CHAPTER 2

METHODS

This section is intended to provide a brief summary of the protocols, techniques, and methodologies employed that are consistent with the goals and objectives for the SPS baseline study. More detailed information can be found in the Protocols sections of the Appendix (sections A-H).

Site Selection

Fairfax County extends across three physiographic provinces or distinct geologic regions, each containing stream systems with specific hydrologic regimes, substrate character, and aquatic communities. The Coastal Plain region lies in the eastern portion of the County and is generally characterized by sandy soils and low gradient topography. The Piedmont Upland region, consisting of rocky substrate and rolling hills, spans the central portion of the County. The Triassic Basin, a sub-region of the Piedmont Upland province, is characterized by areas of low relief and large expanses of shale and red sedimentary sandstone. For the purposes of this study, Piedmont and Triassic Basin regions were evaluated using the same protocols, and Coastal Plain areas were sampled and analyzed using a separate methodology.

The 114 monitoring locations (Figure 2) were selected to provide relatively even coverage of all subwatersheds throughout Fairfax County. The goal was to obtain information for small sub-drainages (typically 2 to 5 square miles in total area) both within tributary environments as well as along system mainstems of primarily second and third order streams (see Appendix A). Stream order was determined using USGS 1:24,000 scale maps. Logistical concerns (i.e., relative ease of accessibility, avoidance of private property, proximity to artificial structures) were taken into account in site placement. In some small watersheds with numerous independent stream systems — like those draining into the Occoquan Reservoir — sites were placed on single streams with conditions that reflected those of the drainage as a whole. No sites were established within the High Point watershed, as systems in the drainage are of a wetland character unsuited to sampling under the protocols established for streams countywide.

A similar approach was used in selecting 11 sites along reference streams within the Quantico Creek drainage in Prince William Forest Park, a largely undeveloped area in Prince William County, Virginia, with some of the highest quality stream systems available locally. The information obtained was used to develop a framework of optimal stream conditions, which ultimately allowed for the ranking of Fairfax County sites based upon their relative level of correspondence to a composite of “reference or benchmark” conditions (see discussion of Andrews Curves in this section or Appendix G).

Each of the individual sites consisted of a 100-meter stream reach that was representative of conditions in the surrounding drainage area.

Countywide Sampling

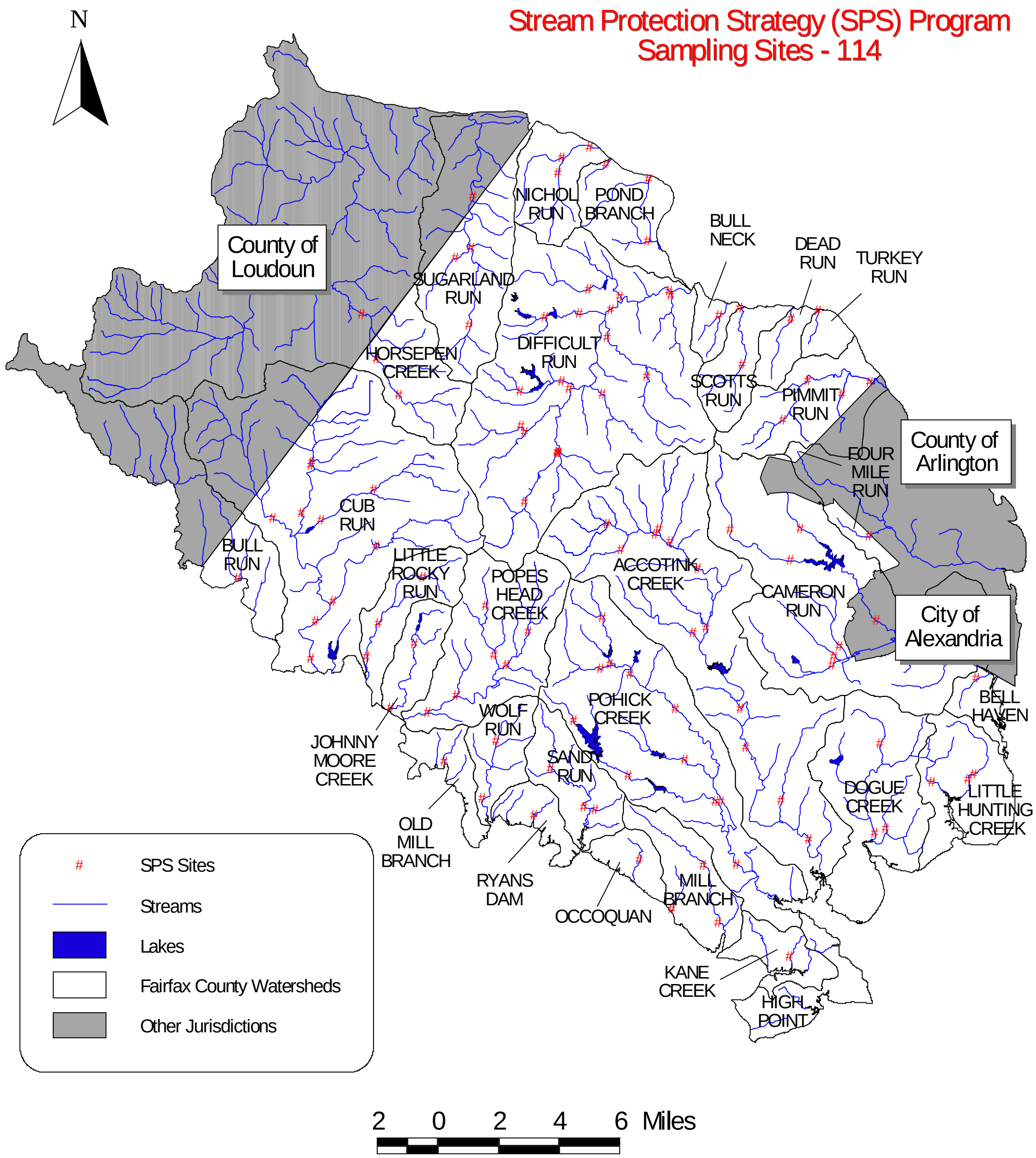

Figure 2. Countywide Stream Protection Strategy monitoring sites.

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Benthic Macroinvertebrate Sampling


Benthic macroinvertebrate samples are collected from riffles and shallow runs, the most productive areas in streams.

Benthic macroinvertebrate samples were collected at all sites in late winter/early spring of 1999, using the established protocols of the U.S. Environmental Protection Agency's (EPA) Rapid Bioassessment Protocol (RBP) for Use in Wadeable Streams and Rivers (Barbour et al. 1999, see Appendix B). Separate methodology was used in the two distinct physiographic regions. At sites within the Piedmont region, a kick sample was taken from one riffle and one run within each study reach, and the collections were combined into one sample. Within the Coastal Plain region, a combined sample was developed from 20 separate "jab" samples taken from representative habitat types in the reach including undercut banks, aquatic vegetation, riffles and snags.

The first 200 randomly selected individuals from each sample were identified to the genus level (Oligochaetes (aquatic worms) and Chironomidae (midges) were categorized at a higher taxonomic level due to time constraints). The resulting data were then used within a framework of a pre-established set of metrics, each a numerical valuation reflecting tolerance or trophic structure variables of each given macroinvertebrate community. An Index of MacroBenthic Integrity (IMBI) metric set developed for use in Northern Virginia Piedmont areas (Jones, 2000, personal communication) was used for sites within the Piedmont and Triassic physiographic regions (Table 2). Analysis of information from sites within the Coastal Plain region was based on a metric set (Table 3) created by Maxted et al. (1999).

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/Triassic sites, comparisons were made to a reference set developed by Jones et al. (2000, personal communication), 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/Triassic region and 5 for the Coastal Plain region) were then added together to develop a single Index of Biotic Integrity (IBI) 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 4).

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Table 2: Metrics for the Index of MacroBenthic Integrity (IMBI) (Jones personal communication 2000).

PIEDMONT AND TRIASSIC BASIN METRICS	
METRICS	**DESCRIPTIONS**
1. Taxa Richness	Number of different taxa in a sample.
2. EPT richness	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 tolerant Net-Spinning Caddisfly (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 (FBI)	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 use shredding as its primary functional feeding group.
10. Percent Predators	Percent of individuals that use predation as its primary functional feeding group.

Table 3: Metrics for the Coastal Plain IBI (Maxted et al. 1999).

COASTAL PLAIN 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 are Mayflies.
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 4: IBI scores and equivalent rating system.

IBI SCORE	SPS 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.

Electrofishing with the use of battery-powered backpack generators allows for a quick assessment of fish community composition.

Fish Sampling

Fish sampling was based upon the techniques detailed in the EPA's Rapid Bioassessment Protocols (Barbour et al. 1999) and involved species-level identification of all fish captured within each reach (see Appendix C). Samples were collected in the field using electrofishing equipment that temporarily stuns fish, allowing them to be netted with relative ease. Individuals were then identified and released back into the stream. Representative specimens of each unique taxa (distinct species) found were preserved to establish a permanent reference collection of the fishes of Fairfax County. An extensive suite of candidate metrics was then developed 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. Of these, only the species richness metric (total number of unique fish taxa collected at each site) was found to be useful in separating sites on a gradient of impairment. 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 High, Moderate, Low, or Very Low. An IBI could not be developed for fish communities due to the poor performance of other candidate metrics.

During the summer of 1999, Fairfax County, like the entire surrounding region, experienced one of the most significant droughts on record. Because the unusual flow regime had the potential to influence fish samples obtained during that time period, 25%

of the sites were randomly selected from subgroups based on stream order and re-sampled in the summer of 2000. No significant difference between years was noted.

Habitat Assessment

Increased storm discharges can have a measurable effect on stream habitat features.

The physical habitat of each SPS site was evaluated using two sets of protocols (see Appendix D). In the spring sampling period, a scored assessment that incorporated aspects of the Rapid Stream Assessment Technique (RSAT) (Galli, 1996) was used. During both spring and summer sampling periods, habitat conditions were examined using a modified version of the EPA's Rapid Bioassessment Protocols (Barbour et al., 1997). This method of habitat assessment consists of a general evaluation of the watershed features (including vegetation and instream features) as well as a more specific evaluation of 10 parameters, each scored on a scale of 0 (Worst Condition) to 20 (Optimal Condition). The scores were summed to obtain an overall rating of habitat quality, which was then used as the basis for countywide comparisons. To account for hydrologic and geographic differences between Piedmont/Triassic streams and those on the Coastal Plain, separate metrics for each were used (Table 5).

Table 5. Habitat metrics for Piedmont/Triassic and Coastal Plain streams (metrics common to each group may be scored based upon different criteria).

Piedmont/Triassic	Coastal Plain
Epifaunal Substrate/Available Cover	Epifaunal Substrate/Available Cover
Embeddedness	Pool Substrate Characterization
Velocity/Depth Regimes	Pool Variability
Channel Alteration	Channel Alteration
Sediment Deposition	Sediment Deposition
Frequency of Riffles/Bends	Channel Sinuosity
Channel Flow Status	Channel Flow Status
Bank Vegetative Protection	Bank Vegetative Protection
Bank Stability	Bank Stability
Riparian Vegetative Zone Width	Riparian Vegetative Zone Width

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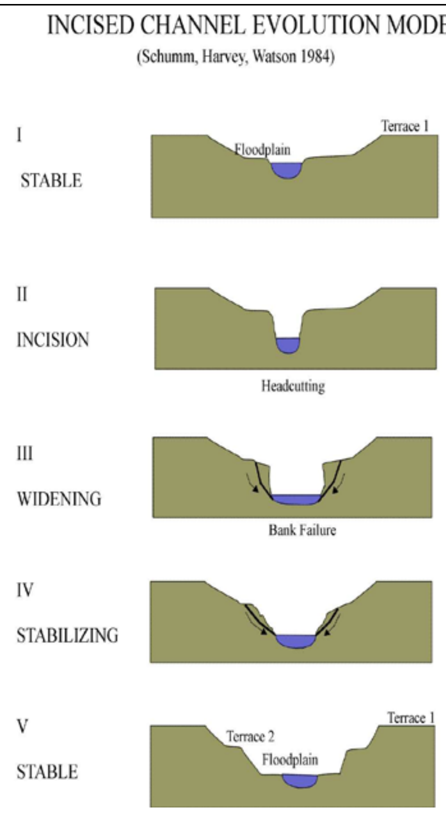
Stream Morphology

During the summer sampling phase, a physical characterization of habitat was conducted using the Incised Channel Evolution Model (ICEM) (Schumm et al., 1984), a broad-scale assessment which involves examination of extensive sections of stream channel above and below each respective sample reach. The ICEM defines the stages through which stream channel morphology progresses after disturbance, and can act as a useful predictor of future conditions (Schumm et al., 1984, Harvey and Watson, 1986). A standardized field check sheet developed by Sewell (1999, personal communication) was used to aid County staff in identifying the respective stages at each site based upon key characteristics such as bank slope, headcutting, sediment deposition and/or erosion, and extent of vegetative colonization (Table 6). Visual assessments were conducted both upstream and downstream of study reaches (approximately a mile at each site) and extended to the nearest major tributary input, road crossing, or other significant feature that had the potential to influence local hydrology and/or morphology.

Table 6. Key characteristics of stream stages, as defined by the Incised Channel Evolution Model (ICEM).



Stage I: Well developed baseflow and bankfull change; consistent floodplain features easily identified; one terrace apparent above active floodplain; predictable pattern and steam bed morphology; floodplain covered by diverse vegetation; stream banks ≤ 45°.
Stage II: Headcuts; exposed cultural features; sediment deposits absent or sparse; exposed bedrock; streambank slopes > 45°.
Stage III: Stream bank sloughing, sloughed material eroding; streambank slopes 60° vertical/concave.
Stage IV: Streambank aggrading; sloughed material not eroded; sloughed material colonized by vegetation; baseflow, bankfull and floodplain channel developing; predictable sinuous pattern developing streambank slopes ≤ 45 °.
Stage V: Well developed baseflow and bankfull channel; consistent floodplain features easily identified; two terraces apparent above active floodplain; predictable pattern and streambed morphology; streambanks ≤ 45°.

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Other Field Sampling

Samples of stream water were tested twice at each site, once when collecting macroinvertebrate samples (spring) and once when sampling fish (summer). Dissolved oxygen (mg/L), pH, temperature (°C), conductivity (μS), % O_2 saturation and turbidity (NTUs) were recorded during both of these periods, while nitrate (mg/L) and fluoride (mg/L) measurements were recorded only once, during the summer sample period (see Appendix E).

Measurements were also made of tree canopy cover using a hand-held densiometer and of stream substrate condition using Pebble Count methodology (Wolman, 1954).

Spatial Analysis

Spatial information (latitude/longitude) on all SPS sites was collected using a portable, differential Global Positioning System (GPS) unit. The resulting data was incorporated into a Geographic Information System (GIS), which was used to assess existing and potential patterns in land use, both within the County as well as within neighboring jurisdictions, that potentially influenced stream quality. The contributing drainage area was delineated for all sites, and percent imperviousness within each of these respective areas was estimated using available Fairfax County data layers (roads, parking lots, buildings, sidewalks). These layers were reflective of conditions within the County in 1997.

Estimates of future imperviousness for these same areas were developed using County zoning information. Districts specified in the County Zoning Ordinance were assigned levels of imperviousness based upon values reported in the Fairfax County Zoning Ordinances for open space requirements, the County's Public Facilities Manual, and the Chesapeake Bay Local Assistance Department (CBLAD) Manual. The current zoning data layer was combined with the delineated drainage boundaries, and the predicted future imperviousness value for individual subwatersheds was obtained by area-weighting each zoning district contained within these subwatersheds. It is important to note that these values reflect future development *potential*, and are used here only as a general, conservative framework for guiding the prioritization of County watersheds. There are several factors that may contribute to over and under estimations of future imperviousness based on zoning information including:

- Site conditions (e.g. soils and slopes) may prevent a parcel from being fully developable resulting in less imperviousness.
- Protected resources such as parks, Resource Protection Areas, wetlands and floodplains may also reduce the developable area resulting in less imperviousness.
- Differences between zoning and the County's Comprehensive Plan will also result in differences in future imperviousness.

Information on all volunteer monitoring sites was also collected using a GPS unit and will be part of future spatial analyses related to stream monitoring.

See Appendix F for a detailed discussion of the methodology employed in generating measures of both current and future imperviousness.

Countywide Stream Ranking System: Multi-dimensional Curves

An overall ranking of stream conditions at sites countywide was developed using a procedure for plotting and analyzing multi-dimensional data suggested by Andrews (1972). A detailed explanation of the procedure can be found in Appendix G. The procedure entails generating a uniquely shaped curve for each set of multi-dimensional data. The procedure provides a consistent graphical means of recognizing and matching patterns across multiple dimensions. The components making up the dimensions of the curves for each site were the IBI score, percent imperviousness of the contributing drainage area, fish taxa richness, and physical habitat assessment scores (see Appendix G for an explanation of how these environmental variables were selected).

The basic approach employed in ranking was to evaluate the degree to which the curve for a site departed from the reference condition curve (Figure 3). The reference condition curve was determined from high quality sites within Fairfax County as well as the Quantico Creek watershed, a largely undeveloped region within Prince William Forest Park.

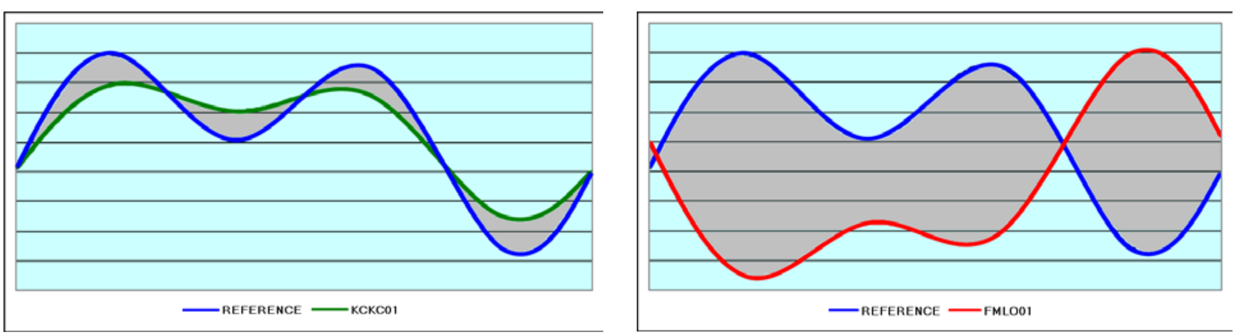

Figure 3: Example Curves. The blue curve on both graphs represents reference conditions. The green curve in the graph on the left represents one of the highest quality sites, and follows the reference curve closely. The red curve in the graph on the right clearly diverges from the reference curve and represents a site along one of the County's poorest quality streams. Numerical rankings were assigned to each site depending on the degree of divergence along the entire length of a given curve from the reference curve (i.e., shaded areas). The scale for the graph's axes are arbitrary and are intentionally excluded from presentation here. See Appendix G for a full discussion of these types of analyses.

CHAPTER 2

Management Categories

Three management categories were established to provide recommendations for future watershed management efforts based on overall stream ranking (composite score) and projected development within each respective subwatershed. These management categories are as follows:

- **Watershed Protection**
- **Watershed Restoration Level I**
- **Watershed Restoration Level II**

These categories are intended for use only as planning level tools. Each of these categories is characterized by a set of goals and strategy recommendations that best suit—in terms of cost-effectiveness, available resources and perceived efficacy of targeted actions—each respective stream environment given current subwatershed development patterns, likely future imperviousness and the current assessment of biological condition. In addition, management categories are not intended to be a means of controlling development or to be confused with adopted land use categories contained within the County's Comprehensive Land Use Plan, or other land use documents currently guided by the County Ordinance. Rather, management categories propose a new technique to group targeted areas that might be recommended for similar treatment for more effective future watershed protection, preservation and restoration efforts. Actual implementation of the recommended treatment might entail more detailed study through watershed master plans and/or necessitate a re-examination of some existing policies and plans through a different process. Some of these strategies, by themselves, represent established steps and initiatives currently being implemented in the County and neighboring jurisdictions. However, SPS attempts to organize these strategies in a more logical manner to foster a more effective watershed planning and management approach. The strategies outlined in this report by no means represent an all inclusive list; rather they will serve as the foundation of a process to identify potential strategies that may require further evaluation for applicability on a subwatershed scale.

The following information describes the criteria used for assigning subwatersheds to a specific management category. The assignment of individual subwatersheds to particular management categories is based on the best information currently available. As more information becomes available in the future, those subwatersheds may be reassigned. A detailed description of the potential strategies for each category, including existing County programs, is presented in Chapter 4 —Watershed Improvement Strategies.

CHAPTER 2

WATERSHED PROTECTION

Subwatersheds that fall into this category will likely be in areas with low development density and which currently possess biological communities that are relatively healthy. Such a ranking will be independent of the likelihood of future development. The primary goal of this category is to preserve biological integrity by taking active measures to identify and protect, as much as possible, the conditions responsible for current high-quality rating of these streams.

Some active measures may still be required to improve certain aspects of stream quality. These will be recommended on a subwatershed basis.

Criteria:
- Composite Rating is Good or Excellent.

WATERSHED RESTORATION LEVEL I

The primary goal of this category is to re-establish healthy biological communities by taking active measures to identify and remedy causes of stream degradation, both broad-scale and site-specific. In general, these watersheds have fair biological conditions and are in areas where substantial development activity is ongoing, but which still hold potential for significant stream quality enhancement. The active approach warranted for subwatersheds in this category would also apply to all stream segments, no matter how degraded, that lie upstream of areas that fall within the WATERSHED PROTECTION category.

Criteria:
- Composite Rating is Fair or, rarely, Poor.
- Projected imperviousness of less than 20%.
- Areas classified as WATERSHED RESTORATON LEVEL II that are upstream of areas in the WATERSHED PROTECTION category.

WATERSHED RESTORATION LEVEL II

Subwatersheds in this category will likely be characterized by high development density, significantly degraded instream habitat conditions, and substantially impacted biological communities. The primary goal of this category is to maintain areas to prevent further degradation and to take active measures to improve water quality to comply with Chesapeake Bay Initiatives, Total Maximum Daily Load (TMDL) regulations and all other existing water quality standards. Some site-specific conditions may warrant further active measures to improve stream habitat or biological condition.

Subwatersheds within this category may also be further classified as Assessment Priority Areas, reflecting a current lack of site-specific information and/or their potential for a WATERSHED RESTORATION LEVEL I categorization.
Criteria:

- Composite rating is Poor, Very Poor or, rarely, Fair.
- Projected imperviousness greater than 20%.
- All watershed mainstems (see below).

Given the fact that the overall quality in the larger, higher order mainstem environments is largely a function of the conditions in their contributing subwatersheds, system-wide improvements will most likely be achieved through strategies that focus on and prioritize tributary and headwaters environments. In recognition of this, mainstem systems in every major watershed within the County are currently designated as WATERSHED RESTORATION LEVEL II, even though specific areas throughout their length may have achieved a high composite rating.

VOLUNTEER MONITORING

Northern Virginia Soil and Water Conservation District (NVSWCD)

The NVSWCD coordinates a Volunteer Stream Monitoring Program first established in 1997 that is open to all individuals or groups interested in water quality issues. The program currently sees the involvement of 50 volunteers assisting in all aspects of the program. Site monitors choose their own sites — or receive assistance in locating sites — and conduct sampling four times during the year.

NVSWCD uses the EPA-approved Izaak Walton League Save Our Streams (SOS) protocol for biological monitoring (see Appendix H). Monitors sample riffles by disturbing the stream bottom and collecting dislodged insects with the use of a 3 foot-square net. Visual assessments are made of community richness; a qualitative water quality rating (Excellent, Good, Fair, or Poor) is generated using pre-established scoring criteria.

Monitors may also make assessments of other site characteristics to include such parameters as basic water chemistry. NVSWCD provides all monitoring equipment and conducts a variety of training workshops in the field. Further information about the program can be found on the World Wide Web:

http://mason.gmu.edu/~jarcisze/StreamMonitoring/index.html

CHAPTER 2

Audubon Naturalist Society (ANS) Water Quality Monitoring Program

The ANS 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 H). All monitoring equipment is provided.

Volunteers assess habitat conditions and macroinvertebrates community composition at specific points throughout the year (May, July, September, with an optional winter sample). Macroinvertebrates are collected using a "kick" sampling technique, and collected individuals are visually identified to the family taxonomic level where possible. Multiple samples are collected from riffle 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 RBP habitat assessment — channel flow status, bank stability, sediment deposition and riparian zone width — are also scored. Readings of pH and water temperatures are taken concurrently.

More information about the Audubon Naturalist Society's water quality program is available through the Webb Sanctuary at (703) 803-8400 or through the website:

www.AudubonNaturalist.org

A variety of other citizen's group and organization are also involved in activities aimed at promoting stream awareness and clean water issues. Their programs, both individually and collectively, are important to the overall effort of improving conditions Countywide.