gauge overall habitat condition by visually assessing parameters such as substrate composition, embeddedness, turbidity, bank cover and canopy cover. Four other components of the EPA's habitat assessment—channel flow status, bank stability, sediment deposition and riparian zone width—are also scored using a visual assessment. Readings of pH and water temperature are taken concurrently.

2.6.2 Northern Virginia Soil and Water Conservation District

The Northern Virginia Soil and Water Conservation District coordinates a volunteer stream monitoring program first established in 1997 that is open to all individuals interested in water quality issues. Training includes indoor and field workshops and mentoring by experienced monitors. Volunteers commit to monitoring their chosen stream four times a year or assist other monitors at their sites. Sites are located throughout the county and in the City of Fairfax.

Blythe Merritt, Northern Virginia Soil and Water Conservation District and Audubon Naturalist Society volunteer monitor, sorting a sample in Cub Run in December 2003. Volunteer data supplements the county's data. (photo NVSWSD)

The conservation district initially used the Izaak Walton League Save Our Streams (SOS) protocol for biological monitoring. The protocol classified stream condition based on the absence or presence of organisms. In 2001, the conservation district adopted the use of a new, modified Virginia Save Our Streams protocol (Figure 4). The new protocol was the result of graduate research at Virginia Polytechnic Institute and State University. The new method takes both abundance and diversity into account when calculating six metrics and using a multi-metric for the final score (see Appendix E).

Monitors sample riffles by disturbing the stream bottom and collecting dislodged insects with the use of a three foot-square net. At least 200 organisms are collected and identified. Monitors calculate six metrics, and then use a multi-metric approach to score the site as having an acceptable or unacceptable ecological condition. The final score ranges from zero to twelve. Volunteers also conduct chemical analyses of turbidity and nitrate/nitrite and make physical observations. The conservation district provides all monitoring equipment.

Virginia Save Our Streams Macroinvertebrate Tally Sheet

Macroinvertebrates	Tally	Count
Worms		
Flat Worms		
Leeches		
Crayfishes		
Sowbugs		
Scuds		
Stoneflies		
Mayflies		
Dragonflies and Damselflies		
Hellgrammites, Fishflies, and Alderflies		

Macroinvertebrates	Tally	Count
Common Netspinner Caddisfly		
Most Caddisflies		
Beetles		
Midges		
Black Flies		
Most True Flies		
Gilled Snails		
Lunged Snails		
Clams		
Other		
Total number of organisms in the sample		

Illustrations from: Voshell, J. R., Jr. 2001. Guide to the Common Freshwater Invertebrates of North America. MacDonald and Woodward Publishing Co. With permission of the author.

Individual Metrics

Metric	Number		Total number of organisms in the sample		Percent
Mayflies + Stoneflies + Most Caddisflies		Divide by		Multiply by 100	
Common Netspinners		Divide by		Multiply by 100	
Lunged Snails		Divide by		Multiply by 100	
Beetles		Divide by		Multiply by 100	

% Tolerant

Taxon	Number
Worms	
Flatworms	
Leeches	
Sowbugs	
Scuds	
Dragonflies and Damselflies	
Midges	
Black Flies	
Lunged Snails	
Clams	
Total Tolerant	
Total Tolerant divided by the total number of organisms in the sample	
Multiply by 100	

% Non-Insects

Taxon	Number
Worms	
Flatworms	
Leeches	
Crayfish	
Sowbugs	
Scuds	
Gilled Snails	
Lunged Snails	
Clams	
Other non-insects (organisms without 6 jointed legs)	
Total Non-Insects	
Total Non-Insects divided by the total number of organisms in the sample	
Multiply by 100	

Figure 4: Example field data sheets for the Virginia Save Our Streams Protocol.

There are between 40 and 50 sites that are monitored during a typical year, with 35 sites that currently have several years' worth of data (Figure 5).

More than 700 volunteers have participated in collecting data. Certified data is forwarded to Fairfax County, the Department of Environmental Quality, Virginia Save Our Streams, and other interested organizations or individuals.

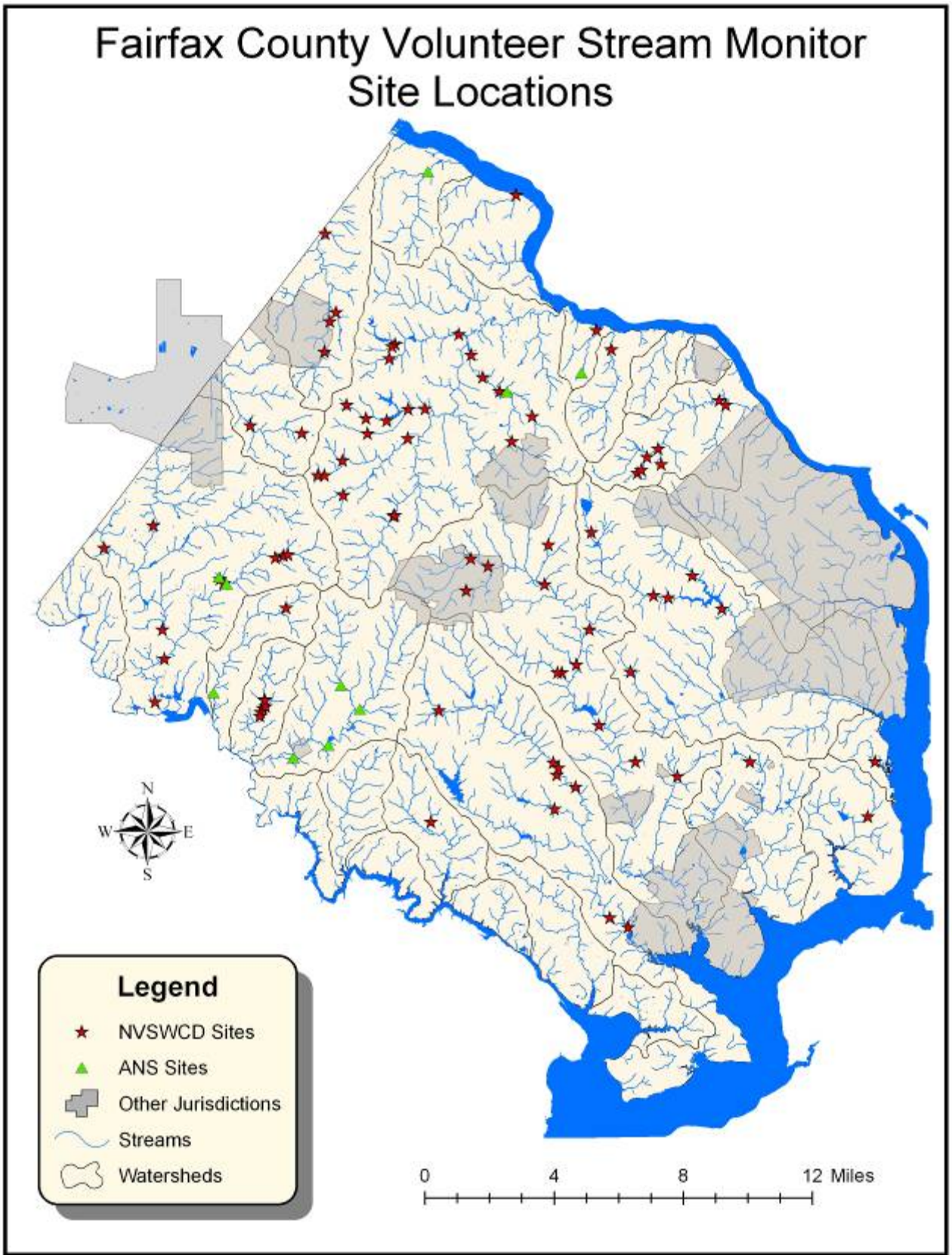


Figure 5: Location of volunteer monitoring site locations.

3. Results

In general, bacteria levels found in a majority of streams make them unsafe for recreational contact (swimming and wading). The benthic macroinvertebrate community lacks sensitive species that are indictors of good water quality and is dominated by tolerant species that are characteristic of degraded streams. The fish community is dominated by habitat generalists, omnivores, and non-native species.

3.1 Bacteria Monitoring Data

In 2003, the Department of Environmental Quality adopted a more stringent bacteria standard for primary contact recreation to all surface water of the state. This action was taken as part of Virginia's commitment to attain the national goal of water quality of surface water for all types of recreation. According to these standards, the following standards now apply:

- Fecal coliform bacteria shall not exceed a geometric mean of 200 fecal coliform bacteria per 100 ml of water for two or more samples over a calendar month
- No more than 10 percent of the total samples taken during any calendar month can exceed 400 fecal coliform bacteria per 100 ml of water
- *E. coli* shall not exceed a geometric mean of 126 bacteria per 100 ml of water or exceed an instantaneous value of 235 bacteria per 100 ml of water.

Since bacteria sampling in the county is only conducted on a quarterly basis, the geometric mean standard cannot really be applied to the data. Comparisons with the 400 f.c./100 ml standard are more meaningful. In 2004, the percentage of samples with fecal concentration less than 400 f.c./100ml decreased to 28 percent from 32 percent in 2002 (Figure 6). However, since the Health Department has historically used 200 f.c./100ml as the cutoff for "good" water quality, the percentage of samples with fecal concentrations less than 200 f.c./100ml are also shown in Figure 6. This percentage, actually showed an increase from 17 percent to 24 percent.

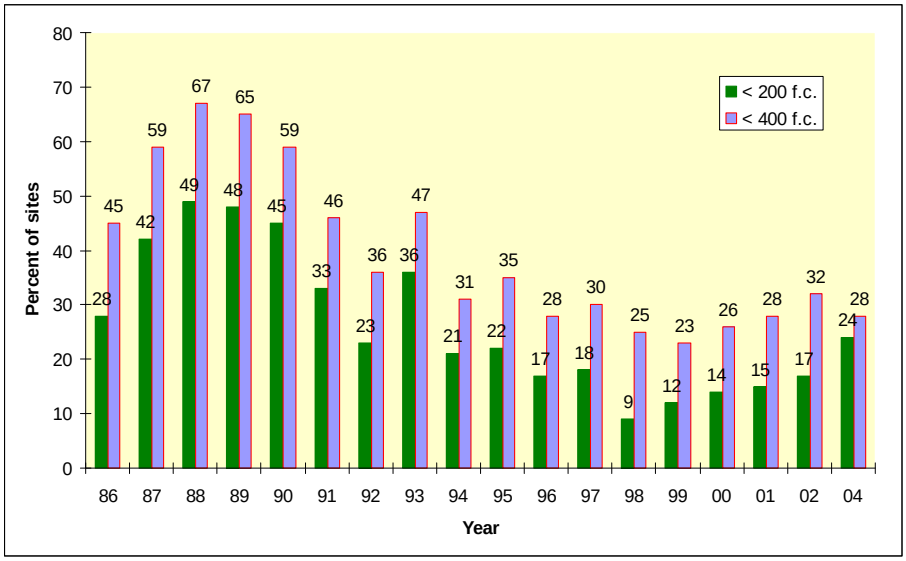


Figure 6: Percent of sites with less than 200 and 400 fecal coliform bacteria per 100ml.

Factors affecting the increase or decrease in the amount of fecal coliform in stream waters include, rainfall and the sample water temperature. Both of these factors are noted in past Health Department stream water quality reports as environmental conditions affecting the fecal coliform results. Plots of fecal concentration counts versus temperature (Figure 7) and fecal concentration geometric means versus 5-day antecedent rainfall (Figure 8) suggests a closer association to temperature.

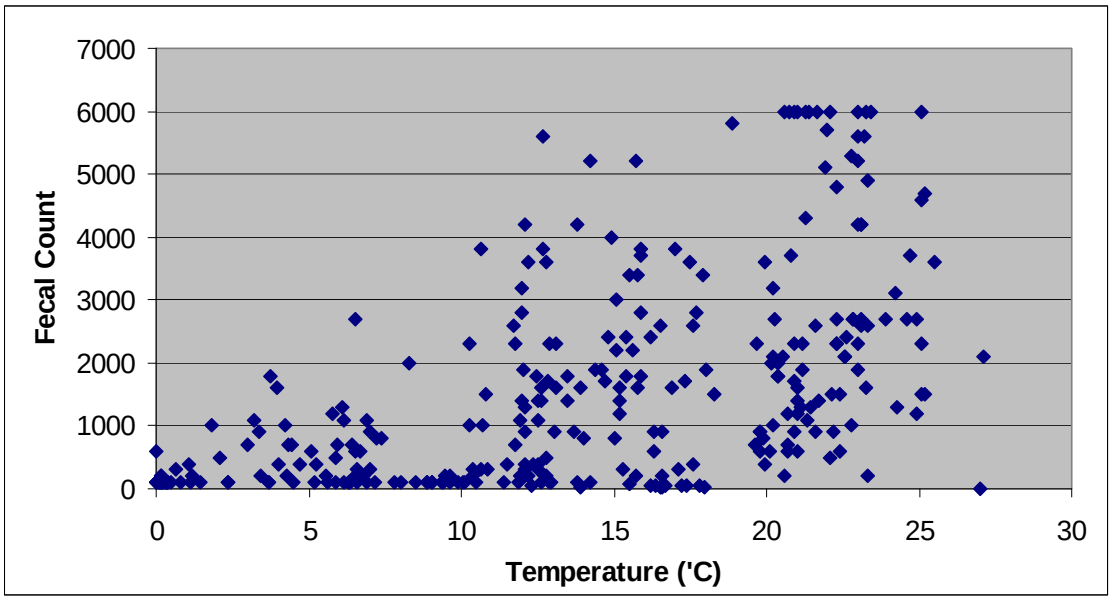


Figure 7: Fecal coliform concentrations versus water temperature.

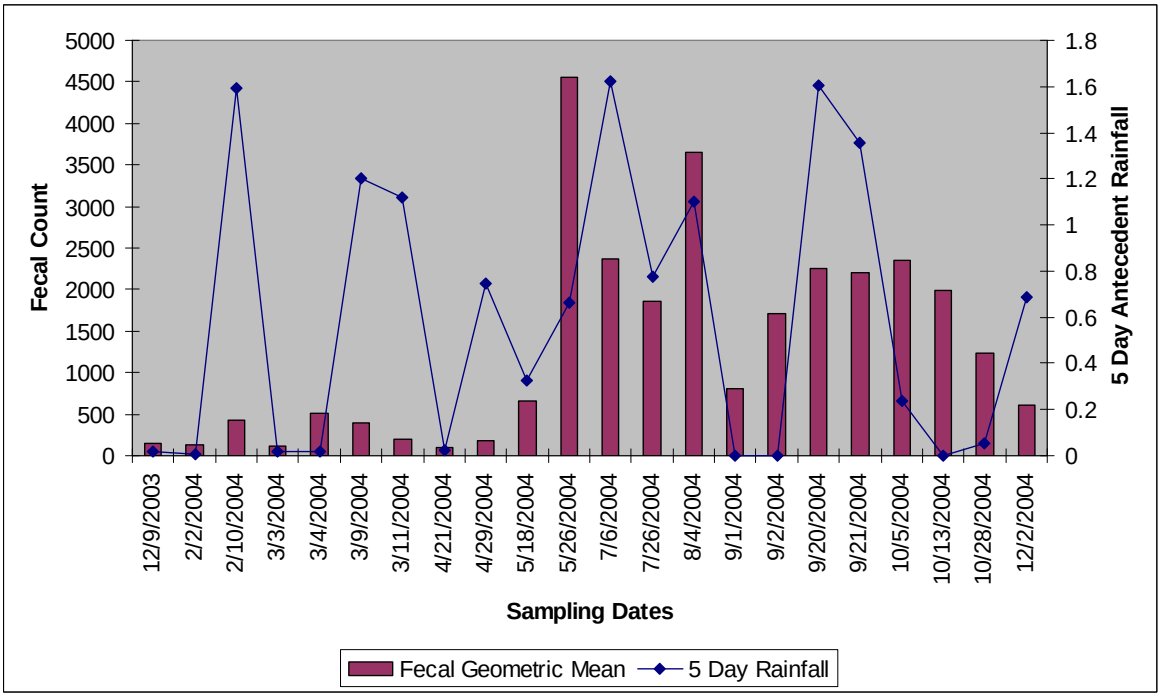


Figure 8: Geometric mean of fecal coliform concentrations versus 5-day antecedent rainfall.

All sites in Fairfax County where at least 4 samples were taken exceeded concentrations of 400 f.c./100ml at least once. The distribution of the number of exceedences in shown in Figure 9, it can be seen that the vast majority of sites (97%) exceeded 400 f.c./100ml two or more times. This would imply that in all areas of the county whether intensely developed or sparsely developed are experiencing a problem with fecal coliform contamination in our waterways. *At any time, any stream in Fairfax County may exceed the level of fecal coliform that the Department of Environmental Quality deems appropriate for recreational contact.*

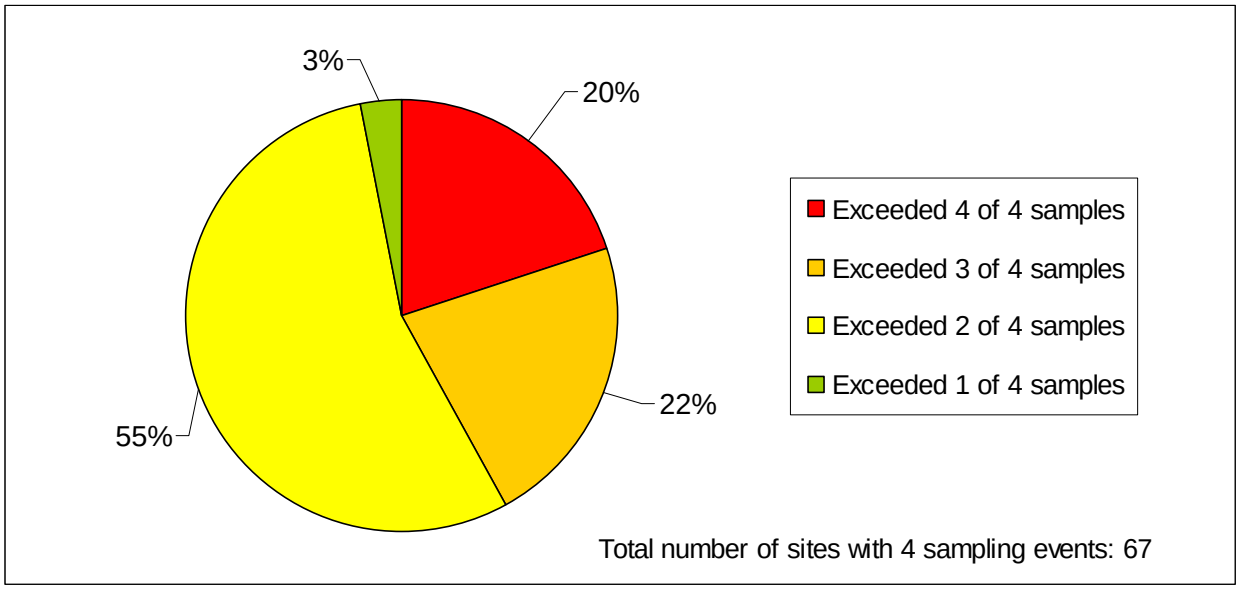


Figure 9: Percentage of sites with exceedences of the state's water quality standard (400 f.c./100ml) for fecal coliform bacteria.

Eighty sites were sampled four times throughout 2004 for a total of 320 samples. The original Health Department sample sites are located on major streams and their tributaries and were picked on ease of access. Only 25 of the 30 watersheds were sampled using the original Health Department bacteria monitoring program locations (Figure 9). Four of these five watersheds are located in downzoned areas of Fairfax County. By disregarding these watersheds, the percent of sites within the acceptable fecal coliform range may be skewed. Future bacteria monitoring efforts will utilize sites selected using stratified random sampling and will provide more representative data.

3.2 Fish Sampling Data

A total of 14 streams within the county were sampled for fish during 2004. All sites were rated in the "fair" to "very poor" range according to the fish community (Figure 10) meaning most streams were dominated by habitat generalists, omnivores, and species that are tolerant of poor water quality. Sixty-four percent of all streams assessed for fish received a "poor" or "very poor" rating and the remaining 36 percent fell into the "fair" rating.

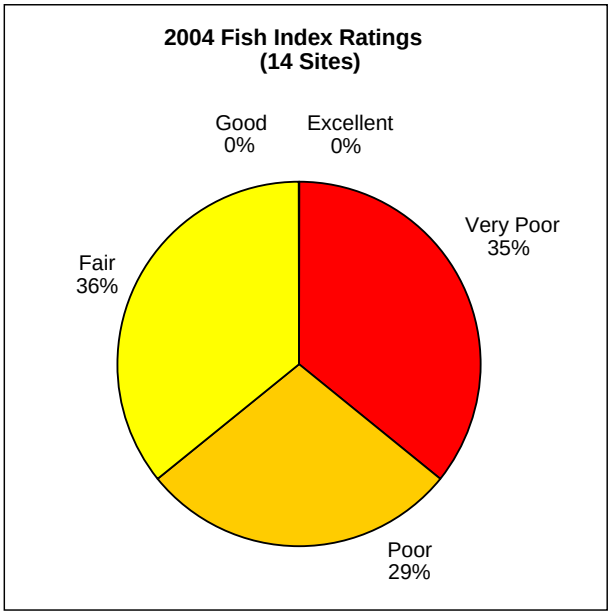


Figure 10: Ratings of 2004 biomonitoring sites based on the Fish Index of Biotic Integrity.

The Blacknose dace, Rhinichthys atratulus, is tolerant of poor water quality. The Blacknose dace is common in streams throughout Fairfax County.

The White Sucker, Catostomus commersoni, is an omnivore. This species is also found throughout Fairfax County.

Larger streams (3, 4, and 5 order) had a higher rating ("fair" to "poor") compared with second order streams based on the mean (Table 8). Second order streams have a higher standard deviation compared with the larger streams meaning there was high variability in the rating scores of second order streams.

Table 8: Fish Index of Biotic Integrity statistics by stream order.

Stream Order	Number of samples	Mean Fish Index	Rating	Standard Deviation
2	7	14.5	Very Poor	9.8
3, 4, and 5	7	24.9	Fair to Poor	5.4

3.3 Benthic Macroinvertebrates

A total of 30 sites within the county were sampled for benthic macroinvertebrates. Consistent with what was reported in the baseline study, a majority of streams within the county are in "fair" to "very poor" condition (80 percent) based on the Benthic Index of Biotic Integrity (Figure 11). For the 2004 sampling season, 6 sites were rated in the "excellent" to "good" range while 24 sites were rated in the "fair" to "very poor" range. Volunteer sampling data from the Northern Virginia Soil and Water Conservation District also shows that 81 percent of the sites that they sampled were rated as "unacceptable" (Figure 12).

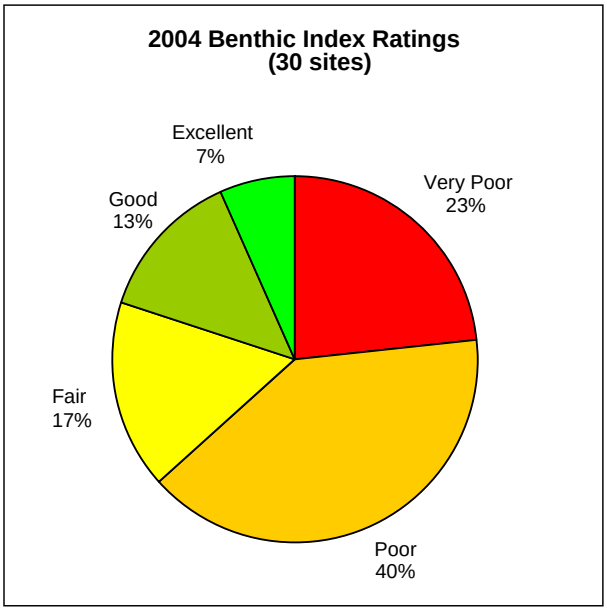


Figure 11: Ratings of 2004 biomonitoring sites based on the Benthic Index of Biotic Integrity.

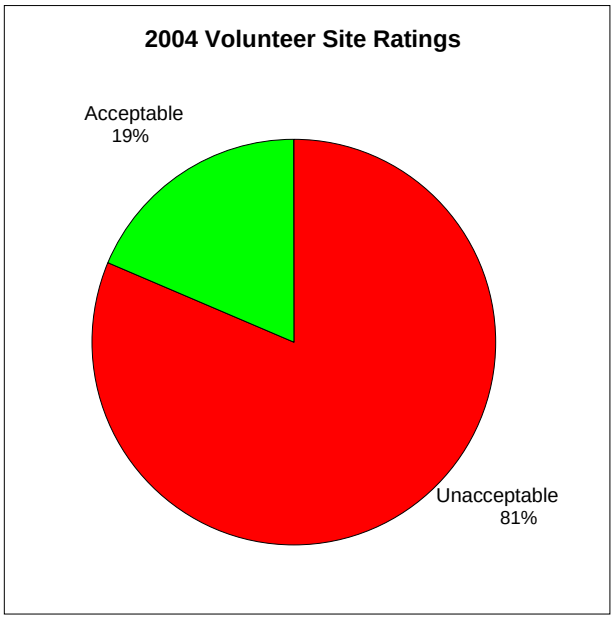


Figure 12: Results from the 48 Northern Virginia Soil and Water Conservation District volunteer monitoring sites.

First order streams and large streams (3, 4, and 5 order) have similar means corresponding to a rating of "fair" (Figure 12). First order streams have a higher standard deviation compared with the other sized streams meaning there was high variability in the rating scores of second order streams, with one stream rated "excellent" and four rated "good".

Table 9: Benthic Index of Biotic Integrity statistics by stream order.

Stream Order	Number of samples	Mean Benthic Index	Rating	Standard Deviation
1	16	40.8	Fair	19.1
2	7	27.3	Poor	11.8
3, 4, and 5	7	40.1	Fair	5.1

3.4 Stream Quality Index

Fairfax County's vision is to protect and enrich the quality of life for the people, neighborhoods, and diverse communities of Fairfax County. An important aspect of achieving this vision is through the practice of environmental stewardship. This includes the wise use of resources, and the protection and enhancement of the county's natural environment and open space.

A number of key indicators have been developed to support the environmental component of Fairfax County's vision. Indicators include one related to watersheds/stream quality. Benthic macroinvertebrate data from the biological monitoring program was used to develop a watersheds/stream quality indicator.

A segment of stream in Accotink Creek Watershed shows eroding banks and inadequate riparian buffer. This segment of stream is rated "poor" and is representative of streams in Fairfax County.

The number of sites placed in each of the five rating categories (excellent; good; fair; poor; and very poor based on the benthic macroinvertebrate monitoring data) was used to develop a stream quality index of overall watershed/stream conditions countywide. The index is computed by multiplying the fraction of total sites rated "excellent" by 5, those rated "good" by 4, those rated "fair" by 3, those rated "poor" by 2, and those rated "very poor" by 1. These values are then summed, resulting in an index ranging from 1 to 5, with a higher value indicating better stream biological conditions. Thus, an index value of 5 would correspond to "excellent", 2.5 would indicate conditions intermediate between "fair" and "poor", and an index of 1 corresponds to "poor". This watershed/stream quality indicator meets a number of criteria including:

- A measurable index, data for which can be collected annually.
- Derived primarily from direct measurement of a key natural resource, the county's receiving waters, which is visible and of great interest to the public.
- Supports the long-term trend analysis of stream conditions.

The stream quality index values for the baseline study and the 2004 stratified random sampling is shown in Table 10. The stream quality index suggests a small decline in overall stream quality from in 2004 compared to 1999. However, it is difficult to make any broad statements about trends based on data from two sampling years. This index will be reported annually to evaluate trends in the overall health of streams countywide.

Table 10: Stream quality index values for sampling completed in 1999 and 2004.

Sampling Year	Fraction of total sites					Index Value
	Very Poor	Poor	Fair	Good	Excellent	
1999	0.11	0.34	0.32	0.14	0.09	2.76
2004	0.23	0.40	0.17	0.13	0.07	2.41

4. Future Efforts

A summary of proposed future efforts in the county's comprehensive monitoring program are presented here. It is anticipated that these efforts will result in more representative countywide data, improved identification of bacteria hotspots, more comprehensive evaluation of trends, and help the prioritization of capital improvement projects to have the most potential to benefit stream biological communities.

Revised Site Selection: In future sampling efforts, a single-stage sampling procedure will be implemented within each stratum to eliminate the need to use correction factors based on sampled stream segment lengths (see Appendix G) when computing stratum means and variances. In addition, a more extensive stratification strategy will be explored, taking into account factors such as physiographic province, and land use within the watershed.

Future Bacteria Sampling: Starting in 2005, the Health Department will drop fecal coliform altogether as an indicator of bacteria contamination, and switch to EPA recommended and the state's standard of enterococci and *E. coli*. Additionally, in 2005 the original Health Department bacteria sampling stations will be dropped. New locations will correspond with the 2005 benthic macroinvertebrate and fish sampling locations. This coordination with the Stormwater Planning Division randomized sampling locations will give provide comprehensive countywide assessment of bacteria levels in the waterways. Each of the new 2005 sites will be sampled four times a year, once per quarter, in order to examine how seasonal conditions affect the level of E. coli and enterococci in the waterways. In the future, "hot spots" or areas with consistently elevated bacteria counts will be tracked and the location(s) of the problem will be investigated with coordinated efforts of Stormwater Management, Wastewater Management, and the Health Department. To isolate these "hot spots" new techniques may be used including Optical Brighteners Monitoring.

Optical Brighteners Monitoring is a technique used to identify potential illicit waste water discharges into the storm drainage network. Optical brighteners are found in most household and industrial laundry detergents and fluoresce or glow under a UV light. To aid in narrowing down the area where potential cross-connections (between the sanitary and storm sewer systems) may be occurring, these techniques may be applied in the upper sections of the site's sub-watershed where streams regularly have bacteria concentrations well above the state standard.

Volunteer Data and Trend Stations: Fairfax County continues to use volunteer data to supplement county data in evaluating general trends. Possible additional volunteer sites will be identified on a yearly basis after random selection of county sites is completed. In working together with volunteer monitoring organizations such as Audubon Naturalist Society and Northern Virginia Soil and Water Conservation District, the county effectively doubles the number of sites it monitors in a given year.

Volunteer data will be standardized to be compatible with county data and data collection will be centralized. Volunteer data will eventually be collected online in an Access database utilizing the same format as the county's data. Land use in each subwatershed will be

characterized to aid in trend analysis. Information and photos of all volunteer sites will be available in the county's GIS-based Stream Assessment Tool.

Project-Specific Monitoring: Currently there are several stream restoration projects that are in the design stages in the Stormwater Planning Division. As projects like these are identified in the watershed management plans, the Stormwater Planning Division, with the help of others, will monitor these locations to assess how quickly biological communities recover and differ from the original community.

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6. Glossary

A

Anthropogenic - Effects or processes that are derived from human activity.
Anomalies – abnormalities

B

Baseline Monitoring - Data collection intended to define existing biological conditions and to set up a framework for long-term study.
Benthic - That portion of the aquatic environment inhabited by organisms which live permanently in or on the bottom.
Benthic Invertivore – An animal that feeds primarily on stream bottom dwelling invertebrates.
Benthic Macroinvertebrate - An aquatic animal lacking a backbone and generally visible to the unaided eye.
Best Management Practice (BMP) - Structural or nonstructural practice that is designed to minimize the impacts of change in land use on surface and groundwater systems.
Biomonitoring - The use of living organisms to assess environmental conditions.

C

Canopy Cover – The amount of cover provided by trees.
Clean Water Act - A law enacted by the United States Congress in 1972 and enforced by the Environmental Protection Agency on the national level and the Georgia Environmental Protection Division on the local level. The Clean Water Act established three main goals: "zero discharge" or the elimination of polluting discharges to the nation's waters by 1985; "fishable and swimmable waters" or the restoration and protection of water quality and wildlife habitat; and "no toxins in toxic amounts" or the prohibition of the discharge of toxic pollutants in amounts that are toxic to the environment or life.
Clingers - An aquatic macroinvertebrate that is able to cling to substrates and maintain itself in fast flowing water.
Coastal Plain - The physiographic province that lies along the Atlantic coast and extends inland to the Piedmont physiographic province. This area is generally characterized by low gradient, meandering streams with mobile sand/silt or gravel substrates.
Community – a group of organisms living together.

D

Darter – Small bottom dwelling fishes belonging to the family Percidae.
Dissolved Oxygen - The amount of oxygen freely available in water and necessary for aquatic life and the oxidation of organic materials.

E

Ecosystem - All of the component organisms of a community and their environment that, together, form an interacting system.
Electrofishing - Fish sampling method using electrical currents to temporarily stun fish to facilitate capture.

Embeddedness - Refers to the extent to which stream substrate (gravel, cobble, boulders and snags) is filled and/or covered with silt, sand, or mud.

Enterococci - Members of two bacteria groups, coliforms and fecal streptococci, commonly found in human and animal feces.

EPT - A group of three orders of insects: mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) which are used to determine stream health based on their sensitivity to pollution.

F

Family Biotic Index (FBI) - The general tolerance/intolerance of a community that considers the numbers of individuals in each tolerance class at the family level taxonomic resolution.

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

Fish Barrier - An obstacle in a stream or river, such as a dam or elevated culvert, that prevents the up and downstream movement of fish and other aquatic species.

Fish Index of Biotic Integrity (F-IBI) - A stream assessment tool that evaluates biological integrity based on characteristics of the fish community at a site.

Functional Feeding Group - A categorization of a biological community based on its trophic or feeding level within its environment (shredder, predator, scraper…).

G

Gastroenteritis - An infection caused by a variety of viruses that results in vomiting or diarrhea.

Genus - A taxonomic category.

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.

Glide - Section of a stream with a relatively high velocity and with little or no turbulence on the surface of the water.

H

Habitat - The environment in which an organism lives.

Hilsenhoff Biotic Index (HBI) - The general tolerance/intolerance of the community which considers the number of individuals in each tolerance class.

I

Impervious Cover - A surface composed of any material that significantly impedes or prevents natural infiltration of water into soil (i.e. sidewalks, houses, parking lots...).

Imperviousness - The percentage of impervious cover within a defined area.

Impoundment - A body of water contained by a barrier, such as a dam.

Index of Biotic Integrity (IBI) - A stream assessment tool that evaluates biological integrity based on characteristics of the fish and benthic community at a site.

Infiltration - The portion of rainfall or surface runoff that moves downward into the subsurface rock and soil.
Insectivore - An animal that feeds primarily on insects.
Intermittent Streams - Streams flowing temporarily or periodically rather than continuously throughout the year.
Intolerant Species - Populations of animals and/or plants that are adversely affected even at low levels of degradation.
Invertivore - An animal that primarily feeds on invertebrates.

L

Lithophils – An animal that lays eggs on clean gravel.

M

Metric - A characteristic of a habitat or biological community structure that changes in some predictable way with increased disturbance or divergence from normal, natural conditions.

N

National Pollutant Discharge Elimination System (NPDES) - Mandated by Congress under the Clean Water Act, a two-phased national program to address nonagricultural sources of stormwater discharge and prevent harmful pollutants from being washed into local water bodies by stormwater runoff.
Native Species – a species that exists naturally in an area, not introduced.
Nitrate - A form of nitrogen, which is found in several different forms in terrestrial and aquatic ecosystems. Sources of nitrates include wastewater treatment plants, runoff from fertilized lawns and cropland, failing on-site septic systems, runoff from animal manure storage areas, and industrial discharges that contain corrosion inhibitors.
Nonpoint Source Pollution - Contaminants such as sediment, nitrogen and phosphorous, hydrocarbons, heavy metals, and toxins whose sources cannot be pinpointed but rather are washed from the land surface in a diffuse manner by stormwater runoff.

O

Omnivores – an animal that feeds on a variety of foods.

P

Peak Flow - Refers to a specific period of time when the discharge of a stream or river is at its highest point.
Perennial Streams - A body of water that normally flows year-round in a defined channel or bed, and is capable, in the absence of pollution or other manmade stream disturbances, of supporting bottom dwelling aquatic animals.
pH - A term used to indicate the alkalinity or acidity of a substance as ranked on a scale from 1.0 to 14.0. Acidity increases as the pH gets lower.
Phosphate - A form of phosphorus, which is found in terrestrial and aquatic systems.

Physiographic Provinces - A region whose pattern of relief features or landforms differs significantly from that of adjacent regions.

Piedmont - This physiographic province bordered by the Atlantic Coastal Plain to the east and the Appalachian Mountains to the west and is generally characterized by rolling terrain with streams of moderate gradient and cobble/gravel substrates.

Q

Quality Assurance/Quality Control (QA/QC) - A system of procedures, checks, audits, and corrective actions to ensure that research design and performance, environmental monitoring and sampling, and other technical and reporting activities are of the highest achievable quality.

R

Rapid Bioassessment Protocol (RBP) - A synthesis of techniques and methodologies for quickly assessing habitat and biological conditions in stream systems.

Reference Conditions - Conditions (i.e. habitat, chemical, biological) that reflect least impaired or best attainable conditions in a given area.

Reference Streams - Streams which exhibit highest quality or least impaired habitat conditions that are used as a standard to which all other streams are compared.

Resource Protection Area (RPA) - That component of the Chesapeake Bay Preservation Area comprised of lands at or near the shoreline of water bodies that have an intrinsic value due to the ecological and biological processes they perform or are sensitive to impacts which may result in significant degradation to the quality of state waters. All other land outside RPAs within Fairfax County is considered RMAs.

Restoration - Improving conditions within a natural system so that its functional characteristics are comparable to its original, unaltered state.

Riffle - A reach of stream that is characterized by shallow, fast moving water broken by the presence of rocks and boulders.

Riparian Buffer - A transitional area around a stream, lake, or wetland left in a natural state to protect the waterbody from runoff pollution. Development is often restricted within such zones.

S

Shredder - Macroinvertebrate functional feeding group in which the individuals feed off of large pieces of plant material (i.e. leaves, twigs and bark) that have fallen into the stream.

Specific Conductance - The ability of water to pass an electrical current while taking into account both temperature and pressure, both factors which may affect the conductivity of a sample.

Stormwater - That portion of precipitation that is discharged across the land surface or through conveyances to one or more waterways.

Subwatershed - A defined land area within a watershed drained by a river, stream or drainage way, or system of connecting rivers, streams, or drainage ways such that all surface water within the area flows through a specific point.

T

Taxon (plural - Taxa) - A taxonomic category or group, such as a phylum, order, family, genus, or species

Tolerant Species - Animals and/or plants that can withstand high levels of degradation.

Total Maximum Daily Load (TMDL) - The maximum levels of a particular pollutant water body can receive in a given day without violating pre-established water quality standards. Total Maximum Daily Loads are the sum of point and nonpoint source loads.

Triassic Basin - This physiographic province is a subprovince of the Piedmont Upland. The geology consists largely of red sedimentary (sandstone, siltstone, shale, and conglomerate) rocks characterized by wide and gently rolling hilltops, with long gently sloping sideslopes and nearly level areas.

Trophic – related to an animal's feeding preferences.

Turbidity - A measure of the suspended solids in a liquid.

W

Watershed - A discrete unit of land drained by a river, stream, drainage way or system of connecting rivers, streams or drainage ways such that all surface water within the area flows through a single outlet.

Watershed Restoration - Improving current conditions of watersheds to restore degraded fish habitat and provide long-term protection to aquatic and riparian resources.

Wetland - Land that is saturated with water and which contains plants and animals that are adapted to living on, near, or in water. Wetlands have hydric soils and are usually located between a body of water and land.

Y

Young of year – juvenile fish hatched that year.

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A. 2001 STREAM PROTECTION STRATEGY BASELINE STUDY UPDATE

1. Introduction

All environmental monitoring relies on repeated observation to provide the most complete picture of environmental processes. In this vein, all county monitoring sites were scheduled to be re-sampled within a five year rotating schedule to both highlight changes in conditions as well as develop a broader information base. Staff began this process in the spring of 2001, collecting biological and habitat data at approximately 25 percent of the original monitoring locations. Specifically, assessments were made at 23 sites randomly selected from the original site list, and at the 11 reference locations within Prince William Forest Park developed as part of the baseline study.

Additionally, seven new sites were added within areas of the county that had been identified as priority assessment areas. Six of these sites were placed on tributaries where no monitoring had yet been conducted but which represented significant drainage areas that had the potential to significantly influence downstream environments. The 7th site, located on the main stem of Little Rocky Run, was established in an attempt to better understand the dramatically different results shown in the baseline study between two adjacent sites. These sub-watersheds will receive updated management category assignments. All 2001 monitoring sites within the county are shown in Figure A1.

Unlike the monitoring conducted in 1999, the 2001 effort included a fish sampling event in the spring (in addition to the annual summer sample). This was done in an effort to understand possible seasonal variations in fish distribution patterns and overall abundance, and their subsequent influence on metric development and scoring. Specifically, large numbers of young-of-year fish were collected and enumerated in the original assessments—which may have led to inflated population measures relative to habitat quality—and it was hoped that early season sampling, prior to emergence and development of fry, would eliminate this potential problem.

2. Results

The Benthic Index of Biotic Integrity scores at the thirty five 2001 resample sites and their rating categories are shown in Table A1 and Figure A1. Overall results show an increase in the proportion of impacted sites when compared to the 1999 baseline study. When plotted against subwatershed impervious surface cover (the major disturbance factor), the benthic index scores for 2001 sites showed good correlation.

	Province		
Category	Piedmont	Coastal Plain	Total
Very Poor	5	1	6
Poor	8	2	10
Fair	14	3	17
Good	0	0	0
Excellent	2	0	2
Total	29	6	35

Table A1: Results of Index of Biotic Integrity based on benthic macroinvertebrates for 2001 sampling locations

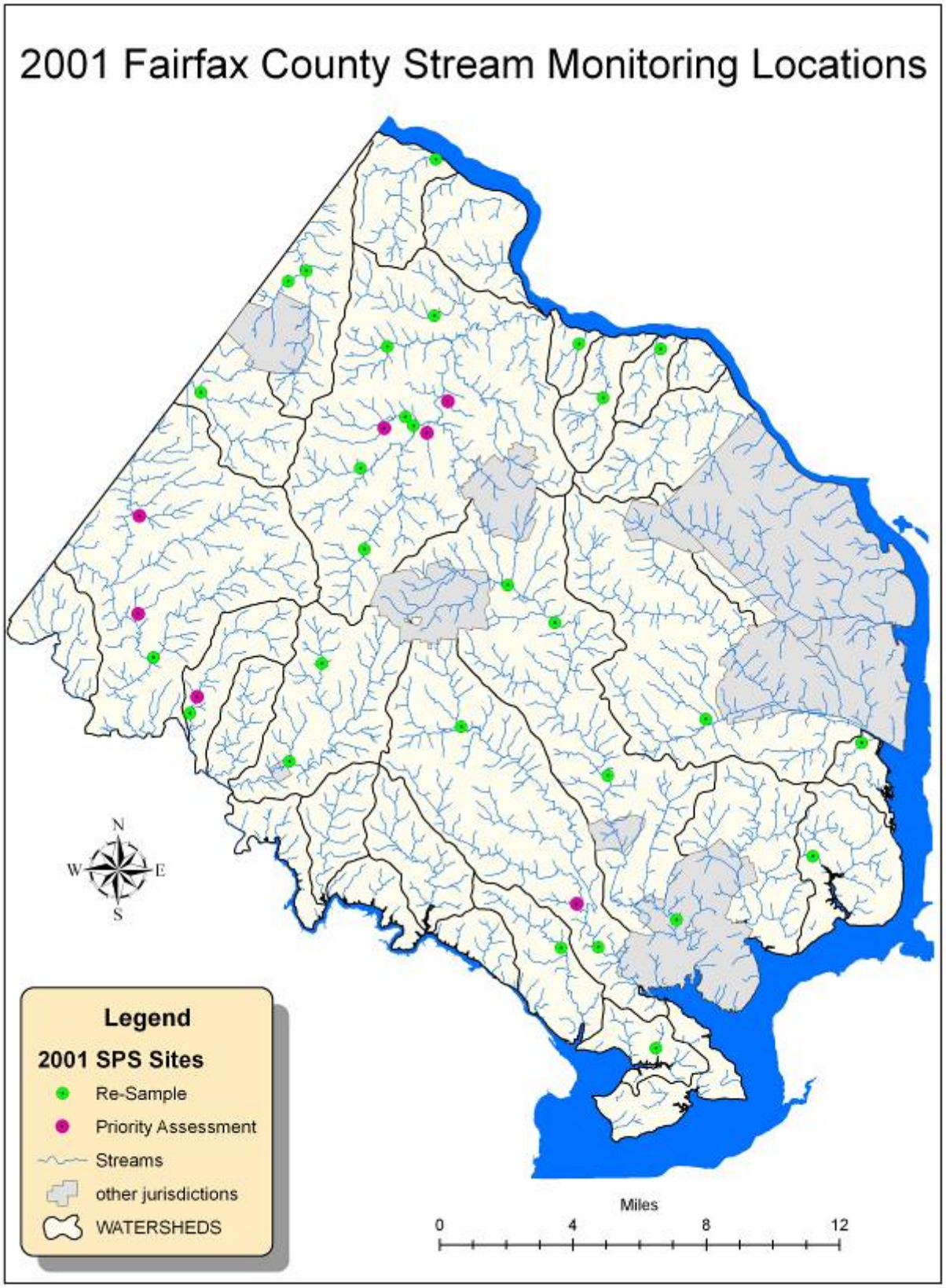


Figure A1: Locations of 2001 biological monitoring sites.

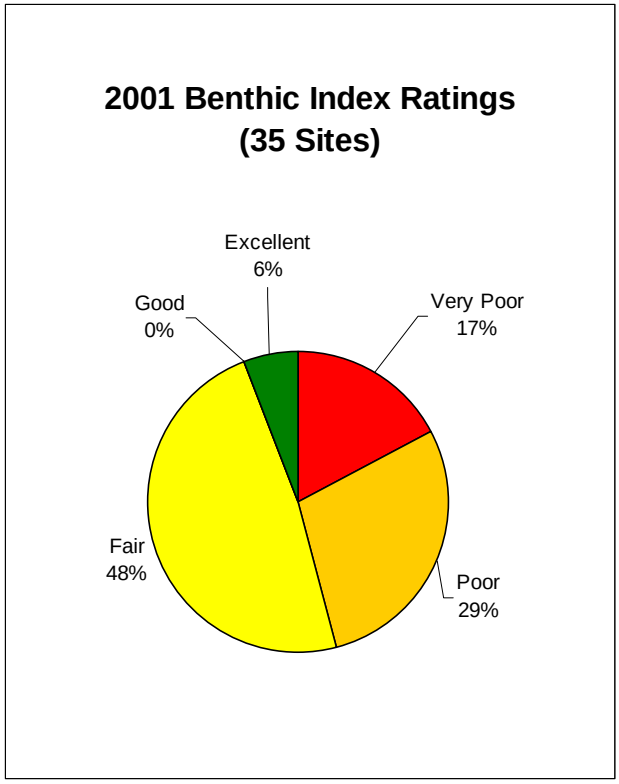


Figure A2: Ratings of 2001 monitoring sites based on the Benthic Index of Biotic Integrity.

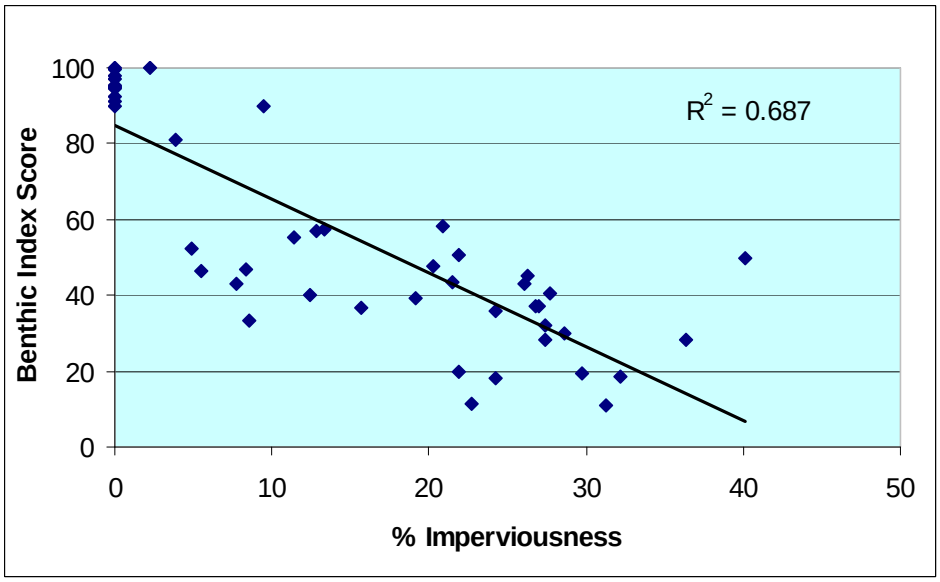


Figure A3: Correlation between the Benthic Index of Biotic Integrity and imperviousness based on 2001 sampling data (includes biological reference sites).

The Index of Biotic Integrity based on fish scores at the thirty four 2001 resample sites and their rating categories are shown in Table A2 and Figure A3. Overall results show a high degree of similarity when compared to the overall 1999 baseline study results.

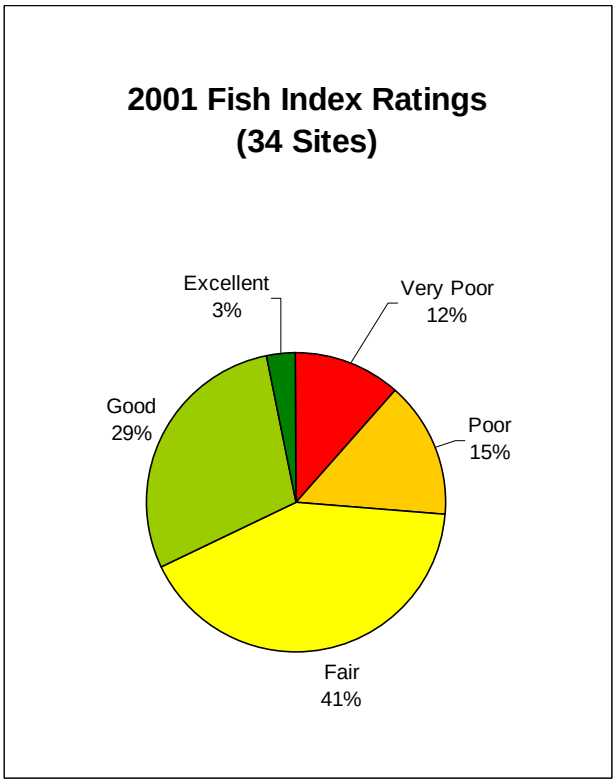


Figure A4: Ratings of 2001 monitoring sites based on the Fish Index of Biotic Integrity.

Table A2: Results of the Fish Index of Biotic Integrity for 2001 sampling locations.

Fish Index Categories	Province		Total
	Piedmont	**Coastal Plain**	
Very Poor	2	2	4
Poor	5	0	5
Fair	11	3	14
Good	9	1	10
Excellent	1	0	1
Total	28	6	34

Results of the spring versus summer fish sampling showed only very minor differences in species counts and total numbers of individuals collected at each of the sampling sites (Figure A3). The data supports continued summer sampling and suggests that spring samples may actually be less representative of actual resident fish populations. One possible explanation for this may be the increased degree of fish migrations in the spring (due to spawning behaviors). Therefore, the annual fish sampling campaign will continue to be performed in the summer season only.

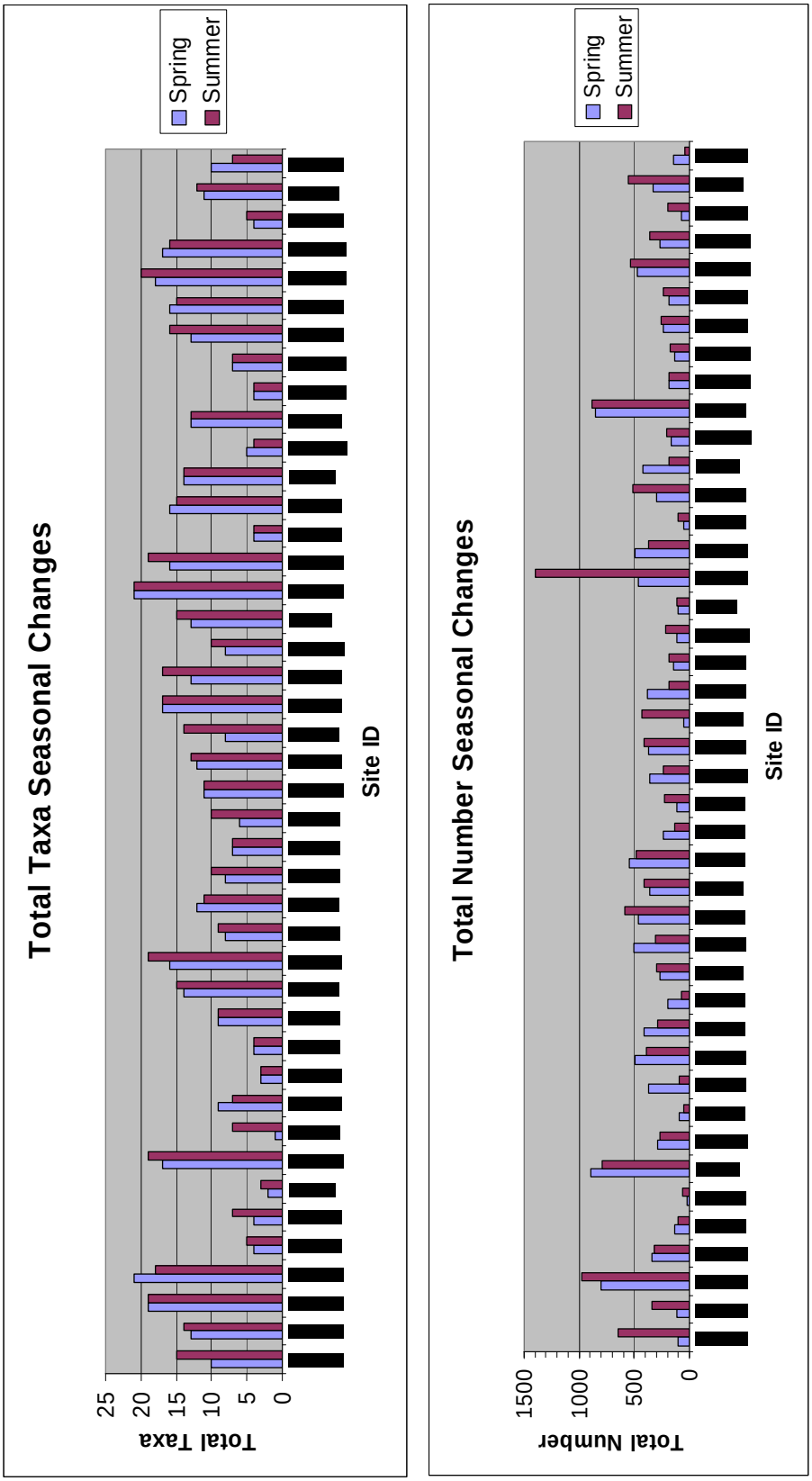


Figure A5: Differences in total taxa and total number of individuals between spring and summer 2001 fish samples.

Seven of the original 11 Priority assessment areas identified in the 1999 baseline study were targeted and sampled in the 2001 monitoring effort. These subwatersheds were then incorporated into the original ranking system employed in 1999 (see original baseline study, Chapter 2 – section titled "Countywide Stream Ranking System: Multi-dimensional Curves) for subsequent management category assignment. The values used for this ranking are shown in Table A3 below, and the resultant management categories are shown in table A4. The remaining four priority assessment areas identified in the original study were not sampled due either to access issues, or jurisdictional limitations (i.e.: the Ft. Belvoir Peninsula, Mason Neck National Wildlife Refuge) or because of their very small drainages. These areas were designated as Watershed protection areas, as they are not predicted to have large increases in impervious cover, and currently have very limited development potential. Using this data and an improved method for determining projected percent impervious area for drainage areas, the countywide management category map has been updated for 2001 (Figure A5).

	Composite	Environmental Variables			
Watershed, Stream Name and Site Code	Site Condition Rating	Benthic Index	Habitat Score	Fish Taxa Richness	Current % Impervious Cover
1 Cub Run - Round Lick Branch (CURL01)	Poor	40	99	Low	24.2
2 Cub Run - Schneider Branch (CUSB01)	Very Poor	53.5	99	Low	40.1
3 Difficult Run - The Glade (DFGL01)	Good	36.1	129	Moderate	15.7
4 Difficult Run - Angelico Branch (DFAB01)	Poor	60.5	81	Low	7.7
5 Difficult Run - Unnamed Tributary (DFUN01)	Excellent	91.5	128	High	9.5
6 Little Rocky Run - Main Stem (LRLR04)	Excellent	56.8	157	High	20.9
7 Pohick Creek - Unnamed Tributary (PCUN01)	Poor	58.5	82	Low	5.5

Table A3: Results of the additional sites sampled in 2001 to complete the management categories for priority assessment areas.

Watershed, Stream Name and Site Code	Management Category
1 Cub Run - Round Lick Branch (CURL01)	Watershed Restoration Level II
2 Cub Run - Schneider Branch (CUSB01)	Watershed Restoration Level II
3 Difficult Run - The Glade (DFGL01)	Watershed Restoration Level II
4 Difficult Run - Angelico Branch (DFAB01)	Watershed Restoration Level II
5 Difficult Run - Unnamed Tributary (DFUN01)	Watershed Protection
6 Little Rocky Run - Main Stem (LRLR04)	Watershed Protection
7 Pohick Creek - Unnamed Tributary (PCUN01)	Watershed Restoration Level II

Table A4: Management categories for priority assessment areas

3. Conclusions

The results in this report are only intended to provide a snapshot of stream quality conditions as they exist today. As such, this first round of (25 percent) baseline study site re-samples should be seen only as the beginning phase of the permanent monitoring effort that will be needed for effective management of aquatic resources

within the county. If appropriate decisions are to be made, trends in stream conditions will need to be identified and assessed over the long term.

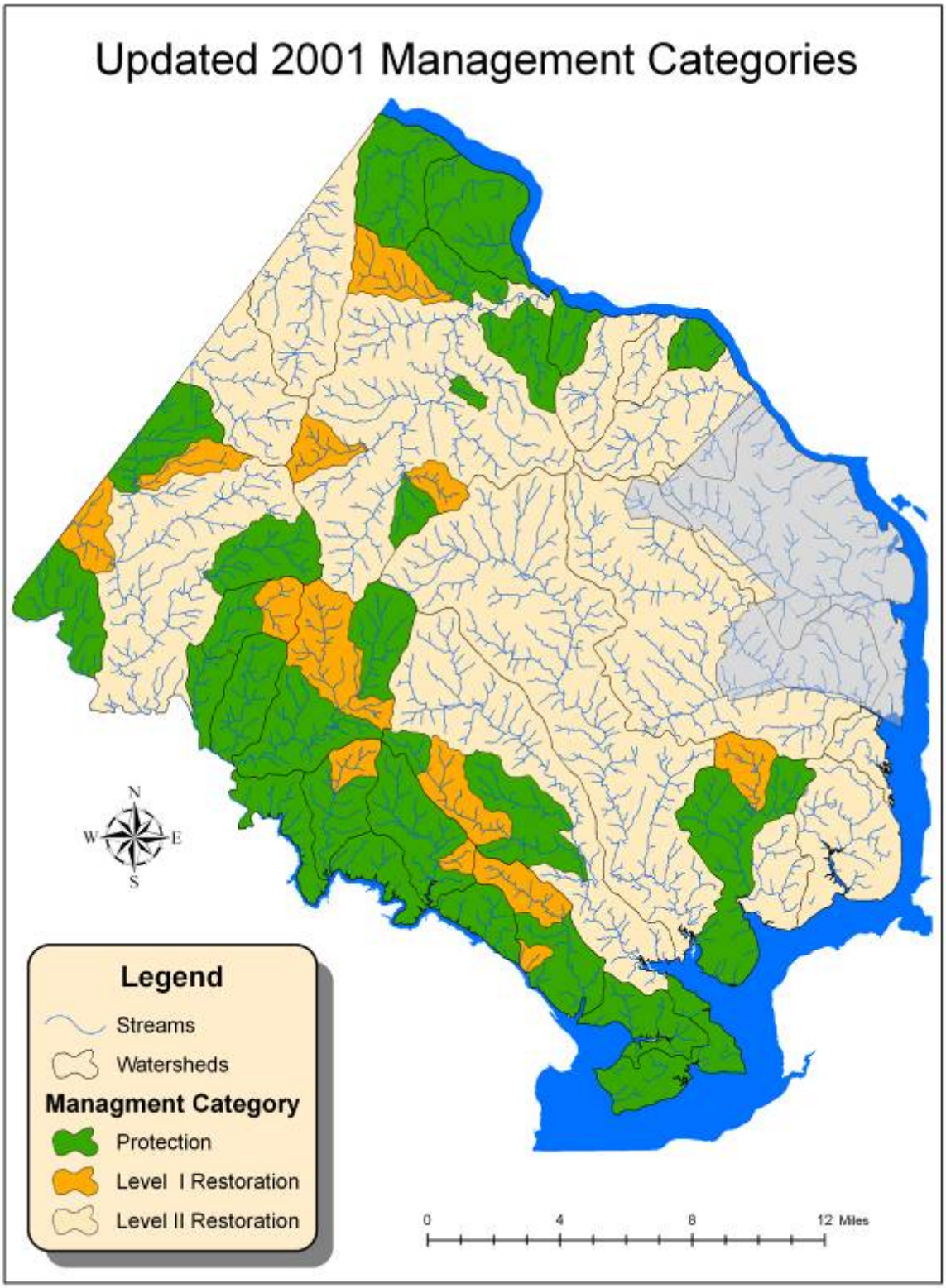


Figure A6: Updated management categories based on 2001 sampling season data.

4. Future directions

Efforts are required to develop a more rigorous sampling procedure for long-term monitoring of county watersheds. The effort will focus on the development of a stratified-random sampling design that will account for accepted variations in stream order, and that will allow for the inclusion of information previously developed form non-randomly selected sites (all monitoring locations established to date). Such an effort will also require the development of spatial information specific to the county's stream coverage, such that the network is separated into 100-meter segments that can then be randomly chosen for future monitoring efforts. The goal will be to have the GIS layers in such a format by December 2002, and to have the design finalized and reviewed by the end of the year so that it can potentially be presented and/or submitted in the spring of 2003.

Uniformity in sampling technique for the collection of macroinvertebrate samples across distinct physiographic provinces has been a concern from the beginning of the program. This concern has been raised by other organizations performing similar monitoring within the mid-Atlantic region. Specifically, the question is over whether or not the RBP kick-sample approached used in riffle/run habitat in the Piedmont produce results that are comparable to the 20-jab methods employed in Coastal Plain steams, environments where the available habitat for macroinvertebrates is much less concentrated and consists of a diverse array of substrate types. Several studies comparing these two methods have shown minimal differences in sample outcomes, and have recommended replacing the kick samples with the 20-jab method. In recognition of these concerns, and the implications they have for the ultimate ranking of county streams relative to each other, macroinvertebrate sampling conducted in the spring of 2002 will include kick-sampling and 20-jab sampling at all monitoring sites within the Piedmont. Subsequent comparisons between the two methods—and across regions—will be used to determine appropriateness of conducting only 20-jab sampling in all future field monitoring.

B. BENTHIC MACROINVERTEBRATE PROTOCOLS

Benthic macroinvertebrate communities are a major component of any healthy stream system. They are an important link in any aquatic food web, forming the core diet of many stream fishes. These organisms are also useful indicators of water quality, due to their short life spans and their varying tolerances to chemical, nutrient, and sediment pollution.

1. EPA's Rapid Bioassessment Protocol Multihabitat Field Sampling Methods

Since Fairfax County contains two different physiographic provinces (Piedmont, and Coastal Plain) that each have a variety of different habitat types, a sampling method that samples all these types of habitats was used. All sites were sampled using the "Twenty Jab" method which was designed by the Mid-Atlantic Coastal Streams Workgroup specifically for streams with variable habitat structure and adopted for use in the protocol (US EPA, 1997), for benthic macroinvertebrate sampling in locations with multiple habitats. Samples collected in the field were preserved with 95 percent ethanol.

The following field equipment was needed for the multi-habitat sampling:

- standard D-frame dip net, 500 µ opening mesh, 0.3 m width (~ 1.0 ft frame width)
- sieve bucket, with 500 µ opening mesh
- 95% ethanol
- sample containers, sample container labels
- forceps
- pencils, clipboard
- Benthic Macroinvertebrate Field Data Sheet
- waders

The Quality Assurance and Quality Control (QA/QC) methodology defined by the protocol was followed. The procedure is designed to ensure that the data collected complies with the Goals and Objectives set forth in the introduction chapter of the SPS Baseline Study. Specific procedures are outlined in separate sections where applicable.

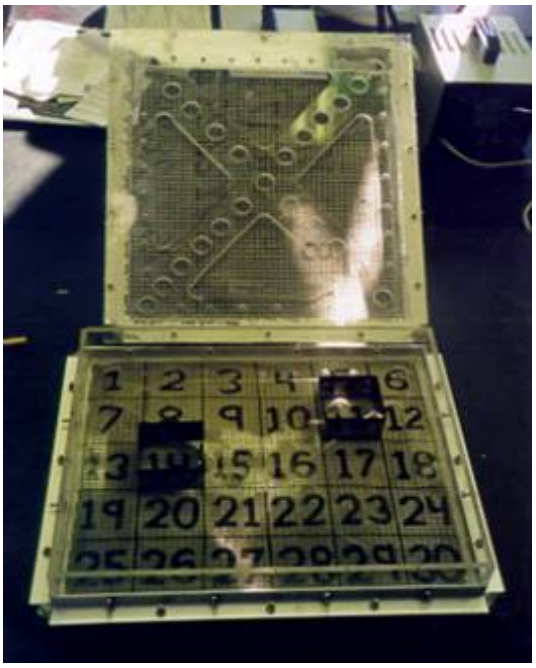
2. Laboratory Identification and Analysis

The following laboratory equipment was used to identify, record, and catalog the benthic macroinvertebrate samples:

- benthic sample
- 8-inch diameter sieve with 500 µ mesh sorting grid, (30 squares) with 500 µ mesh
- polyethylene wash tray
- dissecting microscope
- fiber-optic light source
- 95% ethanol
- sample vials
- 9-unit laboratory counter with grand total counter
- extra-fine/jewelers forceps
- chain-of-custody form and QA/QC log in sheets
- benthic macroinvertebrate laboratory bench sheets (Figures Figure B1and Figure B2)

Upon arrival in the lab, field samples were logged in. Invertebrate collections were developed by spreading each respective sample over the surface of a 30 x 36 cm, 500 µ mesh sorting grid sub-sampler (Caton, 1991) (Figure B1). A sub-sample of individuals was picked from a randomly selected square subdivision marked on the grid's surface (30 total squares). A tally of specimens continued until a minimum of 200 (plus or minus 20 percent) was obtained. If the square containing the 200th individual would result in more than 240 individuals, that square was then subsampled until the total reached was less than 240. The specimens for each site were then transferred to a sample vial, preserved with 95 percent ethanol, and labeled with the following information:

View of top and bottom of sub-sampler built by staff.



- Site code
- Date collected
- Date sorted
- Sorted by
- Total number of organisms in the sample (chironomidae, oligochaeta, others)

In compliance with protocols, after laboratory processing was completed for a given sample, all sieves, pans, trays, etc., that had come in contact with the sample were

rinsed thoroughly, examined carefully, and picked free of organisms or debris. Organisms found were added to the sample residue.

Once all site samples were sub-sampled, sorted, and labeled, taxonomic identifications were then made to the genus level. Genus level classification of all macroinvertebrates samples was performed using selected taxonomic keys (Pennak 1989, Peckarsky 1990, Wiggins 1995, Merritt and Cummins 1996). However, time constraints prevented the more detailed examinations required to identify taxa such as aquatic worms (Oligochaeta) and midge larvae (Chironomidae) to this level. In such cases, oligochaetes were identified at the class level, and chironomids were identified at the family level. The representatives in each respective taxonomic grouping were enumerated and recorded on the macroinvertebrate data bench sheet and on the sample identification log-in sheet. All individuals from the sub-sample were then returned to the 95 percent ethanol solution and archived. To ensure conformity with protocols, these additional steps were taken:

- Ten percent of the already processed and identified samples were randomly selected and rechecked for taxonomic and numerical consistency.
- A voucher collection of all samples and sub-samples was maintained. These specimens were properly labeled, preserved, and stored in the laboratory for future reference.

Figure B1: Benthic Identification Bench Sheet (front page).

SITE ID: _____

Benthic Macroinvertebrate Identification Sheet		
Taxonomist:		**Identification Start Date:**
		Identification Finish Date:
Watershed:		**Sorting Date(s):**
		Collection Date:
Subsample Target: 200 Organisms		
		Number sorted:
QC Sample? Y N	**QC Site? Y N**	**Number ID'ed:**

Organisms			#	L.S.*	T.I.
Order	**Family**	**Genus**			
Oligochaeta				A	
Chironomidae				L	
Hirudinea					
Isopoda					
Amphipoda					
Decapoda					
Ephemeroptera					
Plecoptera					
Odonata					
		Subtotal:			

***Lifestages: A (Adult), P (Pupae), L (Larvae)**

Figure B2: Benthic Identification Bench Sheet (back page).

SITE ID: _____

Benthic Macroinvertebrate Identification Sheet					
Organisms			#	L.S.*	T.I.
Order	Family	Genus			
Trichoptera					
Hemiptera					
Megaloptera					
Coleoptera					
Diptera					
Gastropoda					
Bivalves					
Acariformes					
Other					
		Subtotal:			
		Grand Total:			

*Lifestages: A (Adult), P (Pupae), L (Larvae)

3. Development of a Benthic Macroinvertebrate Index of Biotic Integrity

The response of a given biological community to environmental degradation can provide a useful measure of overall system health. Such responses, often evident as changes in community structure and composition, can highlight single-source environmental stressors, or the cumulative impact of multiple stressors. Potential measures of relative tolerance and intolerance to stressors will be identified from within the various subcategories (i.e., genus, functional feeding group, and habitat) of the macroinvertebrate communities.

These attributes, or "metrics," were used to construct the foundation of an Index of Biotic Integrity (IBI) for ranking each study site. The index has two distinct components; (1) a set of criteria which transforms the metric values into scores that can then be used in the aggregate and (2) narrative "integrity" classes (excellent, good, fair, poor and very poor) which reflect relative correspondence to the numeric rating of the "reference" condition (Table B1).

Table B1: Classification ratings used on the Benthic Macroinvertebrate Index of Biotic Integrity scores.

INDEX SCORE	RATING	DESCRIPTION
80 to 100	Excellent	Equivalent to reference conditions; High biodiversity and balanced community
60 to 80	Good	Slightly degraded site with intolerant species decreasing in numbers
40 to 60	Fair	Marked decrease in intolerant species; shift to an unbalanced community
20 to 40	Poor	Intolerant species rare or absent, decreased diversity
0 to 20	Very Poor	Degraded site dominated by a small number of tolerant species

For the benthic macroinvertebrates, indices were created separately for the Piedmont and the Coastal Plain area. An index was created for the Coastal Plain province using metrics taken from the Mid-Atlantic Integrated Assessment data report

Table B2), *Assessment Framework for Mid-Atlantic Coastal Plain Streams Using Benthic Macroinvertebrates* (Maxted et al. 1999). For the Piedmont the Index of Biotic Integrity (Jones 2000, personal communication) was used since it provided regionally tested metrics and multi-year data for the same reference sites which were used in the baseline study (Table B3).

Table B2: Index of Biotic Integrity metric descriptions for benthic macroinvertebrates for Coastal Plain. (Based on Maxted et al. 1999).

COASTAL PLAIN INDEX METRICS	
METRIC	**DESCRIPTION**
1. Taxa Richness	**Number of different taxa at a site**
2. EPT Taxa	**Number of Mayfly, Stonefly and Caddisfly taxa at a site**
3. Percent Ephemeroptera	**Percent of sample that was in the order Ephemeroptera**
4. Hilsenhoff Biotic Index	**Hilsenhoff Biotic Index - general tolerance/intolerance of the sample**
5. Percent Clingers	**Percent of individuals whose habitat type is clingers**

Table B3: Index of Biotic Integrity metric descriptions for benthic macroinvertebrates for the Piedmont (Jones 2000, personal communication).

PIEDMONT INDEX METRICS	
METRICS	**DESCRIPTIONS**
1. Taxa Richness	**Number of different taxa at a site**
2. EPT richness	**Number of Mayfly, Stonefly and Caddisfly taxa at a site**
3. Percent EPT	**Percent of sample that are Mayfly, Stonefly and Caddisfly excluding the tolerant Net-Spinning Caddisflies (Hydropsychidae)**
4. Percent Trichoptera w/o Hydropsychidae	**Percent of sample that are Caddisflies excluding the tolerant Net-Spinning Caddisflies (Hydropsychidae)**
5. Percent Coleoptera	**Percent of sample that are beetles**
6. Family Biotic Index	**General tolerance/intolerance of the sample**
7. Percent Dominance	**Percent of the most abundant taxa**
8. Percent Clingers + Percent Plecoptera	**Percent of individuals whose habitat type is clingers plus percent of sample that are stoneflies but are not clingers**
9. Percent Shredders	**Percent of individuals that uses shredding as its primary functional feeding group**
10. Percent Predators	**Percent of individuals that uses predation as its primary functional feeding group**

Example 1: For metric values that decrease with increasing disturbance (Total Taxa, EPT Richness, % EPT w/o Hydropsychidae, % Trichoptera w/o Hydropsychidae, % Coleoptera, % Clingers plus % Plecoptera, % Clingers, % Shredders, % Ephemeroptera and % Predators).

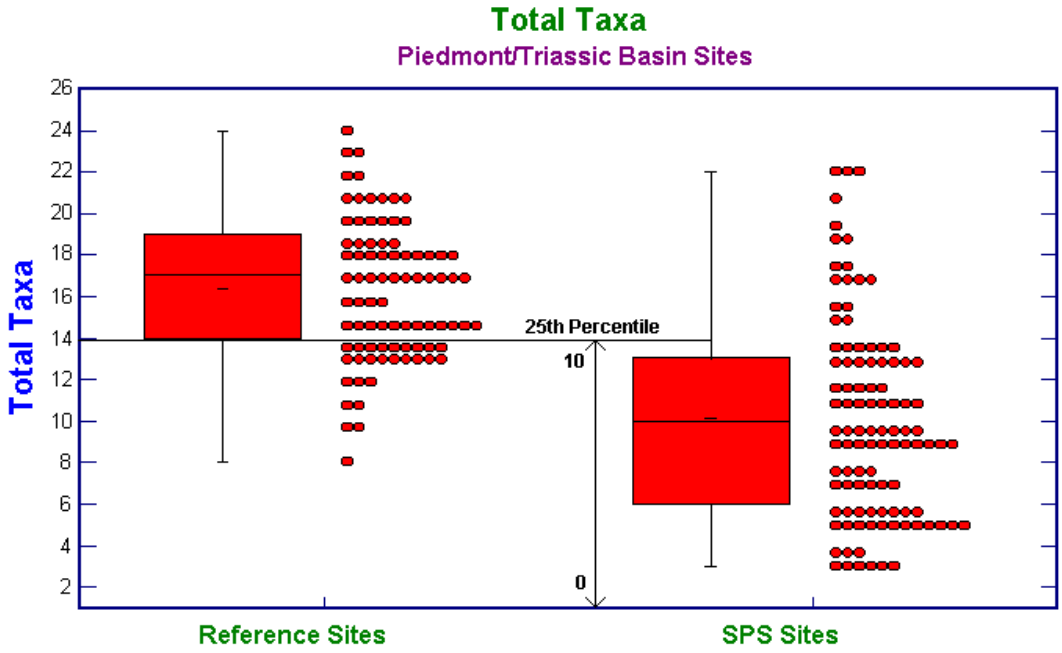


Figure B3: Box and Whisker Plot of Total Taxa for the Piedmont.

The data for total taxa from the Piedmont reference areas and the total taxa data were plotted against each other using a box and whisker plot. The 25th percentile from the reference data was then designated as the "reference condition" value. Therefore, any value above that mark was considered equivalent to reference conditions. The 25th percentile value of the reference data was then divided by 10 to obtain the conversion factor. In this example (Figure B3) the conversion factor would be 14 (the 25th percentile of the reference conditions) divided by 10 (the upper limit of the 10-point scale), which is 1.4. All the county site values for total taxa were then divided by the conversion factor to convert them to the final 0 to 10 scale (Table B4). If the resulting value was more than 10, it was rectified to 10. The resulting values for all metrics were then summed to give each site a rating between 0 – 100. Each site was then given a qualitative ranking based on its final rating (Table B1).

Table B4: Metric value conversions for Example 1.

Site Values	Converted Values	Final Value
7	5	5
10	7.14	7.14
22	15.71	10
13	9.29	9.29
8	5.71	5.71
5	3.57	3.57
4	2.86	2.86
14	10.00	10
6	4.29	4.29
3	2.14	2.14
17	12.14	10

These steps were also performed for the Coastal Plain site data. Unlike the Piedmont sites however, for which spatially and temporally broad reference information was available, the Coastal Plain sites were only compared to the Kane Creek site. The metric scores for the Kane Creek site were used in lieu of the 25th percentile of aggregate reference data for inversely-correlated metrics (Total Taxa, EPT Richness, % Ephemeroptera and % Clingers).

Example 2: For metric values that increase with increasing disturbance (i.e. FBI, HBI and Percent Dominance).

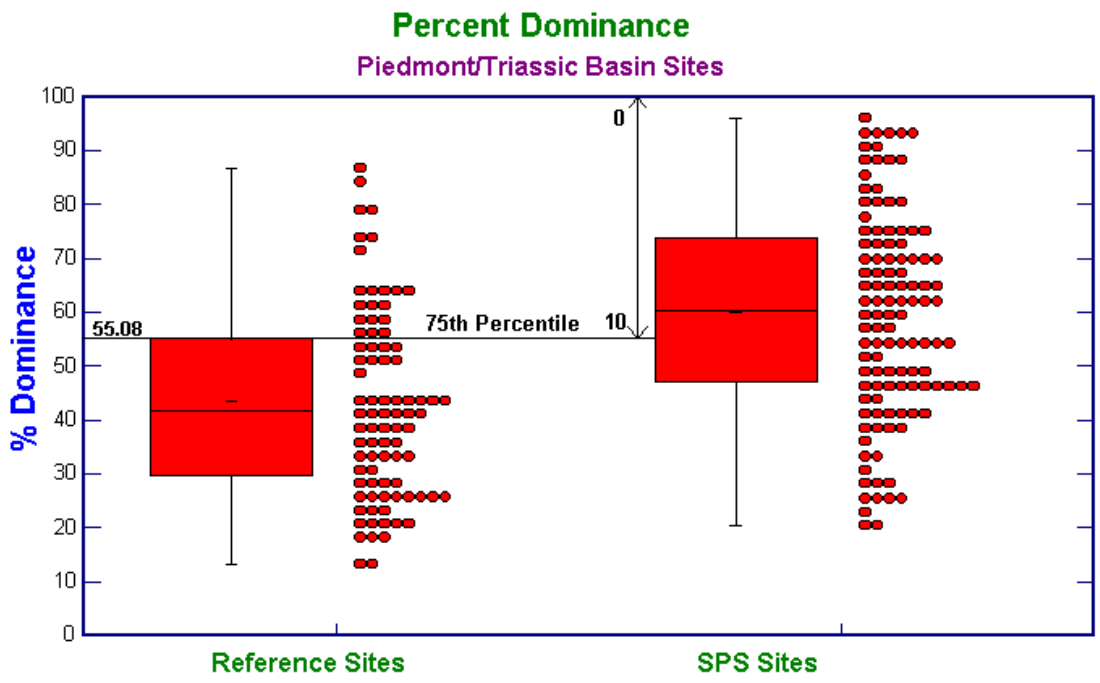


Figure B4: Box and Whisker Plot of Percent Dominance for the Piedmont.

The data for percent dominance from the Piedmont reference areas and the data were plotted against each other using a box and whisker plot. In this case, the 75th percentile from the reference data was designated as the "reference condition" value. The difference between these metrics and those from example 1 is that the best value obtainable is 0 for the metric instead of 100, and the 75th percentile of the reference data, rather than the 25th, is the 10 value on the 0 to 10 scale. In this example (Table B4), 100 percent dominance is the 0 value and 55.08 is the 10 value. In order to obtain the conversion factor, the 75th percentile value for the reference condition was subtracted from its upper limits. This value was then divided into 10 to arrive at the conversion factor. So in this example, the 75th percentile (55.08) is subtracted from the upper limit of this metric (100) to give 44.92. The final step to obtain the conversion factor is to divide 44.92 by 10, which yields 4.492. Individual values from the monitoring sites for percent dominance were then taken and subtracted from 100. Each value was then divided by the conversion factor to give the 0 to 10 value for that site (Table B5). If the value exceeded 10, the site was given a value of 10. This procedure was also followed for the coastal plain sites using the coastal plain reference data. The converted values for each site were then summed to form a 0 to 100 scale. Since the coastal plain index consisted of only 5 metrics, the summed total was doubled to give it a 0 to 100 range (Table B1).

Table B5: Metric value conversions for Example 2.

SPS Site Value	100 - SPS site	Converted Value	Final Value
59.38	40.62	9.04	9.04
49.03	50.97	11.35	10
94.44	5.56	1.24	1.24
88.79	11.21	2.50	2.50
82.14	17.86	3.98	3.98
58.74	41.26	9.19	9.19
90.70	9.30	2.07	2.07
95.83	4.17	0.93	0.93
76.87	23.13	5.15	5.15
95.88	4.12	0.92	0.92
50.72	49.28	10.97	10
49.63	50.37	11.21	10

These steps were also performed for the Coastal Plain site data. Unlike the Piedmont sites however, for which spatially and temporally broad reference information was available, the Coastal Plain sites were only compared to Kane Creek. The averaged metric scores for the two Kane Creek sites were used in lieu of the 75th percentile of aggregate reference data for the one directly correlated metric (Hilsenhoff Biotic Index).

4. 2004 Results at Individual Sites

Table B6: Index(out of 100) and ratings for the 2004 sampling locations based on benthic macroinvertebrate data.

SiteID	Stream Order	Benthic Index Score	Rating
Accotink Creek (AC0401)	3	30.07	Poor
Accotink Creek (AC0402)	3	25.62	Poor
Accotink Creek (AC0403)	1	40.71	Fair
Accotink Creek (AC0404)	2	21.26	Poor
Belle Haven (BE0401)	2	15.91	Very Poor
Cameron Run (CA0401)	2	37.48	Poor
Cameron Run (CA0402)	1	19.05	Very Poor
Cub Run (CU0401)	4	51.53	Fair
Difficult Run (DF0401)	5	85.01	Excellent
Difficult Run (DF0402)	2	53.42	Fair
Difficult Run (DF0403)	2	25.22	Poor
Difficult Run (DF0404)	1	45.25	Fair
Difficult Run (DF0405)	1	15.91	Very Poor
Difficult Run (DF0406)	1	27.34	Poor
Difficult Run (DF0407)	1	71.19	Good
Difficult Run (DF0408)	1	13.56	Very Poor
Kane Creek (KC0401)	1	37.59	Poor
Little Hunting Creek (LH0401)	1	23.43	Poor
Little Hunting Creek (LH0403)	2	13.67	Very Poor
Little Rocky Run (LR0401)	3	27.36	Poor
Little Rocky Run (LR0402)	1	30.80	Poor
Little Rocky Run (LR0403)	1	15.56	Very Poor
Nichol Run (NI0401)	1	79.37	Good
Occoquan (OC0401)	1	86.99	Excellent
Pohick Creek (PC0401)	3	17.81	Very Poor
Pohick Creek (PC0402)	1	70.08	Good
Pohick Creek (PC0403)	1	29.44	Poor
Popes Head Creek (PH0401)	2	27.86	Poor
Sugarland Run (SU0401)	4	44.76	Fair
Sugarland Run (SU0402)	1	61.16	Good

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C. FISH SAMPLING PROTOCOLS

1. Rapid Bioassessment Protocol Field Sampling Methods

Fish assemblages represent the apex of most stream communities. Fish typically are at the top of the food web and are sensitive to both natural and anthropogenic changes within a given system and are, therefore, useful indicators of stream ecosystem health. Fish are also more readily understood and appreciated by the public than are other biological components of streams systems. Therefore, they can be useful tools for developing community interest in environmental and water management issues. The methods employed were based largely upon the EPA's Rapid Bioassessment Protocols V (Barbour et al. 1999). Because of sporadic and sparse occurrence of fish assemblages in first order and intermittent headwater streams, the value and validity of using these assemblages as ecosystem health indicators is questionable. As such, all fish communities were sampled from non-tidal freshwater, perennially-flowing, second order (or greater) streams within Fairfax County.

The following equipment was used for sampling:

- Smith-Root, Model 12-B, 400 watt, backpack electrofisher (battery powered),
- 12-volt DC batteries (2 to 4) for electrofisher,
- rubber gloves (high-voltage rated, insulated),
- chest waders and belts for all participants,
- hand dip-nets, both long- and short-handled (1/8 inch mesh),
- block nets (i.e., seines),
- buckets and live car(s) for fish storage and transport,
- data sheets (Figure C1),
- data log (waterproof) and pencils,
- buffered formalin (17 percent formaldehyde),
- specimen jars,
- waterproof jar labels, and
- species key and field guide (Jenkins and Burkhead, 1994).

2. Fish Sampling, Identification, and Preservation

Using single or multiple battery powered backpack electrofishing units (Smith-Root, model 12), a single sample pass was made through the selected 100-meter reach (number of units will be dependent upon stream width and depth). A block net was deployed at the uppermost reach boundary, and the sample was conducted in the upstream direction. To minimize the risks of mortality or injury to fish, electrofisher unit settings were adjusted to reflect stream water conductivity and corresponding manufacturer recommendations.

Captured specimens were transported in water-filled buckets and maintained in a portable in-stream live car for subsequent examination. Fish were identified to the species level and the representatives in each category were enumerated and recorded. Special note was made of individuals with eroded fins, parasites, tumors, lesions, hemorrhaging, eye maladies and/or other abnormalities (see bottom of Figure C2). Upon final identification, the fish were then released back into the stream. As is the standard practice with fish sampling protocols, juvenile or young-of-year specimens, determined to be those individuals under 20 mm total length, were not counted towards the species counts. This is due to their higher mortality rates in the first year of life, as well as ambiguities (or incomplete development) in proper morphological characteristics necessary for accurate identifications in certain species.

Positive field identification is particularly difficult with some specimens, and preservation of representative individuals, in some cases, may be needed for more detailed laboratory examinations. Other specimens were preserved as part of the development a permanent reference collection of fishes found within Fairfax County. Samples were preserved in a fixative of 10 percent formalin for long-term storage. All specimen collections were carried out in accordance with the guidelines set forth in the current Virginia Department of Game and Inland Fisheries (DGIF) Scientific Collection Permit issued to Fairfax County Ecologists.

A uniform fish sampling data sheet is used during the fish sampling session (Figures C1 & C2) for all county streams.

Figure C1: Fish sampling field data sheet (front).

RBP Coastal Plain Assessment Scores	
Parameter	**Score**
1) Epifaunal Subs./Available Cover	_____
2)Pool Substrate Characterization	_____
3) Pool Variability	_____
4) Sediment Deposition	_____
5) Channel Flow Status	_____
6) Channel Alteration	_____
7) Channel Sinuosity	_____
8) Bank Stability	RB:_____
	LB:_____
9) Bank Veg. Prot.	RB:_____
	LB:_____
10) Rip. Veg. Zone Width	RB:_____
	LB:_____

RBP Piedmont Assessment Scores	
Parameter	**Score**
1) Epifaunal Substrate	_____
2) Embeddedness	_____
3) Velocity-Depth Regimes	_____
4) Sediment Deposition	_____
5) Channel Flow Status	_____
6) Channel Alteration	_____
7) Frequency of Riffles (or Bends)	_____
8) Bank Stability	RB:_____
	LB:_____
9) Bank Vegetative Protection	RB:_____
	LB:_____
10) Rip. Veg. Zone W.	RB:_____
	LB:_____

Water quality	
Temperature	_____
% saturation:	_____
Dissolved oxygen	_____
Conductivity	_____
Specific conductance	_____
pH	_____
Turbidity	_____

Category	Value
# of tree falls	_____
# fish barriers	_____
# of large point bars	_____
# of log jams	_____

Weather Conditions	Today:	storm/heavy rain	showers (intermittent)		partly cloudy	
		rain (steady)	sunny	partly sunny		cloudy (overcast)
	Past 24 hrs:	storm/heavy rain	showers (intermittent)		partly cloudy	
		rain (steady)	sunny	partly sunny		cloudy (overcast)
	Has there been a heavy rain in the past 7 days?		Yes	No		
	Estimated Air Temperature_____					

Riparian zone/ instream features	**Predominant Surrounding Landuse**			**Local water erosion**		
	forest	commercial		none	moderate	heavy
	field/pasture	industrial				
	agricultural	other_____		**Channelized**	yes	no
	residential	other_____				
	Canopy cover			**Local watershed NPS pollution**		
	open	moderate	shaded	no evidence	potential sources	obvious sources

Water	Odors:	normal	sewage	fishy	petroleum	chemical	other_____
	Oils:	none	sheen	globs	slick	flecks	other_____
	Color:	clear	greenish	brownish	other_____		

Comments:

Figure C2: Fish sampling field data sheet (back).

Date:	**Sampling start time:**	**Number of Electorfisher units:**
Site Code:	**Sampling finish time:**	**Gear:** block nets (1/4" mesh) size _____, dipnets (1/8" mesh), backpack electrofisher(s), buckets, livewell(s)
Stream Name:	**Recorder:**	
Stream Order:	**Electrofisher operator(s):**	
Drainage basin:	**Investigators:**	**Electrofisher settings:**
Protocol: EPA RBP		

Species	**Number of Individuals** (Record with tally marks)	**Total**	**Comments**
Ameiurus natalis			
Ameiurus nebulosus			
Anguilla rostrata			
Campostoma anomalum			
Catostomus commersoni			
Clinostomus funduloides			
Cyprinella spiloptera			
Cyprinella analostana			
Erimyzon oblongus			
Etheostoma olmstedi			
Etheostoma flabellare			
Exoglossum maxillingua			
Fundulus diaphanus			
Gambusia holbrooki			
Hypentelium nigricans			
Lampetra aepyptera			
Lepomis auritus			
Lepomis cyanellus			
Lepomis gibbosus			
Lepomis macrochirus			
Lepomis microlophus			
Luxilus cornutus			
Micropterus salmoides			
Nocomis micropogon			
Notemigonus chrysoleucas			
Notropis hudsonius			
Notropis procne			
Noturus insignis			
Pimephales notatus			
Rhinichthys atratulus			
Rhinichthys cataractae			
Semotilus atromaculatus			
Semotilus corporalis			
	Grand Total:		

D=deformity, E=eroded fin, L=lesion, T=tumor, F=fungus, W=wound, I=eye malady, H=hemorrhage, P=parasite

3. Development of a Fish Index of Biotic Integrity for Fish

Fish species were first classified into groups including trophic guilds and tolerance values. Karr et al. (1986) recommended that less than 10 percent of a community be labeled “intolerant” and Karr and Chu (1997) furthered defined that by recommending that 5 – 15 percent of species in a community be designated as tolerant or intolerant. Designations of tolerant or intolerant in Fairfax County were based on field observational data. Trophic and habitat classifications were based on the literature (Smogor 1999, and Teels 2001)(Table C1).

An extensive suite of candidate metrics were evaluated based on trophic characteristics, tolerance, and community structure, and each was then assessed for its usefulness in developing an Index of Biotic Integrity for fish. Metrics and scoring criteria that were tested were similar to those tested by Billy Teels whose work was completed in the Occoquan watershed in 2001 (Teels 2001). In addition metrics and scoring criteria used by the statewide Maryland Biological Stream Survey were also tested (Southerland, personal communication). Metrics were chosen on their ability to correlate with imperviousness, and their ability to distinguish between most impaired sites from least impaired sites (Figure C3).

Studies have shown that there is a significant difference in fish assembalages in the Coastal Plain versus the Piedmont (Smogor 1999, and Roth et al. 2000). A small portion of Fairfax County is in the Coastal Plain, but there are few undisturbed or reference areas available in this small portion. The fish index for the Coastal Plain will be based on metrics and scoring criteria used in Maryland Coastal Plain streams (Southerland, personal communication)(

Table C2). The scoring criteria for the “percent tolerant” metric was adjusted because differences in number of species designated as tolerant between the studies. Metrics used for Piedmont streams are similar to those used by Teels. Scoring criteria was based on 1999 data and was determined using the tri-sectioning method as detailed by Fausch et al. (1984) and Karr (1986) and results are similar to Teels (Figure C4). Further refinement of the metrics and/or scoring criteria could occur in the future as more data is collected particularly for the Coastal Plain.

Classification ratings were based on the maximum and minimum score and five categories were created from the difference. There was no “Excellent” category for Coastal Plain streams because it was known that a stream in the Coastal Plain isn’t in “Excellent” condition because attempts were made to find one for a reference location (Table C3).

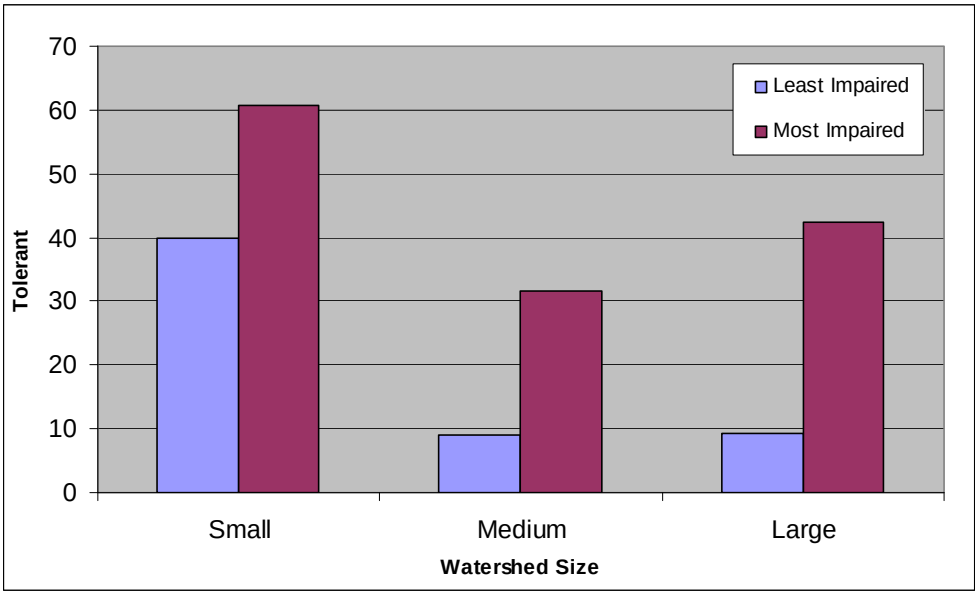
The results of the fish community analysis for 1999 are presented here because the analysis was not previously presently (Figure C5, Figure C6).

Table C1: Trophic guilds and tolerance ratings for fish species found within Fairfax County.

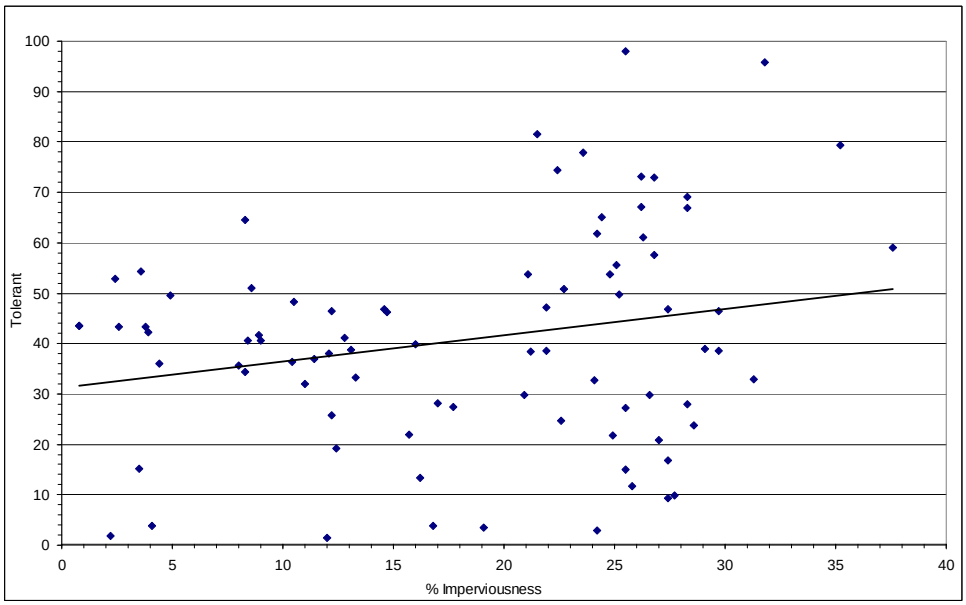
Abbreviations for tolerance ratings are as follows: T = Tolerant, M = Moderate, I = Intolerant. Abbreviations for trophic guilds are as follows: AHI –algivore/herbivore/invertivore, DAH – detritivore/algivore/herbivore, INV – invertivore, IP – invertivore/piscivore, PIS – piscivore.

CommonName	FamilyType	Tolerance	TrophicGuild	Non-Native	Benthic	Lithophils
Least Brook Lamprey	Lamprey	M	DAH			
American Eel	Eel	M	IP			
Alewife	Herring	M	AHI			
Gizzard Shad	Herring	M	AHI			
Chain Pickerel	Pike	M	PIS			
Eastern Mudminnow	Mudminnow	M	INV			
Common Carp	Minnow	T	AHI	X		
Goldfish	Minnow	T	AHI	X		
Golden Shiner	Minnow	T	AHI			
Rosyside Dace	Minnow	I	INV			X
Fallfish	Minnow	M	IP			
Creek Chub	Minnow	M	IP			
River Chub	Minnow	M	IP		X	
Cutlips Minnow	Minnow	I	INV			
Blacknose Dace	Minnow	T	INV			X
Longnose Dace	Minnow	M	INV		X	
Central Stoneroller	Minnow	M	DAH			X
Eastern Silvery Minnow	Minnow	M	AHI			
Common Shiner	Minnow	M	INV			X
Satinfin Shiner	Minnow	M	INV			X
Spotfin Shiner	Minnow	M	INV			
Bluntnose Minnow	Minnow	T	AHI	X		
Fathead Minnow	Minnow	T	AHI	X		
Comely Shiner	Minnow	M	INV			X
Spottail Shiner	Minnow	M	INV			
Swallowtail Shiner	Minnow	M	INV			X
Silverjaw Minnow	Minnow	M	AHI			X
White Sucker	Sucker	T	AHI			X
Creek Chubsucker	Sucker	M	INV		X	
Northern Hogsucker	Sucker	I	INV		X	X
Shorthead Redhorse	Sucker	M	INV	X	X	X
Blue Catfish	Catfish	M	IP	X		
Channel Catfish	Catfish	M	IP	X		
Yellow Bullhead	Bullhead	M	IP			
Brown Bullhead	Bullhead	M	IP			
Margined Madtom	Madtom	M	INV			
Banded Killifish	Killifish	M	INV			
Mummichog	Killifish	M	INV			
Mosquitofish	Livebearer	M	INV			
Potomac Sculpin	Sculpin	I	INV		X	
White Perch	Striped Bass	M	IP			
Redbreast Sunfish	Sunfish	M	IP			
Green Sunfish	Sunfish	M	IP	X		
Pumpkinseed Sunfish	Sunfish	M	INV			
Warmouth	Sunfish	M	IP	X		
Bluegill	Sunfish	M	INV	X		
Longear Sunfish	Sunfish	M	INV	X		
Redear Sunfish	Sunfish	M	INV	X		
Smallmouth Bass	Black Bass	M	PIS	X		
Largemouth Bass	Black Bass	M	PIS	X		
Black Crappie	Sunfish	M	IP	X		
Tessellated Darter	Darter	M	INV		X	
Fantail Darter	Darter	M	INV		X	
Greenside Darter	Darter	M	INV	X	X	
Shield Darter	Darter	I	INV		X	X
Yellow Perch	Perch	M	IP			

Figure C3: An example of the analysis completed to chose metrics for the Piedmont for metric #3, Percent Tolerant, for the Index of Biotic Integrity based on fish.



A) Watershed size versus the percentage of the sample tolerant individuals. Least impaired sites have less than 5% imperviousness and most impaired have greater than 25%. Average size for small watersheds is 7 km^2, medium 24 km^2, and large 56 km^2.



B. Correlation between percentage of the sample as tolerant individuals and percent imperviousness in the watershed.

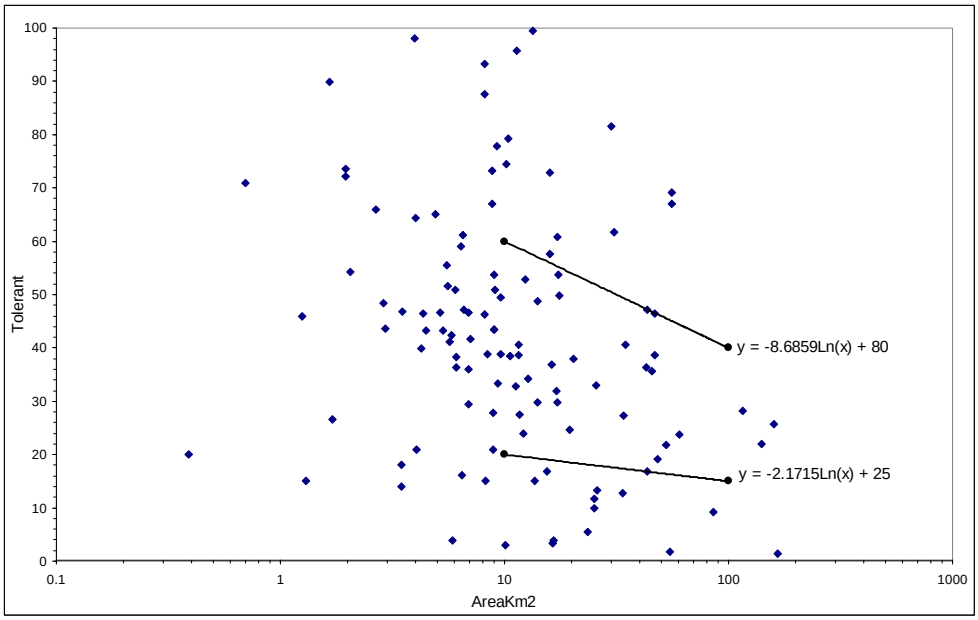


Figure C4: Example of tri-sectioning completed for metrics in the Piedmont.

Table C2: Scoring criteria for Fish Index of Biotic Integrity.

Piedmont	1	5
1. Number of Native Species	< 1.7648Ln(x) + 2.1597	> 2.3922Ln(x) + 5.1659
2. Number of Darter Species	<2	>2
3. Percent Tolerant	> -8.6859Ln(x) + 80	< -2.1715Ln(x) + 25
4. Number of Intolerant Species	<2	>2
5. Percent Generalists (AHI)	> -2.1715Ln(x) + 35	< 10
6. Percent Benthic Invertivores	< 2.1715Ln(x)	> 2.1715Ln(x) + 15
7. Percent Carnivores (IP + PIS)	< 2.1715Ln(x)	> -1.3029Ln(x) + 28
8. Percent Lithophils	< 20	> 40
9. Percent Anomalies	> 2	0
Coastal Plain		
1. Percent Tolerants	> -8.6859Ln(x) + 80	< -2.1715Ln(x) + 25
2. Percent Omnivores and Invertivores (AHI, DAH, and INV)	100	<= 92
3. Percent Non-tolerant Suckers	0	>= 2
4. Percent Dominant Species	> 69	<=40

x is watershed area in kilometers squared

Table C3: Classification rating for the Fish Index of Biotic Integrity.

Piedmont	Coastal Plain	RATING
> 34	-	Excellent
30 to 34	>17	Good
25 to 29	14 – 17	Fair
20 to 24	10 - 13	Poor
< 20	< 10	Very Poor

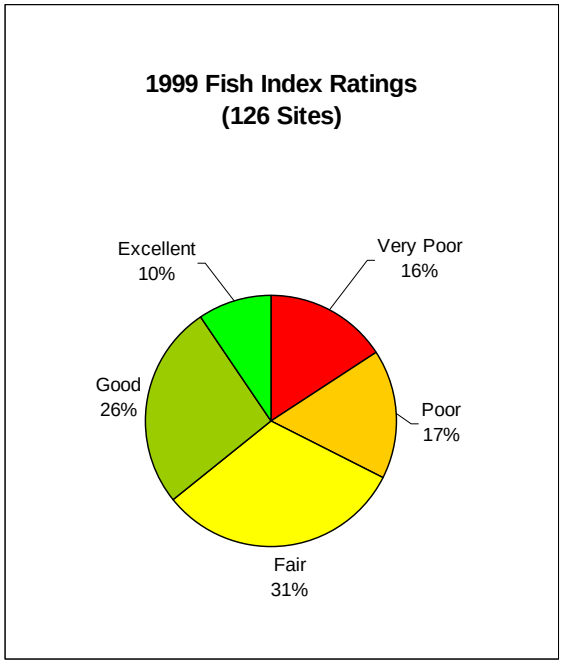
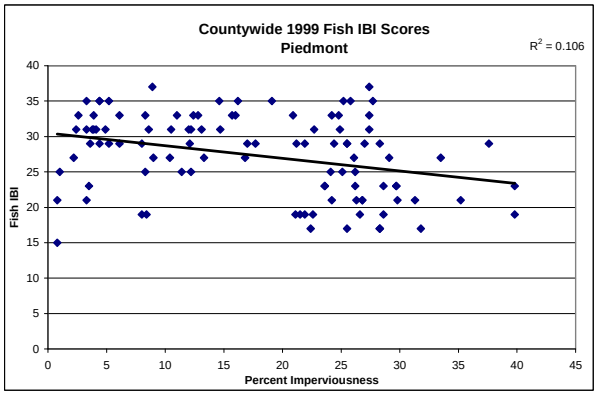
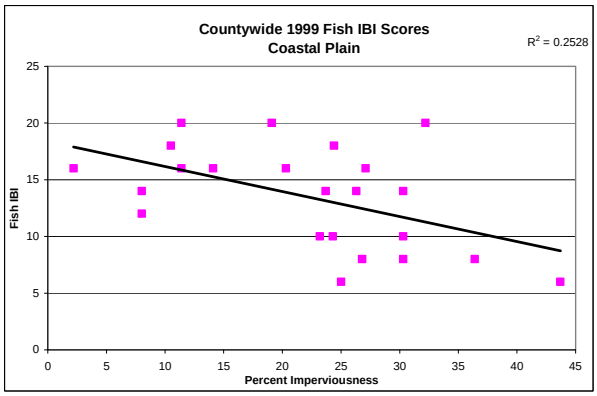


Figure C5: Ratings of 1999 biomonitoring sites for the Fish Index of Biotic Integrity.



A. Piedmont



B. Coastal Plain

Figure C6: Correlation between the Fish Index of Biotic Integrity and imperviousness based on the 1999 data.

4. 2004 Results at Individual Sites

Large differences in the percentage of sites score of the fish index between the 1999 and 2004 sampling seasons can be explained by the change in method of determining the sampling locations. The 2004 sites were randomly selected throughout the county resulting in a larger quantity of impaired sites whereas the 1999 sites were targeted to ensure a sampling location in all watersheds.

Table C4: Fish Index of Biotic Integrity and ratings for the 2004 sampling locations based on fish community data.

SiteID	Physiographic Province	Stream Order	Fish Index Score	Rating
AC0401	Piedmont	3	23	Poor
CU0401	Piedmont	4	17	Very Poor
DF0401	Piedmont	5	27	Fair
DF0402	Piedmont	2	29	Fair
DF0403	Piedmont	2	23	Poor
LR0401	Piedmont	3	25	Fair
PC0401	Piedmont	3	29	Fair
PH0401	Piedmont	2	23	Poor
SU0401	Piedmont	4	29	Fair
AC0402	Coastal Plain	3	8	Very Poor
AC0404	Coastal Plain	2	8	Very Poor
BE0401	Coastal Plain	2	12	Poor
CA0401	Coastal Plain	2	6	Very Poor
LH0403	Coastal Plain	2	8	Very Poor

References

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D. BACTERIA MONITORING PROTOCOL

1. Sampling Location and Methods

Sampling stations for the original Health Department bacteria monitoring program are located on the major streams and their main tributaries. Only 25 out of the 30 watersheds in Fairfax County have established sampling locations as, according to the Health Department Stream Water Quality Report, "five watersheds are small and do not contain any well-defined streams; therefore, these are excluded from the program." These five watersheds are Ryans Dam, Occoquan, Kane Creek, High Point, and Belle Haven. Four out of these five watersheds are in the down-zoned area along the Occoquan. The statement from the Health Department report and sampling scheme may be a legacy left over from when the bacteria sampling program started and access to streams within smaller watersheds may have been difficult and too time consuming. The sample station identification number is a two-part number identifying the watershed and the sample site. There are gaps in the sequential numbering system due to additions and eliminations of sample sites over several years. In 2004, there were a total of 80 sampling sites which were divided into nine sampling zones which were then sampled four times a year. The stream sample site locations have been evaluated for run-off potential and possible sources of pollution. The sites are located on tax maps and diagrams of the sites are available for reference. Past Stream Water Quality Reports and data can be found at:

http://www.fairfaxcounty.gov/service/hd/strannualrpt.htm#data.

2. Equipment Requirements

The following field equipment is required for bacteria monitoring:

- Data sheet (see Figure D-2) and pencils
- Nasco Whirl-pak, sterilized water sampling bags
- Sterile 500 ml plastic bottles
- Meters (YSI 85, YSI 556, and Accument Portable pH meters)
- Cooler with ice

3. Laboratory Procedures

All water samples are kept on ice and brought to the Health Department lab within six hours for analysis. The Stormwater Planning Division does not perform any laboratory analysis. All laboratory procedures used to determine concentrations of various parameters are defined in "Standard Methods for the Analysis of Water and Wastewater, 18th Edition", 1992. The fecal coliform procedure utilizes the Millipore filter and gives a direct count per 100 ml of sample. The determination of *E. coli* also uses a membrane filter to give a direct count per 100 ml of samples. The nitrate nitrogen is determined by the automated cadmium reduction method and phosphates are determined by persulfate digestion followed by the ascorbic acid colorimetry.

Figure D1: Example field data sheet for bacteria monitoring (front).

Water Chemistry: Streams Bacteriological Study

Fairfax County Health Dept, Laboratory
10777 Main St., #301, Fairfax, VA 22030

Sampling Zone 1
Report Results to: Danielle Derwin; 703-324-5616

Date Collected: _____
Collected by: _____
Team # _____
Meter type: _____

FIELD RESULTS

Sample ID #	*Point of Collection*	*Address/ Location*	*Time of Sample*	*pH*	*Sample Temp (°C)*	*Dissolved Oxygen (mg/L)*	*Specific Conductance (µS/cm)*
5-15	stream-Hickory Run (Difficult Run)	Roos Trail off of Manning St.					
5-16	stream-Difficult Run	Georgetwon Pike, near Difficult Run Park					
4-1	stream-Mine Run Branch (Pond Branch)	River Bend Road					
4-2	stream-Clarks Branch (Pond Branch)	Club View Drive					
4-3	un-named stream going into the Potomac (Pond Branch)	Blackberry Lane					
3-3	stream-Nichols Run	Springvale Road					
3-4	stream-Nichols Run	Beach Mill Road					
2-3	stream-Sugarland Run	near Intersection of Rt. 7 and Dranesville Rd.					
2-2	stream-Folly Lick Branch (Sugarland Run)	Cliveden Street					
2-4	stream-Sugarland Run	Spring St., in Sunset Business Park					

COMMENTS

Figure D2: Example field data sheet for bacteria monitoring (back).

Sample ID #	Lab Assigned Sample ID #	Sample ID #	Lab Assigned Sample ID #
5-15		3-3	
5-16		3-4	
4-1		2-3	
4-2		2-2	
4-3		2-4	

References

Fairfax County Health Department. 2002. Stream Water Quality Report. 48pp.

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VDEQ. 2004. Virginia Water Quality Standard. 175pp.

E. VOLUNTEER MONITORING PROTOCOLS

There are two established programs for concerned citizens interested in volunteer stream monitoring in Fairfax County. The Audubon Naturalist Society, which coordinates a local program through the Webb Sanctuary in Clifton, Virginia, and the Northern Virginia Soil and Water Conservation District. The following pages consist of general and detailed volunteer monitoring instructions and the official data forms for the two organizations. The Northern Virginia Soil and Water Conservation District material is presented first, followed by the Audubon Naturalist Society forms. For even more detailed protocols or other general information call (703) 324-1425 to reach the Northern Virginia Soil and Water Conservation District or (301) 652-9188 to reach the Audubon Naturalist Society.

The Northern Virginia Soil and Water Conservation District's volunteer stream-monitoring program uses the Virginia Save Our Streams protocol. Compared with the Save Our Streams protocol developed by the Issak Walton League, this protocol consists of fine-tuning of the taxa tolerance ratings, such as the separation of net-spinning caddisflies from other less tolerant forms. The protocol also uses actual counts of insects, allowing a better definition of the community structure. Lastly, a quantitative multi-metric-index has been developed similar to the Benthic Index of Biotic Integrity to give an overall quantitative ranking of stream health.

In addition to learning about stream monitoring, many volunteers also become involved in watershed groups, clean-up programs, and educational programs. Newsletters and calendars are sent to about 700 people and forwarded to hundreds more, a very effective way to reach large numbers of existing and potential monitors.

Over 700 volunteers have participated in collecting data. Certified data is forwarded to Fairfax County, Department of Environmental Quality, Virginia Save Our Streams, and other interested organizations or individuals.

The Northern Virginia Soil and Water Conservation District would like to recognize the following outstanding volunteers: Blythe Merritt has been star volunteer for more than 5 years. Blythe not only monitors her healthy site on Cub Run, but also assists at many additional sites every season. Blythe introduces many new monitors to the joys of stream monitoring. She is active in watershed planning and stream cleanups.

Ivy Main and her daughter Llewelyn have been monitoring their backyard stream for more than 5 years. They usually include other family members and friends. Llewelyn is one of our younger monitors and has been certified since the age of 10.

Deana Crumbling and Jim McGlone found love as a result of being very dedicated stream monitors. Together, they monitor four sites and have volunteered hundreds of hours. Deana was our volunteer coordinator before a paid position was created.

Ivy Main and family

Deana Crumbling and Jim McGlone, who met through volunteer monitoring

The Audubon Naturalist Society uses a modified version of the U.S. EPA Rapid Bioassessment Protocol for benthic macroinvertebrates. They also combine visual habitat assessment with the benthic sampling. Invertebrates are identified to family, where possible, or to the highest taxonomic resolution practicable. Currently, the protocol does not include a biological rating system. Plans are underway to incorporate an Index of Biotic Integrity-type rating system into the protocol. This would allow much more direct comparison with professional data.

Renee Kitt, Audubon Naturalist Society Volunteer Coordinator (blue hat). (photo ANS)

Without the dedication and hard work of the volunteer water quality monitors, Audubon Naturalist Society would be unable to consistently collect high-quality data on local streams. Monitors also serve as ambassadors for streams to the larger community by sharing their experiences, knowledge, and concern with families, co-workers, and friends. Audubon Naturalist Society would like to recognize the following monitors active in Fairfax County:

Leslie Burke, Nancy Byrd, Bob Cantor, Amanda Hencken, Renee Kitt, Martha Lang, Virginia Lathrop, Bret Leslie, Peter Mecca, Blythe Merritt, Kurt Moser, Jerry Odhner, Lee Regan, Linda Rosen; Sandy and John Schaeffer, Jeff Schuman, Charles Smith, Neil Sullivan, and Karen Waltman.

Fairfax County Volunteer Stream Monitoring Program

Coordinated by the Northern Virginia Soil and Water Conservation District

VA Save Our Streams

Stream Quality Survey
Rocky Bottom Method

Biological Monitoring Directions

1. Place the net perpendicular to the flow of water immediately downstream of the sampling area. Remember that the area you are sampling and the duration is dependant on the abundance of life in your stream. You can sample areas of: 1 by 1 foot, 2 by 2 foot, or 3 by 3 foot. You can sample from 20-90 seconds. You take a maximum of 4 samples. If you are unsure, please ask for help.
2. Weight down the bottom of the net with rocks.
3. Sample the area for 20-90 seconds.
   - (adjustable - remember the goal is 200 bugs).
   - To sample, lift and rub underwater all large rocks.
   - Dig around in the small rocks and sediments to dislodge any burrowing macroinvertebrates.
4. After sampling, carefully rub off any rocks used to anchor the net.
5. Remove the net with an upstream scooping motion to keep all the macroinvertebrates in the net.
6. Place the net on a flat, light colored surface. Pick all the organisms off the net into the ice-cube tray.
7. Once all the macroinvertebrates are removed from the seine, count the number of organisms in the sample. If at least 200 organisms have not been sampled, another net must be collected from a different area in the same riffle or nearby riffle. The organisms from the second net will be added to the first. The length of sampling time can be adjusted depending on the number of organisms collected in the first, with the maximum sampling time per net being 90 seconds.
8. This process is repeated until at least 200 organisms are found or 4 nets are collected, whichever is first. Each net collected must be sorted in its entirety, even if that leads to a sample of well over 200 organisms.

REMEMBER THAT THE GOAL IS TO GET 200 BUGS or more.

Chemical Monitoring Directions
Hach Nitrate/Nitrite Test Strip Instructions

Prepared by Deana Crumbling

The Hach Test Strip is a quick, simple, and safe way to estimate the concentration of nitrate and nitrite in stream water. Nitrate (NO3-) and nitrite (NO2-) are forms of inorganic nitrogen that are very soluble in water and are readily taken up by plants. Nitrate is more common in streams than

nitrite. The nitrite result will usually be "0" in streams unless the stream is being heavily impacted by a pollution source. Once in a while the nitrate result may be "0", but usually the result will be "0-1". The nitrate result may be higher than 1, especially if the water sample is taken when (or where) there is a lot of runoff entering the stream. Results higher than 5 should be double-checked, and reported for a follow-up investigation.

Increased amounts of nutrients in surface water cause algae blooms, which in turn cause other problems for streams. Increased levels of nutrients in Fairfax County streams reach the Chesapeake Bay where they contribute to the destruction of Bay habitat and fisheries.

In Fairfax County (where agriculture has been largely replaced by suburban development), fertilizer runoff (from lawns and golf courses) is the predominant source of nitrate to streams. The presence of nitrate from fertilizer also indicates that other applied lawn chemicals directly toxic to stream ecosystems, such as herbicides and insecticides, may be running off into streams. Another chronic source of nitrate addition is the atmospheric deposition of automobile emissions to impervious surfaces. Stormwater runoff then carries the excess nutrients directly into streams.

Leakage from sewer lines running alongside or under streams can cause very high levels of nitrate, and the nitrate can be used as a marker to localize the leak. Septic systems can also leak nitrate into nearby streams. Sewage leaks can contribute harmful bacteria and viruses to streams that drain into drinking water reservoirs.

Directions

1. Be sure to replace the cap immediately when removing a strip from the bottle. The test strips are sensitive to moisture in the air.
2. Hold a test strip by the bare end. When dipped in water containing these nitrogen species, the pads will develop a pink color, which is matched to the color blocks on the outside of the bottle. Do not hold a wet test strip against the bottle. The water will ruin the color blocks and make them difficult to read.
3. A test strip is dipped into the water for 1 second. You can collect a fresh water sample in a clean container or dip the strip directly into the stream.
4. Time for 30 seconds and then look at the nitrite test pad on the strip. If there is no pink color, the test is negative, and the result can be recorded by circling the "0" in the nitrite row. If there is pink color, but it is not as dark pink as the 0.15 color block, circle the "0-0.15" option on the Sheet. If the pink color looks exactly the same as the 0.15 color block, circle the "0.15" option on the Sheet, and so on. At 60 seconds after dipping the strip, match up the nitrate test pad in the same way, and circle the appropriate option on the Sheet.

Chemical Monitoring Directions
Turbidity Instructions
Prepared by Deana Crumbling

Turbidity is the measure of the cloudiness of water. It is important because…

Remember: It is more accurate to perform the test immediately at stream-side. To do so, you must take along a small bottle of tap water.

1. Fill one of the cylinders to the 50 mL mark with stream water and the other with tap water. If the water appears very turbid/cloudy, fill the cylinders only to the 25 mL mark.
2. SHAKE the bottle of Standard Turbidity Reagent vigorously to resuspend the latex particles in the reagent.
3. To the cylinder containing TAP WATER, use the dropper to add Standard Turbidity Reagent in 0.5 mL increments-(NOT drop-by-drop). Add 1 squirt of 0.5 mL Reagent, then use the plastic stirring rod to mix.
4. Compare the fuzzy appearance of the black dot at the bottom of the tap water cylinder with the dot in the stream water cylinder (DO NOT try to match the color-the latex particles are white and will never match the brownish or greenish tint of most stream water). The goal is to add enough of the Standard to the tap water so that the cloudiness (as judged by the appearance of the black dots) of the tap water is made to match that of the stream water.
5. Count the number of "squirts" required to get a match. Read the turbidity (in units called JTU) off the chart on the kit's package insert/directions. Make sure you read off the correct column-one column is for use with a 50-mL volume, the other column is for a 25-mL volume.
6. On the reporting sheet, fill in the result and the number of squirts and test volume used. Examples: 15 JTU (3 squirts/50 mL) or 30 JTU (3 squirts/25 mL)
7. If the stream water looks just as clear as the tap water, report the result as "less than 2.5 JTU" by circling that option on the SOS Report Sheet.
8. If the stream water looks a little more cloudy than the tap water at the start, but when you add 1 squirt of turbidity reagent it looks like the tap water column becomes much cloudier than the stream water, report the result as "about 2.5 JTU" by circling that option on the Sheet.

Tip: If you are not sure if you have a match, add another squirt of turbidity reagent. If you can see that you've "gone ever," you can feel sure that the previous number of squirts was indeed the correct number.

Note: You may interpolate your result, if you wish. For example, if the match seems like it was between squirts 2 and 3 for a 50 mL volume, you could report the result as " ~12.5 JTU" (which means "about half-way between 10 and 15 JTU"). Or you could use the higher number (15 JTU) or the lower number (10 JTU), whichever one you feel is closest to the match. Any of these choices is acceptable, since the turbidity measurement is only an estimate.

Turbidity Test Results

Number of Measured Additions	Amount in mL	50 mL Graduation	25 mL Graduation
1	0.5	5 JTU	10 JTU
2	1.0	10 JTU	20 JTU
3	1.5	15 JTU	30 JTU
4	2.0	20 JTU	40 JTU
5	2.5	25 JTU	50 JTU
6	3.0	30 JTU	60 JTU
7	3.5	35 JTU	70 JTU
8	4.0	40 JTU	80 JTU
9	4.5	45 JTU	90 JTU
10	5.0	50 JTU	100 JTU
15	7.5	75 JTU	150 JTU
20	10.0	100 JTU	200 JTU

Submission of Data

You have plenty of choices for your convenience.

Regular mail:
Northern Virginia Soil and Water Conservation District
Attn: Volunteer Stream Monitoring Coordinator
12055 Government Center Parkway, Suite 905
Fairfax, VA 22035

Email:
You can scan the forms if you have access to a scanner and send them as an attachment.
jarcisze@gmu.edu

You can use the Excel spreadsheet and email that as an attachment to jarcisze@gmu.edu.

You can type into the Word document and email that as an attachment to jarcisze@gmu.edu.

Fax:
You may fax the form to the number: (703) 324-1421

Figure E1: Data sheet for the Volunteer Stream Monitoring (front).

Fairfax County Volunteer Stream Monitoring Program

Coordinated by the Northern Virginia Soil and Water Conservation District

VA Save Our Streams Stream Quality Survey

Rocky Bottom Method

For Office Use Only
Name of Reviewer_____

Date Reviewed_____

Data Sent To_____

The purpose of this form is to aid you in gathering and recording important data about the health of your stream. By keeping accurate and consistent records of your observation and data from your macroinvertebrate count, you can document changes in water quality. When conducting rocky bottom sampling, select a riffle where the water is not running too fast, the water depth is between 3-12 inches, and the bed consists of cobble-sized stones (2 to 10 inches) or larger.

Stream_____ Station #_____ # of Participants_____

County_____ State_____ Latitude_____ Longitude_____

Location (please be specific) _____

Names of Participants_____

Name of Certified Monitor_____

Weather Conditions Last 72 Hours_____

Date_____ Stream (water) width_____ft Channel (bank-to-bank) width_____ft

Start Time_____ End Time_____ Stream Flow Rate: High_____ Normal_____ Low_____ Negligible_____

Water depth in riffle _____ in. Average stream depth_____ft Water temp_____ °F or °C Air temp_____ °F or °C

Biological Monitoring Collection Times

Collection Time:

Net 1:_____sec Area sampled:_____

Net 2:_____sec Area sampled:_____

Net 3:_____sec Area sampled:_____

Net 4:_____sec Area sampled:_____

Comments related to sampling:

_____

_____

_____

_____

_____

Chemical Tests (refer to NVSWCD instructions as needed):

Nitrite/Nitrate Test Strip Results (circle)	LaMotte Kit **Turbidity** Results, JTU (circle)
Nitrite Nitrogen, ppm (mg/L): 0 0-0.15 0.15 0.15-0.3 0.3 >0.3	Vol: 25 or 50 mL <2.5 ~2.5 5 10 15 20
Nitrate Nitrogen, ppm (mg/L): 0 0-1 1 1-2 2 2-5 5 >5	# squirts: _____ 25 30 35 other: _____

Are there any discharging pipes? ☐ No ☐ Yes If yes, how many? _____

What types of pipes are they? ☐ Sewage treatment ☐ Runoff (field or stormwater) ☐ Industrial: type of industry _____

Describe types of trash in and around the stream.

_____

Provide comments to indicate what you think are the current and potential future threats to your stream's health. Feel free to attach additional pages or photographs to better describe the condition of your stream. _____

_____

_____

_____

Figure E2: Data sheet for the Volunteer Stream Monitoring (back).

HABITAT ASSESSMENT
NORTHERN VIRGINIA SOIL AND WATER CONSERVATION DISTRICT
VOLUNTEER STREAM MONITORING PROGRAM

Fish Water Quality Indicators:
☐ scattered individuals
☐ scattered schools
☐ trout (pollution sensitive)
☐ bass (somewhat sensitive)
☐ catfish (pollution tolerant)
☐ carp (pollution tolerant)

Barriers to Fish Movement:
☐ beaver dams
☐ man-made dams
☐ waterfalls (>1ft)
☐ other
☐ none

Salamanders:
☐ present
how many? _____
☐ none

Stream: _____
Station #: _____
Date: _____

Surface Water Appearance:
☐ clear
☐ clear, but tea-colored
☐ colored sheen (oily)
☐ foamy
☐ milky
☐ cloudy/turbid
☐ muddy
☐ other _____

Stream Bed Deposit (Bottom):
☐ gray
☐ orange/red
☐ yellow
☐ black
☐ brown/tan
☐ silty/muddy
☐ sandy
☐ other_____

Odor:
☐ rotten eggs
☐ musky
☐ oil
☐ sewage
☐ other_____
☐ none

Stability of Stream Bed:
Bed sinks beneath your feet in:
☐ no spots
☐ a few spots
☐ many spots

Coverage of Stream Bank by Plants, Rocks, Logs, etc. (vs. exposed soil):	Good	Fair	Poor
	(>70%)	(30-70%)	(<30%)
- Stream banks (sides)	☐	☐	☐
- Top bank (slope and floodplain)	☐	☐	☐

Algae Located:
☐ everywhere
☐ in spots
_____% of bed covered
☐ none

Algae Color (if present):
☐ light green
☐ dark green
☐ brown coated
☐ matted on stream bed
☐ hairy/filamentous

Describe Stream Bank sides and Top: (Mostly shrubs or trees or paved or soil)
_____
_____
_____
_____
_____

Stream Channel Shade:
☐ >80% excellent
☐ 50% - 80% high
☐ 20% - 49% moderate
☐ <20% almost none
☐ <20% winter/leaf off

Stream Bank Erosion:
☐ >80% severe
☐ 50% - 80% high
☐ 20% - 49% moderate
☐ <20% almost none

Pebble Count Results (optional)
100 pebble count
_____ # silt (< 1/4" grains)
_____ # sand (1/16" - 1/4" grains)
_____ # gravel (1/4" - 2" stones)
_____ # cobbles (2" - 10" stones)
_____ # boulders (>10" stones)

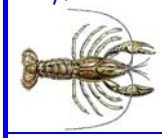
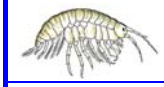
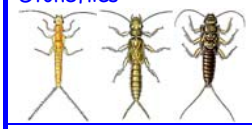
Land Uses in the Watershed: Look at a map. Walk your stream in your area. Record all land uses in the watershed area upstream and surrounding your site. Indicate whether these land uses have a High (**H**), Moderate (**M**), Slight (**S**), or No (**N**) potential (even if present) to impact the quality of your stream. If the land use is not present in your watershed, record **NP** for Not Present. Leave blank if unsure.

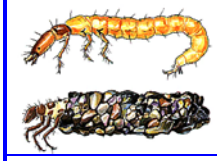
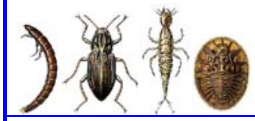
____ Housing Developments
____ Forest
____ Logging
____ Urban Uses (e.g., parking lots, highways, etc.)
____ Sanitary Landfill
____ Active Construction
____ Cropland
____ Recreation
____ Trash Dump
____ Fields
____ Livestock Pasture
____ Other _____
_____

Please return completed form to: Northern Virginia Soil & Water Conservation District
12055 Government Center Parkway, Suite 905, Fairfax, Virginia 22035
Phone: (703) 324-1425 Fax: (703) 324-1421
Jarcisze@gmu.edu

Figure E3: Field sheet for the Volunteer Stream Monitoring (1 of 3).

Virginia Save Our Streams Macroinvertebrate Tally Sheet

Macroinvertebrates	Tally	Count
Worms		
Flat Worms		
Leeches		
Crayfishes 		
Sowbugs		
Scuds 		
Stoneflies 		
Mayflies		
Dragonflies and Damselflies		
Hellgrammites, Fishflies, and Alderflies		

Macroinvertebrates	Tally	Count
Common Netspinner Caddisfly		
Most Caddisflies 		
Beetles 		
Midges		
Black Flies		
Most True Flies		
Gilled Snails		
Lunged Snails		
Clams		
Other		
Total number of organisms in the sample		

Illustrations from: Voshell, J. R., Jr. 2001. Guide to the Common Freshwater Invertebrates of North America. MacDonald and Woodward Publishing Co. With permission of the author.

Figure E4: Field sheet for the Volunteer Stream Monitoring (2 of 3).

Individual Metrics

Metric	Number		Total number of organisms in the sample		Percent
Mayflies + Stoneflies + Most Caddisflies		Divide by		Multiply by 100	
Common Netspinners		Divide by		Multiply by 100	
Lunged Snails		Divide by		Multiply by 100	
Beetles		Divide by		Multiply by 100	

% Tolerant

Taxon	Number
Worms	
Flatworms	
Leeches	
Sowbugs	
Scuds	
Dragonflies and Damselflies	
Midges	
Black Flies	
Lunged Snails	
Clams	
Total Tolerant	
Total Tolerant divided by the total number of organisms in the sample	
Multiply by 100	

% Non-Insects

Taxon	Number
Worms	
Flatworms	
Leeches	
Crayfish	
Sowbugs	
Scuds	
Gilled Snails	
Lunged Snails	
Clams	
Other non-insects (organisms without 6 jointed legs)	
Total Non-Insects	
Total Non-Insects divided by the total number of organisms in the sample	
Multiply by 100	

Figure E5: Field sheet for the Volunteer Stream Monitoring (3 of 3).

Save Our Streams Multimetric Index

Determine whether each metric should get a score of 2,1, or 0. Write your metric value from the previous page in the 2nd column (Your Metric Value). Put a check in the appropriate boxes for 2,1, or 0. Then calculate the subtotals and Save Our Streams Multimetric Index score and determine whether the site has acceptable or unacceptable ecological condition.

Metric	Your Metric Value	2	1	0
% Mayflies + Stoneflies + Most Caddisflies		Greater than 32.2	16.1 – 32.2	Less than 16.1
% Common Netspinners		Less than 19.7	19.7 – 34.5	Greater than 34.5
% Lunged Snails		Less than 0.3	0.3 – 1.5	Greater than 1.5
% Beetles		Greater then 6.4	3.2 – 6.4	Less than 3.2
% Tolerant		Less than 46.7	46.7 – 61.5	Greater than 61.5
% Non-Insects		Less than 5.4	5.4 – 20.8	Greater than 20.8
		Total # of 2s:	Total # of 1s:	Total # of 0s:
Subtotals:		Multiply by 2:	Multiply by 1:	Multiply by 0:

Now add the 3 subtotals to get the Save Our Streams Multimetric Index score:_____

_____Acceptable ecological condition (7 to 12) _____Unacceptable ecological condition (0 to 6)

Within each sample site, a representative sample reach is selected. Each sample reach should be a minimum of one riffle-pool-riffle sequence. The riffles should have a substrate of cobble and rubble (2"-10" stones), gravel and sand. Water depth should be less than 1 foot. Water velocity should be at least sufficient to carry dislodged stream bed material downstream approximately 12-16 inches. Pools should have coarse particulate matter (sticks, roots, leaves) and a slower water velocity. Pools may be deeper than 1 foot.

Complete Site Information, Habitat Assessment, and Abiotic Data sections of the Stream Quality Survey form BEFORE you begin collecting macroinvertebrates.

A. TEMPERATURE COLLECTING METHOD

1. To take the ambient air temperature:

   a) Hold or hang thermometer in shaded area approximately 3 feet above ground.
   b) Wait at least 3 minutes before reading.
   c) Record air temperature and time of day on data sheet.
   d) Record Celsius temperature, then use conversion formula to determine Fahrenheit temperature. Record Fahrenheit temperature.

2. To take the water temperature:

   a) Totally submerge the thermometer within the pool sampling area for a minimum of three minutes by placing the thermometer inside a 1 pint clear container and placing the thermometer and container in stream.
   b) Remove the container from the stream, keep thermometer bulb in water-filled container and read water temperature as quickly as accuracy permits.
   c) Repeat this two more times in different areas of your reach, then record the average temperature in both Celsius and Fahrenheit.

B. PH COLLECTING METHOD

Rinse tube first with stream water. Follow instructions accompanying the pH kit and record reading on data form. Dispose of solution on land, <u>then</u> <u>rinse</u> <u>tube</u> <u>in</u> <u>stream</u>.

C. EMBEDDEDNESS MEASUREMENTS

Embeddedness is defined as the degree to which larger substrate materials (gravel, rubble, cobble, boulder) are surrounded or covered by sand/silt. Four embeddedness readings will be taken and recorded: two each in the downstream and upstream riffle areas.

1. Begin in the downstream riffle area. Make the first observation near the midpoint of the riffle area as measured from streambank to streambank. The second observation in the downstream riffle area should be taken near the left streambank, when looking upstream.

2. Use the half-square to frame the observation area, placing it under water within the riffle to define the area being measured for embeddedness.

3. Observe the tops, then the sides of all rocks > 3 inches across. Gently pick up several rocks, one at a time, from the sample area and watch for plumes of silt as you move them. Record embeddedess values.

4. Repeat the midpoint and left side observations in the upstream riffle and record embeddedness values.

D. BENTHIC MACROINVERTEBRATE COLLECTING METHOD

1. Macroinvertebrate collection will begin in the riffle area farthest downstream in your reach.

   a) Position the D-net about 12-16 inches downstream of the collector in a portion of the riffle where the water current will carry dislodged material into the net. Select one team member to hold the D-net so that the flat end is flush with the stream bottom. Select one or more other team members to carefully and gently wash all benthic macroinvertebrates from the rocks within a 1 foot square area immediately upstream of the net. As each rock is cleaned, place it outside of the sample area. After all rocks have been cleaned, carefully use the hand to disturb the stream bed sand and small rocks to a depth of 3 inches. (If stream bed appears to be littered with glass or other sharp objects, use your feet instead of your hands.)

   b) Collect at three spots within your downstream riffle for a duration of one minute per spot. Choose three spots which represent different microhabitats: e.g. areas with different sized stones, areas with more/less leaf matter, areas with faster/slower water. If there are leaf packs between the substrate materials, be sure to rinse them off in front of the net to collect the organisms which may be feeding/hiding on them.

   c) After collecting at each of three spots in the downstream riffle, return all the rocks to their 1 square foot sampling area.

   d) Before emptying the collected material into the pans, pour streamwater through the net and its contents until the water runs clear. This is a particularly important step for the pool sample and for streams where sediment is a problem. This should help reduce the murkiness of the water which can make finding and sorting macros so difficult.

   e) Empty the net contents into the white pans (see step f) for directions) <u>BUT DO NOT BEGIN TO SORT AND IDENTIFY MACROS until you have repeated the collecting procedures in the upstream pool and then the upstream riffle end of your reach.</u> Collecting at each of these sections should follow the same procedure as for the

downstream riffle: collect at three different spots within the section for a period of one minute of scrubbing/agitating per spot. In the pool section, samples should be taken from leaf packs and root balls/masses, as well as the substrate.

f) Empty the net contents into the white pans. Invert the net and wash it with stream water, letting the water run through the net into the collection container, to dislodge any benthic macroinvertebrates that may have attached to the net. Check the net for macroinvertebrates that still remain attached and remove them, using forceps, to the collecting container. Remove collected organic matter (leaves, sticks) from the collecting container, being careful to check for and remove macroinvertebrates which may be attached. Return this "picked over" organic matter to the stream.

2. Sort and identify a subset (100 organisms) of the collected macros to Order (for insects and crustaceans) or Class (for leeches, aquatic worms, bivalves and gastropods).

   a) Try to correct the bias toward selecting larger organisms by picking our several large, then several small, etc.

   b) *Using the Lehmkuhl key & keys from the MACRO ID II classes, take time to determine discernibly different forms of the Orders: i.e., different Families and, in some cases, genera. This will take extra time, but it makes our data more useful and gives us a more detailed picture of the site's condition.* If you feel you don't have the skills or the time to ID down to the Family level, please separate out the different forms and return one of each different form in the bottle of alcohol. Make note on the data sheet how many of each form you found, as well as some descriptive language so we can match up the family--once it's identified--with the numbers in which you found it.

   c) If you cannot identify an individual(s), place in the vial of alcohol and return with the data sheets. Note the date and team number on the vial's label.

3. Record number of individuals per Order/Class on the main survey form and *the number of individuals per Family on the MD Benthos Taxonomic Key.* Sort and record until 100 individuals have been identified. STOP SORTING/IDENTIFYING ONCE YOU HAVE REACHED 100.

4. If 100 individuals cannot be sorted and identified, repeat Step 3: i.e. make a collecting "sweep" through your riffle-pool-riffle reach.

   a) Sort and ID until a total of 100 individuals has been identified.
   b) If you still do not reach 100 individuals, do NOT collect again. Return all benthic macroinvertebrates proportionately to the sample areas.

5. Make sure all information is recorded in the proper place on the field data sheets.
6. Once you have conducted the macroinvertebrate collection and have checked to make sure the Stream Quality Survey form is complete, make sure all of the monitoring equipment is gathered together to be returned with the Survey form.

_____ 1 hand lens
_____ 1 pint jar
_____ 1 thermometer
_____ 2 field microscopes
_____ 2 forceps
_____ 2 medicine droppers
_____ 2 pencils
_____ 2 plastic spoons
_____ 2 vials of alcohol

_____ 3 ice cube trays

_____ clipboard
_____ data survey sheet
_____ 3 collecting pans
_____3 plastic cups/bowls
_____ pH kit
_____ D-net
_____ embeddedness bar
_____ 3 "scope" dishes
_____macroinvertebrate keys
(Lehmkuhl, Ohio DNR key)

Thank you returning the equipment as soon as it is feasible. There are not enough sets of equipment for every team.

Figure E6: Field sheet for the Volunteer Stream Monitoring (front).

AUDUBON NATURALIST SOCIETY

AUDUBON NATURALIST SOCIETY Date:_____

STREAM QUALITY ASSESSMENT SURVEY

Data Collectors' Name(s) _____ Team Leader _____ Phone # _____

_____ _____

_____ _____

SITE INFORMATION

Watershed _____

Stream _____ Order _____ Site No. _____ Season/year: _____

County _____ State ____ Specific Location _____

HABITAT ASSESSMENT

Choose an appropriate reach (riffle-pool-riffle stretch of stream) for macroinvertebrate collection, then conduct this assessment BEFORE collecting macroinvertebrates. Check box which best represents actual conditions.

1. BED COMPOSITION OF RIFFLES

Riffle 1	Riffle 2	
_____	_____	% silt (mud)
_____	_____	% sand (1/16" - 1/4" grains
_____	_____	% gravel (1/4" - 2" stones)
_____	_____	% cobbles (2" - 10" stones)
_____	_____	% boulders (>10" stones)

Make sure these total 100%

2. EMBEDDEDNESS

Percentage of substrate (stream bottom) covered or surrounded by sediments. Check (✓) for each.

Riffle 1 Center	Riffle 1 Left		Riffle 2 Center	Riffle 2 Left
_____	_____	less than 25%	_____	_____
_____	_____	25 - 50%	_____	_____
_____	_____	50 - 75%	_____	_____
_____	_____	more than 75%	_____	_____

Embeddedness Values:

EXCELLENT less than 25%. Tops of the majority of rocks > 3 inches across are clean of silt or sediment. Sides of the majority of rocks > 3 inches across are not surrounded by silt or sediment. Plume of sediment almost nonexistent. Most rocks look as if they have been set on the stream bed.

GOOD 25 to 50%. Tops of the majority of rocks > 3 inches across are clean of silt and sand. Sides of the majority of rocks are surrounded, or mostly surrounded, by silt or sediment giving them a "cemented in" look. Plume of sediment small to moderate.

FAIR 50 to 75%. Tops of the majority of rocks > 3 inches across are partially covered by silt or sediment. Sides of the majority of rocks are surrounded by silt or sedimnent giving them a "cemented in" look. Plume of sediment moderate to extensive.

POOR . more than 75%. Tops of the majority of rocks are covered by silt or sediment. Sides of a majority of rocks are surrounded by silt or sediment giving them a "cemented in" look. Sediment plume extensive.

3. STREAMSIDE COVER

- ☐ Dominant vegetation trees with thick shrub/grass and perennial understory.
- ☐ Dominant vegetation trees with sparse perennial/ annual understory.
- ☐ Dominant vegetation woody shrubs and annuals.
- ☐ Majority plants present are annuals.

ABIOTIC DATA

Time _____ pH _____

Water temperature _____C _____F [F=(1.8 x C) + 32]

Ambient air temperature _____C _____F

General weather conditions _____

Date/time of last rainfall (if known) _____

Return form to: Audubon Naturalist Society, 8940 Jones Mill Road, Chevy Chase, MD 20815 (301) 652-9188
or
Webb Sanctuary, 12829 Chestnut Street, Box 51, Clifton, VA 20124-0051 (703) 803-8400

Figure E7: Field sheet for the Volunteer Stream Monitoring (back).

HABITAT ASSESSMENT

Habitat Parameter	Optimal 20-19-18-17-16	Sub-optimal 15-14-13-12-11	Marginal 10-9-8-7-6	Poor 5 -4-3-2-1-0
Channel Flow Score ☐ Comments:	Water reaches base of both banks; and minimal amount of channel substrate exposed.	Water fills more than 75% of available channel.	Water fills 25-75% of the available channel; and/or riffle substrates mostly exposed.	Very little water in channel, and mostly present as standing pools.
Bank Stability Score ☐ Comments:	Banks stable; no evidence of erosion or bank failure; side slopes; little potential for future problems.	Moderately stable; infrequent, small areas of erosion mostly healed over; slight potential in extreme floods.	Moderately unstable; moderate frequency and size of erosional areas; high erosion potential during extreme high flow.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends.
Bottom Deposition in Slow Areas of Stream Score ☐ Comments:	Less than 5% of the bottom affected by scouring and/or deposition.	5 - 30% affected; scour at constrictions and where grades steepen; some deposition in pools.	30 - 50% affected; deposits and/or scour at obstruction, constriction, and bends; filling of pools prevalent.	More than 50% of the bottom changing frequently; pools almost absent due to deposition; only large rocks in riffle exposed.
Riparian Forest Zone Width (Least Buffered Side) Comments: Score ☐	Width of riparian forest zones > 54feet; human's activities have not impacted this zone.	Zone between 36-54 feet; human's activities have impacted this zone only minimally	Zone between 18 and 36 feet; human's activities have impacted the riparian zone a great deal.	Zone 18 feet: little or no riparian forest due to man-induced activities (i.e. parking lots, roadbeds, clearcuts, lawns, or crops).

Total score ☐

ADDITIONAL WATERSHED OBSERVATIONS

Canopy Cover (check one):

_____ Fully shaded _____more shaded than open _____More open than shaded _____Open

Comments:_____

Turbidity (check one):

_____Clear _____Slightly turbid (cloudy) _____Turbid (very cloudy) _____Opaque (no light transmission)

Comments:_____

Stream bank (observe bank from water line to 6" up the bank slope)

Soil color _____

Soil type or mix of types (choose from list below) _____

- Sandy. Porous soils, you can see sand grains.
- Loamy. Rich in humus or organic material, dark in color.
- Clay. Nonporous, when squeezed between thumb and forefinger, clay soils usually stick together.

F. IMPAIRED WATERBODIES

There are 19 Category 5 waterbodies (*impaired – requiring a TMDL*) with drainage areas in Fairfax County included in Virginia Department of Environmental Quality's 2004 Integrated Report. A summary of the Category 5 waterbodies in Fairfax County is provided in Table F1, and their locations are shown in Figure F1.

Of the listed waterbodies, 12 are riverine systems totaling 58.45 miles, six are estuarine systems with a total area of 23.23 square miles, and one is a drinking water reservoir with an area of 1,700 acres. The cause of impairment for the majority of the riverine waterbodies is either fecal coliform or general standards (benthic). For the estuarine waterbodies, the cause of impairment for the majority of systems is PCBs in fish tissue and fecal coliform. Ten of the 19 waterbodies are multi-jurisdictional i.e. include drainage areas outside Fairfax County. According to the current schedule, seven waterbodies require TMDL studies to be completed by 2010, nine require studies to be completed by 2014, with three to be completed by 2016.

Notes:

1. Several waterbodies in previous listing cycles have additional impairment causes shown in the 2004 report, mainly for fecal coliform. (This is usually due to the change in the bacteria water quality standard from 1,000 cfu/100mL to 400 cfu/100mL, which went into effect in February, 2004.)
2. Several waterbodies are listed as "fully supporting with an observed effect" for additional constituents.
3. This summary only considers waterbodies in Category 5. There are several segments listed under Category 3 (*indeterminate – waters needing additional information*) based primarily on citizen monitoring data that may in the future be included in Category 5.

Table F1: Summary of Category 5 waterbodies in Virginia Department of Environmental Quality 2004 Integrated Report with drainage areas in Fairfax County.

No.	Waterbody Name	Impaired Segment extent and Location	Multi-jurisdictional ?[#]	Impairment cause[*]	Listing Date	Scheduled TMDL completion
1	Sugarland Run	5.75 mi (from confluence of Folly Lick Branch to confluence with Potomac River)	Yes (Loudoun)	Fecal Coliform	2002	2014
2	Difficult Run	2.93 mi (from confluence of Captain Hickory Run to confluence with Potomac River)	No	Benthic Fecal Coliform/*E Coli*	1994/2004	2010
3	Pimmit Run	7.38 mi (headwaters of Pimmit Run to confluence with Potomac River)	Yes (Arlington)	Fecal Coliform	2002	2014
4	Tripps Run	2.25 mi (headwaters of Tripps Run to start of Lake Barcroft)	No	Benthic	2004	2016
5	Holmes Run (upper segment)	5.8 mi (headwaters of Holmes Run to start of Lake Barcroft)	No	Benthic	2004	2016
6	Holmes Run (lower segment)	3.59 mi (mouth of Lake Barcroft to confluence with Backlick Run)	Yes (Alexandria)	Fecal Coliform	2004	2016
7	Backlick Run	6.45 mi (headwaters to confluence with Holmes Run)	Yes (Alexandria)	Fecal Coliform	2002	2010
8	Accotink Creek	8.62 mi (confluence of Calamo Branch to the tidal waters of Accotink Bay)	Yes (City of Fairfax)	Benthic Fecal Coliform	1996 2004	2010

[#] Water body drainage includes areas outside Fairfax County.

[*] Water body is considered nonsupporting or partially supporting of one or more of designated uses because water quality standards for constituent(s) listed are not being met.

Table F1: Summary of Category 5 waterbodies in Virginia Virginia Department of Environmental Quality 2004 Integrated Report with drainage areas in Fairfax County (con't).

No.	Waterbody Name	Impaired Segment extent and Location	Multi-jurisdictional ?[#]	Impairment cause[*]	Listing Date	Scheduled TMDL completion
9	Pohick Creek	3.2 mi (confluence of South Run to the end of free-flowing portion of Pohick Creek)	Yes (City of Fairfax?)	PCBs, PAHs in fish tissue	2002	2014
10	Mills Branch	1.81 mi (headwaters of Mills Branch to confluence with the Occoquan River)	No	Fecal Coliform	2002	2014
11	Popes Head Creek	4.92 mi (confluence of Piney Branch to confluence of Bull Run)	City of Fairfax	Benthic Fecal Coliform	1998 2004	2010
12	Bull Run	4.8 mi/5.75 mi (confluence of Cub Run to confluence of Popes Head Creek)	Yes (Prince William, Loudoun, Fauquier)	Benthic Fecal Coliform, PCBs in fish	1994 2004	2010
13	Virginia Tidal waters	20.3 mi^2 (from Woodrow Wilson bridge to Brent Point at mouth of Aquia Creek)	Yes (Alexandria, Prince William,Stafford)	PCBs in fish tissue	2002	2014
14	Hunting Creek/Cameron Run	0.71 mi^2 (0.22 river mile above Telegraph Rd. to confluence with Potomac includes embayment)	Yes (Alexandria)	Fecal Coliform PCBs in fish tissue	1998 2002	2010
15	Little Hunting Creek	0.24 mi^2 (upstream limit of tidal waters to confluence with Potomac River)	No	PCBs in fish tissue Fecal Coliform	2002 2004	2014

[#] i.e. Does waterbody drainage includes areas outside Fairfax County ?

[*] Waterbody is considered nonsupporting or partially supporting of one or more of designated uses because water quality standards for constituent(s) listed are not being met.

Table F1: Summary of Category 5 waterbodies in Virginia Virginia Department of Environmental Quality 2004 Integrated Report with drainage areas in Fairfax County (con't).

No.	Waterbody Name	Impaired Segment extent and Location	Multi-jurisdictional ?[#]	Impairment cause[*]	Listing Date	Scheduled TMDL completion
17	Occoquan Bay	0.69 mi^2 (half-mile radius around monitoring station located in center of bay)	Yes (Prince William)	pH, PCBs in fish tissue	2002	2014
18	Occoquan River	0.05 mi^2 (half-mile radius around monitoring station located at Route 123 bridge)	Yes (Prince William, Fauquier, Loudoun)	PCBs in fish tissue Fecal Coliform	2002 2004	2014
19	Occoquan Reservoir	1,700 ac (start of inundated waters on Bull Run and Occoquan River to lower end of reservoir)	Yes (Prince William, Fauquier, Loudoun)	Dissolved Oxygen (bottom waters)	2002	2010

[#] i.e. Does waterbody drainage includes areas outside Fairfax County ?

[*] Waterbody is considered nonsupporting or partially supporting of one or more of designated uses because water quality standards for constituent(s) listed are not being met.

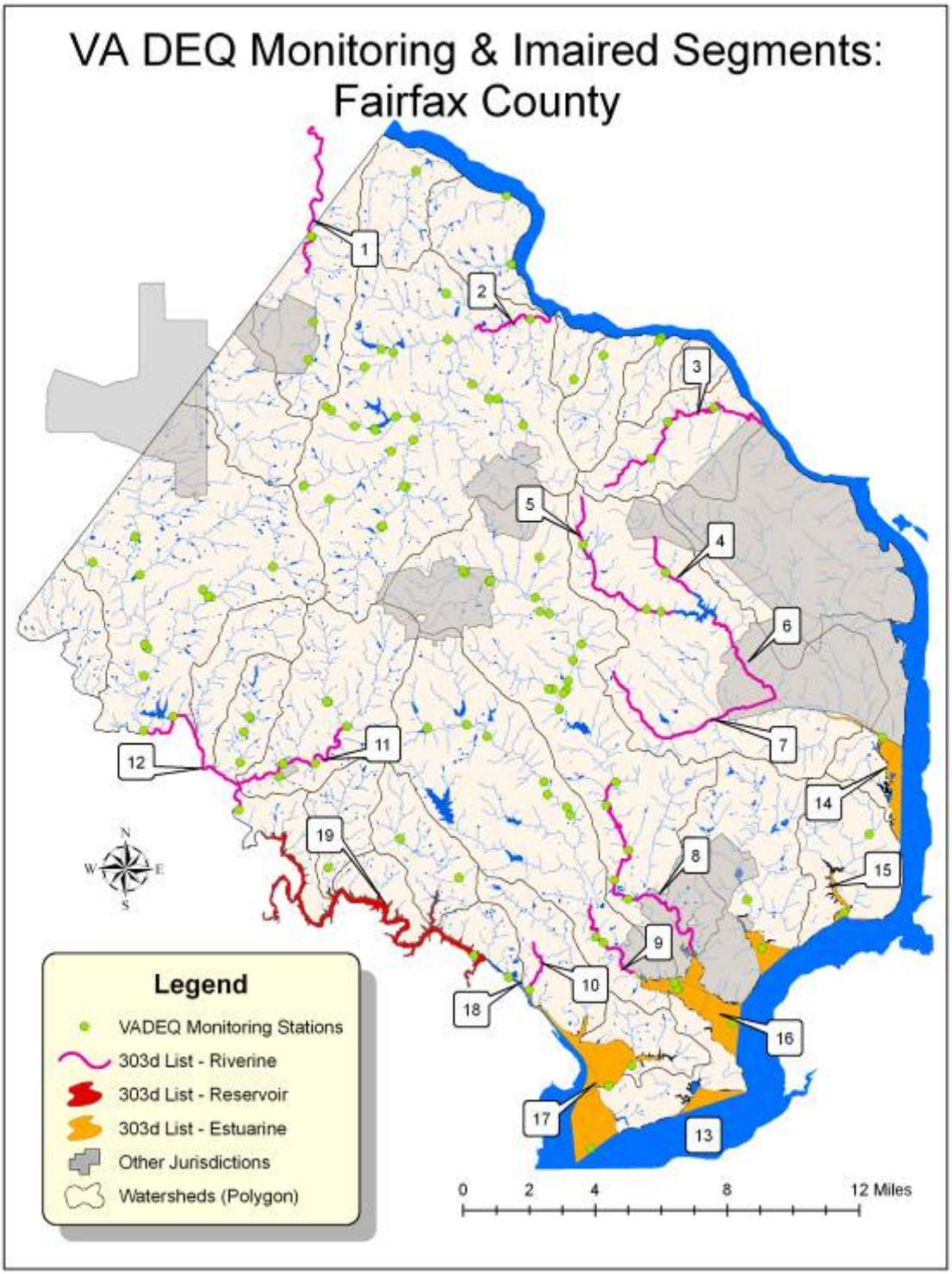


Figure F1: Virginia Department of Environmental Quality monitoring stations and locations of riverine (1-12) and non-riverine (13-19) Category 5 waterbodies in Fairfax County (numbers correspond to those used in Table F1).

G: COMPUTATION OF STRATUM AND OVERALL MEAN AND VARIANCES

A Digital Elevation Model derived synthetic stream network, generated at a 50 acre threshold, was utilized as the sampling frame. The stream network was stratified by Strahler stream order (1st through 5th) and samples allocated according to the proportion of total stream length in each stratum (Figure G1).

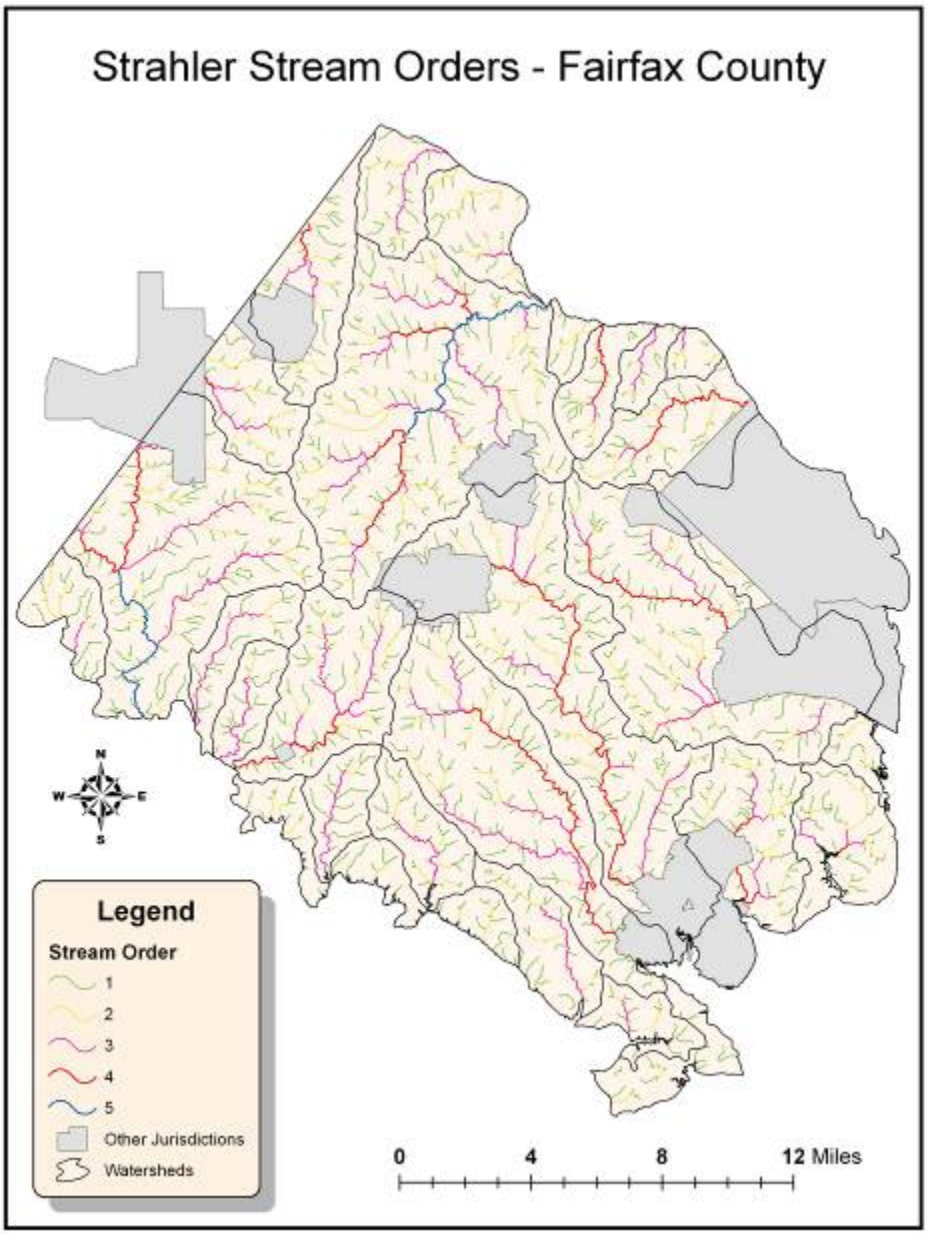


Figure G1: Digital Elevation Model derived stream sampling frame.

Stratum weights were therefore calculated as

$$W_h = \frac{L_h}{L_T}$$

where W_h is the weight of stratum *h*, L_h is the total stream length in the stratum, and L_T is the total stream length for the strata under consideration,

$$L_T = \sum_{h=1}^{n_s} L_h$$

and where n_s is the number of strata of interest. The sum of all weights must equal unity as

$$\sum_{h=1}^{n_s} W_h = 1/L_T \sum_{h=1}^{n_s} L_h = 1.0$$

A two-stage procedure was employed to determine sampling locations. Within each stratum, a stream segment was first selected at random. A sampling location was then randomly selected within this segment. The segment was then replaced, and the process repeated to obtain the required number of samples in each stratum.

Sample means and variances within each stratum were calculated based on computational procedures presented by Cochran (1977) and Gilbert (1987) for two-stage sampling when primary units are of unequal size and have the same chance of being selected. Stratum means were computed from

$$\bar{I}_h = \frac{\sum_{i=1}^{n_h} L_i I_i}{\sum_{i=1}^{n_h} L_i}$$

where $\bar{I}_h$ is the mean index in stratum *h*, I_i is the index value of the *ith* sample in the stratum, L_i is the length of the segment on which the *ith* sample was taken, and n_h is the number of samples taken in the stratum. If the total number of segments in each stratum is large compared to the number of segments sampled, then,

$$s_h^2 = \frac{1}{\bar{L}_h^2 (n_h - 1)} \sum_{i=1}^{n_h} L_i^2 (I_i - \bar{I}_h)^2$$

where s_h^2 is the index variance in stratum *h*, and is the mean segment length in the stratum.

The overall mean ($\bar{I}_o$) and variance (s_o^2) across two or more strata are obtained as

$$\bar{I}_o = \sum_{h=1}^{n_s} W_h \bar{I}_h$$

$$s_o^2 = \sum_{h=1}^{n_s} W_h^2 s_h^2$$

+

The variance of the overall mean , $s_o^2(\bar{I}_o)$, is computed as

$$s_o^2(\bar{I}_o) = \sum_{h=1}^{n_s} \frac{W_h^2 s_h^2}{n_h}$$

H: OTHER MONITORING EFFORTS

Stormwater Planning Division

National Pollutant Discharge Elimination System (NPDES) Requirements
Section 402 of the Clean Water Act established the National Pollutant Discharge Elimination System to limit pollutant discharges into streams, rivers, and bays. The Department of Conservation and Recreation is the issuing authority of the county's Virginia Pollutant Discharge Elimination System – Municipal Separate Storm Sewer (VPDES-MS4) Permit 0088587. The county's comprehensive stormwater management program focuses on seven major areas to meet the federal and state regulations in the permit:

- watershed management planning;
- capital improvements and infrastructure retrofits;
- maintenance and operations of existing infrastructure;
- strategic initiatives, policy, management, and emergency response;
- monitoring and assessments; and
- public outreach and education

The monitoring and assessment section of the annual report discusses the county's ongoing monitoring and watershed assessment program, which includes:

- dry weather screening
- wet weather screening
- industrial and high risk runoff program
- watershed monitoring
- water quality monitoring
    - bioassessment
    - bacteria
- floatable monitoring

As required by the county's permit, an annual report is prepared by the Stormwater Planning Division staff. The 2003 and 2004 reports are available on-line at:

www.fairfaxcounty.gov/dpwes/stormwater/ms4permit.htm

Kingstowne and South Van Dorn Monitoring Stations
Fairfax County staff has managed the Kingstowne Environmental Monitoring Program since 1986. This program assists the county in evaluating the sediment removal efficiencies of erosion and sediment controls installed at the developing Kingstowne tract, as well as provides data on nutrient and heavy metal loadings to Dogue Creek. The U.S. Army Corps of Engineers permit required the developing South Van Dorn road extension to install a second station, in 2002 to evaluate nutrient loadings and removal efficiencies by stormwater management facilities from the entire Silver Springs segment of the Dogue Creek watershed.

Countywide Stream Physical Assessment

A countywide stream assessment project was initiated by the Stormwater Planning Division of the Department of Public Works and Environmental Services in the spring of 2002.

The services of CH2M HILL were retained to conduct assessments of approximately 800 stream miles countywide. The assessments included an evaluation of overall stream habitat and physical conditions and descriptions of features such as stream crossings, stormwater drainage pipes, utility crossings, streambank erosion, deficient buffers, and stream obstructions.

The completion of the stream assessment project represents a major milestone in the County's watershed planning program, and will provide necessary information for the development of management plans in each of the County's watersheds.

Data from this project will allow a more comprehensive understanding of streams and watersheds in Fairfax County. The data will be integrated with other watershed and stream assessment information to develop predictive tools for evaluating the impact of watershed changes on stream quality.

Accotink Creek Bacteria Source Tracking Study

A 4.5 mile stretch of Accotink Creek, immediately upstream of Lake Accotink was placed on the 1998 state's 303(d) list for a fecal coliform Total Maximum Daily Load (TMDL).

With a goal of reducing human inputs into the stream by 99 percent, Stormwater Planning Division staff partnered with the United States Geological Survey (USGS) to identify human inputs of wastewater into the system throughout the upper Accotink Creek watershed. The USGS and the division are cooperating with the Virginia Department of Conservation and Recreation and the City of Fairfax with this project.

Federal Monitoring Efforts: United States Geological Survey (USGS)

The USGS investigates the occurrence, quantity, quality, distribution, and movement of surface and underground waters and disseminates the data to the public, state and local governments, public and private utilities, and other federal agencies involved with managing the nation's water resources. Surface-water data are collected by field personnel or relayed through telephones or satellites to offices where it is stored and processed. Once a complete day of readings are received from a site, daily summary data are generated and stored in the data base. Annually, the USGS finalizes and publishes the daily data in a series of water-data reports. Daily streamflow data and peak data are updated annually following publication of the reports (USGS, 2005).

The USGS has collected streamflow data for varying lengths of time at 11 stations in Fairfax County. Two of those stations are still active:

- USGS 01646000, Difficult Run near Great Falls, has been sampled since 1935 and has data record of 25,020 daily streamflow values.
- USGS 01654000, Accotink Creek near Annandale, has been sampled since 1947 and has data record of 20,454 daily streamflow values.

The USGS also collects and analyzes chemical, physical, and biological properties of water, sediment and tissue samples from across the Nation. At selected surface-water and ground-water sites, the USGS maintains instruments that continuously record physical and chemical characteristics of the water including pH, specific conductance, temperature, dissolved oxygen, and percent dissolved-oxygen saturation. Supporting data such as air temperature and barometric pressure are also available at some sites. The USGS has collected water quality data for varying lengths of time at 106 stations in Fairfax County.

Low Impact Development (LID) Projects

Federal and State guidelines are placing an increasing emphasis on controlling stormwater runoff close to its source. Environmentally sensitive site design and low impact development practices that serve to minimize impervious cover and replicate natural hydrologic conditions are widely recommended approaches for accomplishing this goal. The county's Environmental Agenda calls for better site design practices that protect our streams and other natural resources. Fairfax County's objective is to encourage the use of low impact development concepts and techniques, especially in new residential and commercial areas, and seek opportunities for retrofitting established areas.

- ***Stormwater Retrofit—Providence Supervisor's Office***

  This low impact development demonstration project is located within the Accotink Creek watershed. In addition to the Providence Supervisor's Office, the site is also the location of the county's Merrifield Fire Station. The Department of Public Works and Environmental Services and Northern Virginia Soil and Water Conservation District are partnering in the analysis, design and construction. The overall complex encompasses a land area of 1.8 acres with approximately 1.44 acres being impervious surfaces. The proposed work will serve as a highly visible demonstration project featuring three practices: a bioretention basin (rain garden), a green roof, and permeable pavers. The bioretention basin and permeable pavers with underlying gravel infiltration bed will allow runoff to drain into a retention area where it can then slowly infiltrate into the surrounding soil. The green roof installation on an existing concrete storage structure will serve to reduce rooftop stormwater runoff and provide a comparison to an adjacent storage structure with a conventional roof. These three integrated practices will work in harmony to address both water quality and water quantity retrofit goals on the site. This site will be monitored by the department for water quality and quantity both entering and exiting the bioretention basin.

- ***Yorktowne Square Green Roof***

The 5,000-square-foot green roof at Yorktowne Square Condominium is one of the first retrofitted green roofs in the state. Building Logics' German design green roof system was chosen because it is lightweight and the 35-year-old building has structural limitations. There were 8,400 sedums planted on the roof. A pair of cisterns have been set up to measure the effectiveness of the green roof in reducing water runoff by measuring the volume of water draining from the green roof and an identical roof without vegetation. In addition, the water runoff from both roofs will be tested to measure any filtering qualities the green roof may provide. The Stormwater Planning Division will be taking over the monitoring of this site.

Yorktowne Square green roof

State Monitoring Efforts: Virginia Department of Environmental Quality

Water quality monitoring has been ongoing in Virginia for decades. In 1997, the Virginia General Assembly enacted the Water Quality Monitoring, Information, and Restoration Act, which provides the Virginia Department of Environmental Quality (DEQ) with a mandate to perform a minimum amount of water quality monitoring. In accordance with WQMIRA, monitoring programs are developed for the maintenance, support and restoration of surface waters with regard to the following uses: aquatic life, drinking water, recreation, fishing and shellfish consumption (VADEQ, 2003). The following monitoring programs are implemented to accomplish this:

- Ambient Watershed: represents the largest single section of the monitoring program. Stations are sampled every other month for two years and then rotated to a new set of stations, completing a statewide cycle in six years.
- Coastal 2000: federally funded tidal probabilistic program designed by U.S. EPA and sampled by Virginia Department of Environmental Quality staff.
- Chesapeake Bay: designed through the U.S. EPA Chesapeake Bay Program Office and encompasses a multi-state water quality characterization effort.
- Citizen Monitoring: stations in segments identified through public participation as targeted for specific monitoring by Department of Environmental Quality.
- Facility Inspection: integral to determining compliance with discharge limits.
- Freshwater Probabilistic: program covers the nontidal free flowing waters of the state and is designed to characterize the overall water quality of free-flowing streams in Virginia.

- Fish Tissue: conducted by central office staff from the Office of Water Quality Standards to determine the human health risks associated with consuming fish. Stations are rotated through the state in a five-year cycle.
- Incident Response: similar to pollution complaints but are not of petroleum in origin.
- Pollution Complaints: special samples collected as a result of a petroleum spill.
- Pfiesteria Monitoring: in cooperation with the Virginia Department of Health, monitors tidal portions of the state for the presence of Pfiesteria.
- Quality Control: generally between two and ten percent of the samples collected under each of the individual programs are quality control samples.
- Regional Biological: determines the health of the benthic macro invertebrate community as a tool to determine water quality conditions and follows the U.S. EPA Rapid Bioassessment Protocol II.
- Reservoir Monitoring: the largest lakes are sampled every year, and the others are sampled based on a rotating schedule.
- Special Studies: specialized, intensively targeted monitoring efforts designed to answer specific questions related to water quality conditions.
- TMDL: associated with the development of a TMDL implementation plan for segments listed on the 303(d) list.
- Trend: long-term stations sited for permanent monitoring for the purpose of detecting short-, medium- and long-term water quality trends for a wide variety of environmentally important water quality parameters.
- Carryover: usually have small data sets that indicate a potential problem and will be sampled until data sufficient to assess water quality conditions.

In FY 2004 (July 1, 2003 through June 30, 2004), the Department of Environmental Quality sampled 20 stations in Fairfax County, primarily for residue (filterable and non-filterable), turbidity, total nitrogen, total phosphorus, and bacteria (VADEQ, 2005). Data collected by DEQ and other agencies with approved QA/QC procedures is used to develop the Integrated 305(b) and 303(d) report which identifies waters that are not supporting their designated uses and lists them as impaired. A Total Maximum Daily Load (TMDL) outlining the reductions in pollutant sources required to restore water quality must be developed for all impaired waters. A summary of impaired waters and Total Maximum Daily Load development activities in Fairfax County is presented in Appendix F.

Regional Monitoring Efforts

<u>Occoquan Watershed Monitoring Laboratory</u>
The Occoquan Watershed, which lies in the southwest portion of the County, consists of all the land, including tributary streams, draining into the Occoquan Reservoir, one of the County's two primary sources of drinking water. Seventeen percent of the watershed, or roughly 64,500 acres, lies in the County. The rest of the 590 square-mile watershed lies in parts of Prince William, Fauquier, and Loudoun counties. In July of 1971, the State Water Control Board adopted the Occoquan Policy, which recognized that an indirect re-use of treated wastewater would become the operational norm in the

Occoquan Watershed. In order to protect the public health, the Policy not only specified the type of waste treatment practice to be adopted on a basin-wide scale, but also provided for an ongoing program of water quality monitoring to quantify the success of the water quality protection effort. The Occoquan Watershed Monitoring Subcommittee created an independent facility to conduct the required monitoring program. The resulting facility, the Occoquan Watershed Monitoring Laboratory, was established by the Virginia Polytechnic Institute Department of Civil Engineering. The laboratory began its on-site operations in 1972, and has since developed a comprehensive database of water quality in the Occoquan Basin (New Millennium Occoquan Watershed Task Force, 2003).

The laboratory maintains a network of nine stream gaging stations in the watershed, three of which are located in Fairfax County (OWML, 2005). These stations are:

- ST40, located on Bull Run where it flows into the Occoquan Reservoir
- ST45, located on Bull Run at the bridge on State Highway 28 (Centreville Road)
- ST50, located on Cub Run at the bridge on State Highway 658 (Compton Road)

In addition to gaging streamflow, the laboratory also monitors for a host of organic and chemical pollutants, including total nitrogen, total phosphorus, total suspended solids, turbidity, chemical oxygen demand, foaming agents, and a number of non-volatile synthetic organic chemicals. The sampling stations are configured with equipment and instrumentation to allow the automatic retrieval and storage of samples during all storm events. The analytical results of such samples, combined with streamflow data, allow the laboratory to make accurate calculations of loads of various chemical constituents (New Millennium Occoquan Watershed Task Force, January 27, 2003).

Reston Association – Environmental Monitoring Program

The Reston Association has been monitoring the water quality of lakes Anne, Thoreau, Audubon and Newport, since 1981; Lake Newport was added to the monitoring program in 1982. Additional sampling of Bright Pond and Butler Pond were added in 2003. The monitoring and annual reports are completed by Aquatic Environment Consultants. The annual reports are used by the association for monitoring long-term trends and general lake management purposes. Information is submitted for Environmental Quality Advisory Council's consideration and inclusion in their Annual Report on the Environment.