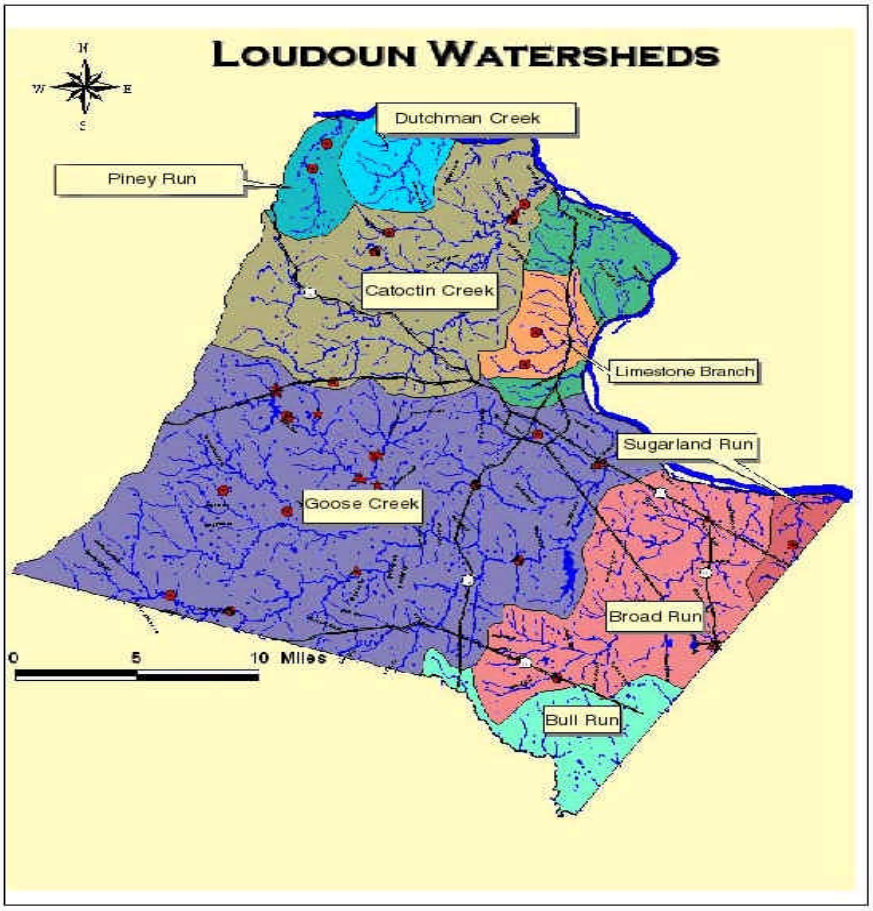
Loudoun County
Comprehensive Stream Monitoring Strategy

Plan Design and Guidelines



Loudoun Watershed Watch

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INTRODUCTION

Stream monitoring by state and local government, and citizen watershed organizations plays a critical role in water resource protection and the development of watershed management plans. Monitoring is needed not only to provide baseline data, but also to assess stream health, identify stream degradation problems, and to assess stream protection and restoration activities. Data provided by stream monitoring also provide an important component to watershed management plans. These needs are of increased importance as Loudoun County grows at an unprecedented rate. The county needs a revised strategy that better organizes state and local monitoring efforts.

The Virginia Department of Environmental Quality (DEQ) has determined that most streams in Loudoun have segments that do not meet the Virginia Water Quality Standards and are classified as **impaired**. DEQ is required under the Federal Clean Water Act to establish total maximum daily loads (TMDLs) for pollution sources that cause the impairments. The Virginia Department of Conservation and Recreation (DCR) has been designated to develop implementation plans that provide staged reduction targets. A comprehensive, countywide monitoring program that provides statistically valid baseline and trend data can be used to assess the effectiveness of these needed initiatives.

CURRENT GAPS IN STREAM MONITORING ACTIVITIES

In 2002 Loudoun Watershed Watch (LWW) published The State of Loudoun Streams: 2002[1] report that provided an assessment of watershed conditions. LWW concluded that Loudoun County needs watershed management plans to implement the Federal Clean Water Act, the Chesapeake Bay Act, the Virginia Water Quality Standards, and the policies of Loudoun's Green Infrastructure and River and Stream Corridor Overlay District in the Comprehensive Plan. In order to develop watershed plans, Loudoun County should: (1) create a **water management authority** to develop watershed management plans and oversee the implementation of TMDL plans for Loudoun streams; (2) support a **countywide stream monitoring program** to assess changes in stream health and progress in restoring water quality to supplement state efforts; and (3) collaborate to develop an updated **stream monitoring strategy** to provide more representative data on watersheds.

In September 2003 the Loudoun County Sanitation Authority (LCSA) issued the findings and draft recommendations regarding the development of a source water protection (SWP) program for drinking water in Loudoun County. The plan adopts a multi-barrier approach that will protect drinking water sources within the Goose Creek watershed. The SWP program includes a "risk monitoring & compliance" component that relies upon stream monitoring. Reports identifying stream protection needs in Loudoun County have also been issued by the Center for Watershed Protection and the Conference of Governments.

In 2004 DEQ issued their (305(b)/303(d) Integrated Report that is required under the Federal Clean Water Act. This report identified six new stream segments in Loudoun County with water quality impairments since 2002. It also reported that approximately 75% of the waters in Loudoun County have not been assessed by DEQ because of the scarcity of monitoring stations and resources to generate monitoring data.

The gaps in the current stream monitoring activities that are identified in the State of Loudoun Streams: 2002 Report, the SWP Program, and these other reports that have been prepared in recent years regarding Loudoun water resources are as follows:

- There is little joint planning or collaboration between state, regional, and county authorities, and citizen groups involved in stream monitoring in Loudoun County. Each entity has unique goals, protocols, sampling stations, and schedules.

[1] Loudoun Watershed Watch. "State of Loudoun Streams: 2002." 2002.

- DEQ cannot meet stream monitoring needs on its own and DCR relies largely on county and stakeholder groups to develop TMDL Implementation Plans and watershed management plans. Currently, Loudoun County does not fund stream monitoring activities, and no county authority or other groups are able to respond to decreases in state monitoring to ensure that monitoring is maintained at a minimum acceptable level.
- Most stream monitoring is conducted by DEQ and they only monitor at a limited number of stations. 75% of the stream miles including entire subwatersheds are not sampled.
- Stream monitoring has not been designed to support watershed management planning at the subwatershed level. This has created the overlaps and gaps in data collection, and there is no data available for Loudoun County that can be extrapolated to assess stream health over an entire stream length with known statistical confidence.

STREAM MONITORING PROGRAM STRATEGY

Developing watershed management plans that incorporate national, regional, and state legislative commitments as well as community priorities need to be a function of local governments and citizen watershed organizations. It is Loudoun Watershed Watch's vision that Loudoun County government and County Agencies will become the principal authorities that collect water resource data, and prepare and implement watershed management plans with the support of citizen watershed organizations. In Loudoun County stream monitoring can best be achieved through the collaboration of federal, state, regional, local authorities, and citizen watershed organizations working together to provide the most effective use of limited state, county, and volunteer resources.

A well-planned stream sampling design will ensure that resulting data are adequately representative of the target stream and defensible for their intended use. There are two main categories of sampling design: judgment designs and probability-based designs. **Judgment sampling** involves selection of monitoring sites on the basis of expert knowledge or professional judgment. Such stations can be used to track trends in the water quality in a watershed. **Probability-based designs** involve random selection of monitoring sites. This allows statistical inferences to be made about the sampled population from the data obtained. These data allow baseline assessments to be made with an efficient use of resources.

STREAM MONITORING GOALS

On March 6, 2003 state, regional, and local stakeholders participated in the "Comprehensive County Stream Monitoring Plan Design Development Conference" sponsored by Loudoun Watershed Watch. Participants identified the stream monitoring goals needed for a comprehensive stream monitoring program for Loudoun County that will help realize this vision.

- **Goal #1: Characterize and Assess Stream Health**:
  - To develop baseline data using probability sampling to characterize the health of a stream and determine whether water quality standards are being met;
  - To provide data to develop watershed management plans and to establish stream preservation and restoration priorities; and
  - To identify problem streams for targeted special studies.
- **Goal #2: Provide Trend Assessments and Forecasts:**
  - To document water quality trends over time; and
  - To provide data to develop watershed management plans.
- **Goal #3: Evaluate TMDL Implementation and Watershed Management Plans:**
  - To determine whether TMDL implementation is working; and
  - To determine if watershed management plans are effective.
- **Goal #4: Provide Environmental Stewardship and Education:**
  - To provide data and documentation to support pollution prevention, stream restoration, and environmental stewardship; and
  - To provide avenues for citizens to demonstrate concern regarding stream health.
- **Goal #5: Coordinate State, County, and Citizen Resources**:
  - To divide monitoring needs rationally between state, county, and citizen groups.

STREAM MONITORING DESIGN

In May 2003 Loudoun Watershed Watch sponsored the "Loudoun County Stream Monitoring Strategy Workshop." At this two-day workshop, state, regional, and local stakeholders outlined a structure for an updated stream monitoring program. The following sampling designs were agreed upon to achieve the different monitoring goals.

- **Watershed Survey Design** – A watershed survey is the collection of new and existing information on conditions and processes at the watershed level.[2] This information can be used to identify the type of additional monitoring that may be needed and problem areas for corrective action, and to bolster watershed awareness and education at all levels, including the individual landowner, community groups, and county authorities. It has two parts:
  - **Information Research Survey** – Existing information from reports, interviews, and public meetings regarding stream and watershed conditions and characteristics is compiled; and
  - **Field Surveys** – Field data and visual observations on various watershed conditions and characteristics are collected.

- **Trend Monitoring Design** – Representative water quality data from any permanent monitoring station can be used to evaluate trends in water quality at the station. Documentation of short-term, mid-term, and long-term trends can be used to assess water quality and best management practices implemented to restore water quality. Trend sampling stations must be carefully selected based upon professional judgment to provide data to answer specific questions about water quality and stream health. Trend data from one monitoring site can be combined with other trend data to produce trend analyses for larger drainage areas. The sampling methods and laboratory analytical methods must be standardized to combine data from various stations or to compare trends in different streams.

- **Probabilistic Monitoring Design** – The probabilistic monitoring design is used to characterize the impact of nonpoint pollutants and other stress factors on the health of benthic communities and stream habitats. It provides comprehensive information about large geographic areas, while keeping costs reasonable. Loudoun County should follow the sample design recommended by DEQ and collect samples once at each probabilistic site. Sites should be stratified by stream orders to assure approximately equal representation among headwater, mid-watershed, and lower watershed streams.

- **TMDL Validation Monitoring Design** – A validation assessment is designed to document the effectiveness of the best management practices (BMPs) that have been installed to improve the water quality. The primary assessment conducted by DEQ will be limited to small stream segments currently designated as impaired. Supplemental assessments conducted by Loudoun County and citizen groups will target stream segments not monitored by DEQ. If data results suggest that the implemented management controls are not effective, recommendations on redesigning the management controls are considered by DEQ. Data collected through the trend monitoring designs will be used to validate TMDL implementation.

RECOMMENDATIONS

Loudoun Watershed Watch's recommends[3] that Loudoun County government and County Agencies become the principal authorities that collect water resource data, and prepare and implement watershed management plans with the support of citizen watershed organizations. Stream monitoring can best be achieved through the collaboration of federal, state, regional, and local authorities; and citizen watershed organizations. A countywide stream monitoring plan that incorporates the contributions of each party will provide comprehensive coverage and

[2] Pennsylvania Citizen's Volunteer Monitoring Program and River Network. "Designing Your Monitoring Program." 2001. p. 5-6.
[3] Loudoun Watershed Watch. "State of Loudoun Streams: 2002." 2002.

effective use of limited state, county, and volunteer resources. The following are needed to adopt a countywide stream monitoring program.

State agencies have the legal mandate and professional staff to monitor streams and ensure that state water quality standards are met. DEQ and DCR should provide:

- Technical guidance, training and QA oversight;
- Laboratory support for benthic macroinvertebrate identification; and
- Utilization of county and citizen data in documenting impaired waters and in validating TMDL implementation.

County Government and Agencies – Loudoun County and County Agencies have laws and ordinances that protect stream corridors; and professional staff to provide safe drinking water, monitor and control point discharges of pollution, protect citizens from water related health hazards, and monitor and manage stormwater facilities, as resources permit. Loudoun County and County Agencies should provide:

- Fund full-time Water Resources Program Coordinator and part-time support positions to administer a stream monitoring program, collect monitoring samples, and ID macroinvertebrate samples;
- Training and QA oversight of county operations; and
- Chemical test kits, mapping, GPS units, data management and reporting, and website support for a countywide stream monitoring program.

Citizen Groups – Citizen groups and environmental organizations help lead efforts in Loudoun County to promote environmental stewardship and stream habitat protection. These groups provide trained volunteers who collect water samples for physical and chemical analyses, monitor benthic macroinvertebrates, and assess stream habitats. Environmental organizations have experienced staff to provide environmental education. Citizen groups should provide:

- Citizen Stream Monitoring Coordinators;
- A Stream Monitoring Protocol Committee;
- Citizen stream monitor and watershed survey volunteers;
- Training for stream monitors; and
- Field QA implementation.

INTRODUCTION

Stream monitoring by state and local government, and citizen watershed organizations plays a critical role in water resource protection and the development of watershed management plans. The Department of Environmental Quality (DEQ) reports[4] that intergovernmental agreements such as the Chesapeake Bay Preservation Act are demanding more of state and local monitoring programs. Monitoring is needed not only to provide baseline data, but also to assess stream health and to resolve degradation problems. Data provided by stream monitoring provides an important component to watershed management plans. These new focuses require a revised strategy and better organization of state and local monitoring efforts.

The assessment, protection, and restoration of local watersheds provide a variety of benefits for Loudoun County's environmental resources. Stream monitoring and the watershed management plans it supports can protect and improve the quality and quantity of water for the survival of fish, wildlife, and people. Stable floodplains and buffer systems, with a diversity of native flora and fauna, reduce the likelihood of flood events and provide aesthetic benefits like natural beauty and community-wide recreation opportunities.

Effective watershed management can help communities ensure that surface and ground water supplies do not become degraded over time, that drinking water supplies are sustained, that soil and streambank erosion is reduced, and that wildlife habitat is restored. Watershed management plans can also enhance real estate values for homes and businesses located near river greenway trails, protect parks and open spaces, and restore recreational opportunities for fishing and canoeing. Loudoun watersheds are shown in **Figure 1**.

Regulatory Basis for Stream Monitoring[5]

Stream monitoring and the development of watershed management plans will enable Loudoun County to meet new regulatory requirements, including the Total Maximum Daily Load (TMDL) and storm water provisions of the federal Clean Water Act. It will also help Virginia meet the following commitments under the Chesapeake 2000 Agreement:

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

Designated Use Standards for Streams

Loudoun County streams are designated for three uses[6]:

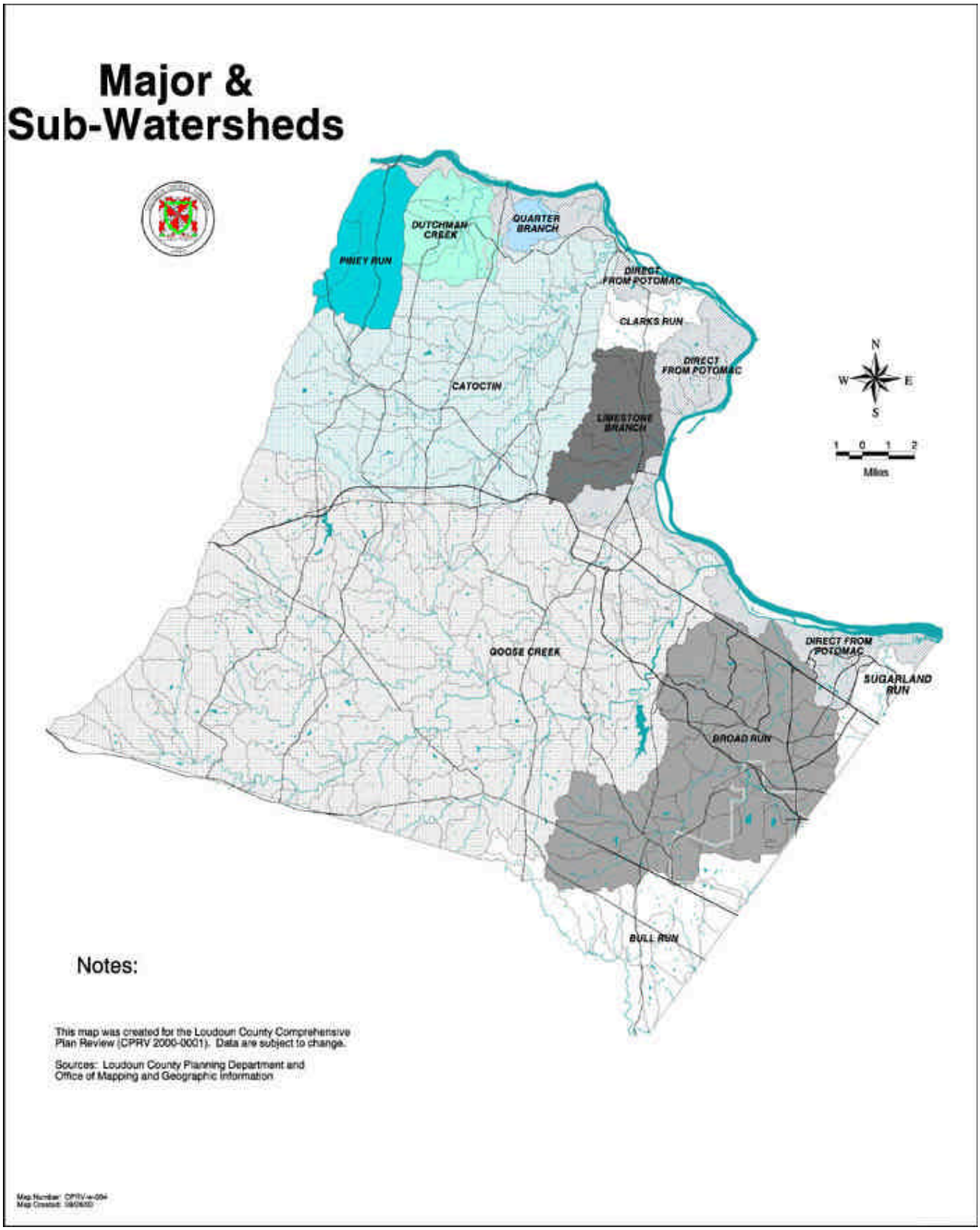
- Recreation (e.g., swimming and boating);
- Aquatic life, including game fish which might reasonably be expected to inhabit them; and
- Wildlife.
- Some streams are also designated for use a source of drinking water.

The designated uses determine the water quality criteria applicable to Loudoun streams. Water quality criteria can include general narrative statements that describe good water quality and specific numerical concentrations that are known to protect aquatic life and human health.

[4] Virginia Department of Environmental Quality (DEQ). 1999. "Virginia's Water Quality Monitoring Strategy." Draft: December 1999.

[5] Firehock, Karen. "A Watershed Planning Primer for Virginia," University of Virginia, 2003.

Figure 1. Major and Subwatersheds in Loudoun County, VA.



- Narrative criteria include general protective statements known as the "free froms." This narrative criteria says that “all state waters shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or interfere directly or indirectly with designated uses of such water or which are inimical or harmful to human, animal, plant, or aquatic life.”
- There are physical and chemical criteria for temperature, pH, dissolved oxygen, ammonia, and chloride; and bacteriological criteria for fecal coliform and *E. coli* bacteria. These standards are listed in **Table 1**. There are currently no standards for other parameters such as nitrogen, phosphorous, turbidity, suspended solids, or biological oxygen demand (BOD). However, nutrient criteria are currently being developed in Virginia, and are scheduled for completion in about 3 years. Virginia has also agreed to nutrient and sediment load allocation caps for stream flowing into the Potomac River to protect the Chesapeake Bay.

Table 1. DEQ Water Quality Criteria for Recreational, Aquatic Life, and Wildlife Uses in the Piedmont Zone[7].

Parameter	State Standard (Acute/Chronic)	Significance
Temperature	Maximum = 32^0C	Affects rates of chemical processes in cells and the water’s dissolved oxygen content
pH	6.0 – 9.0	Level of acidity -- affects cell membrane functions
Dissolved Oxygen (DO)	Minimum = 4 mg/l & Daily Avg. = 5 mg/l	Affects biological metabolism
Ammonia	0.83 – 32 mg/l as N acute/ 0.19 – 3.02 chronic[1]	Form of nitrogen that in excess causes eutrophication and loss of dissolved oxygen; a toxin
Chloride	860/ 230 mg/l	Indication of salt content
Fecal Coliform Bacteria	200 colonies/100ml or no more than 10% $\geq$400/100ml per month[8]	Common bacteria in animals’ digestive tracts. Indicator of human sewage or animal droppings
E. coli Bacteria	monthly mean $\leq$ 126 cfu/100ml, and no sample >235 cfu/100 ml	Specific bacteria in animals’ digestive tracts. Indicator of human sewage or animal droppings

1 Standard varies with temperature and pH

Impaired and Threatened Streams in Loudoun County

Many waters in Loudoun County are impacted by pollution because of land uses around them. Lists of impacted streams are provided in **Tables 2 and 3** and are shown in **Figure 1**. Impaired waters are documented as being unsuited for their intended use for aquatic life and recreation, and threatened waters are those that DEQ is still monitoring to document the impairment. These lists provide a focus for county and citizen efforts to protect the quality of Loudoun streams and stream buffers, and to restore those that are impacted and unsuited for their intended use for aquatic life and as recreational waters. Keeping excessive sediments, nutrients, organic materials, and harmful chemicals and bacteria out of streams requires the application of best management practices (BMPs). These BMPs need to be applied to the immediate stream bank buffers, the drainage areas along the streams, and throughout the upstream drainage area.

[7] Virginia State Water Control Board. 1997. *Water Quality Standards.*9 VAC 25-260-5 et seq.
[8] DEQ. 2002. Public Hearing, Water Quality Standards–Triennial Review. Amendment adopted May 2002 that will “sunset” after 12 data points or June 2008 when an *E. coli* standard will be adopted.

Table 2. Comprehensive List of Impaired Waters in Loudoun County – 2003. (Highlighted listings are new in 2004.)

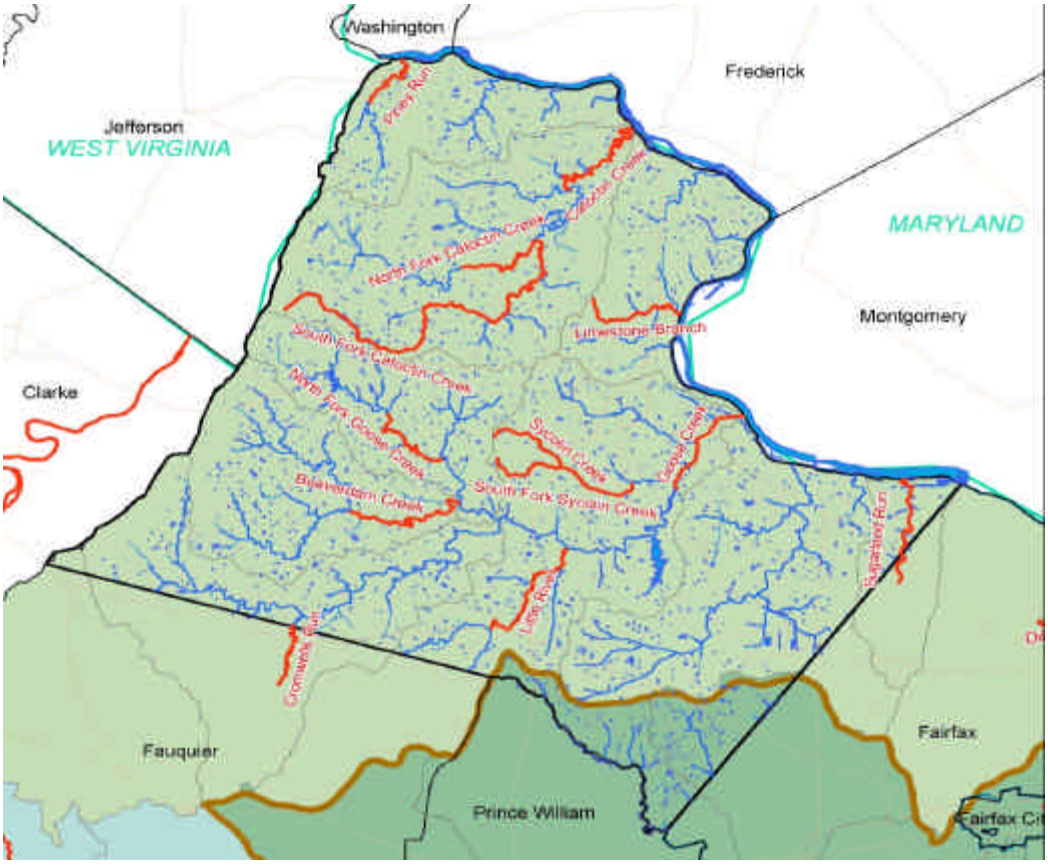
Stream Name	Cause[1]	Boundaries of Impaired Segment
IMPAIRED WATERS LISTED BY DEQ		
Piney Run	FC	3.5 mile segment from the mouth at the Potomac River upstream to the confluence with an unnamed lake
Catoctin Creek	FC	7.2 mile segment from its mouth at the Potomac River upstream to the confluence with Milltown Creek
North Fork Catoctin Creek	FC	4.1 mile segment from the confluence with Catoctin Creek upstream to a point 0.2 miles downstream of the Rt. 287 bridge
North Fork Catoctin Creek	FC	2.5 mile segment that includes the waters through the town of Hillsboro
South Fork Catoctin	FC	17.3 miles from the mouth at Catoctin Creek upstream to the headwaters
South Fork Catoctin Creek	Benthic	3.4 mile segment through the town of Purcellville
Limestone Branch	FC	4.8 miles from the mouth at the Potomac River upstream to the headwaters, but not including two unnamed tributaries
Middle Goose Creek	FC	7.2 mile segment upstream from the confluence with the NF Goose Creek
North Fork Goose Creek	FC, Phosphorus	4.3 mile segment from the confluence with Crooked Run upstream to the confluence with an unnamed tributary approx. 0.25 m upstream from the Rt. 611 bridge
Beaverdam Creek	FC	6.3 mile segment from the confluence with the North Fork Goose Creek upstream to the confluence with North Fork Beaverdam Creek
Lower Goose Creek	FC, Benthic	4.8 mile segment from the mouth at the Potomac River to the Goose Creek impoundment
Little River	FC, Benthic	6.1 mile segment from the confluence with Goose Creek upstream to the confluence with Hungry Run
Sycolin Creek	FC	10 mile from the mouth at Goose Creek upstream to the headwaters
South Fork Sycolin Creek	FC	3.3 miles from the mouth at Sycolin Creek upstream to the headwaters
Tuscarora Creek	FC	3.6 miles from the mouth at Goose Creek upstream to the confluence with Town Run
Broad Run	FC	2.9 miles from its mouth at the Potomac River upstream to the confluence with Horsepen Run
Sugarland Run	FC	4.42 mile segment from the mouth at the Potomac River upstream to the Fairfax County line

[1] Causes of Impairments: FC = Fecal Coliform Bacteria; Benthic – Aquatic Life

Total Maximum Daily Loads (TMDLs)

DEQ is required under the Federal Clean Water Act to establish total maximum daily loads (TMDLs) for pollution sources that cause the impairments. The TMDLs are developed to delineate pollution load allocations and a margin of safety to provide reasonable assurance that those streams will be restored to their designated uses. The TMDLs are based upon a model that predicts the response of the stream to different levels of pollution loads. These predictions are used to establish pollution load allocations that must be met if the stream is to meet the water quality standards.

Figure 1. DEQ Designated Impaired Waters in Loudoun County – 2003.



- **TMDL Implementation Plan** -- The Virginia Department of Conservation and Recreation (DRC) is required to develop an implementation plan that provides staged reduction targets. The implementation plan relies upon voluntary application, and is to be administered by local officials. DEQ is to track the effectiveness of pollution controls and implementation.
- **Best Management Practices** -- Restoring the health of streams will require protecting existing forested riparian buffer zones and installing best management practices along degraded stream corridors. Better control and natural treatment of stormwater runoff is also needed. A comprehensive, countywide monitoring program that provides statistically valid baseline data can be used to measure the effectiveness of these needed initiatives.

CURRENT STREAM MONITORING ACTIVITIES

The Federal Clean Water Act of 1972 guarantees citizens the right to be informed about the quality of their drinking and recreational waters, and to help keep these waters healthy. Water quality standards establish numerical criteria for the safe use of waters for aquatic life, drinking, swimming, fishing, and boating. The intent is to limit pollutants entering a stream so degradation that prevents these uses does not occur.

Stream Monitoring Parameters

There are several parameters being used to measure human impacts that upset the balanced conditions found in a natural stream ecosystem and cause major degradation problems to the stream water. These parameters include measurements of: (1) physical and chemical quality, (2) water flow, (3) bacteriological quality, (4) stream habitat, and (5) the type of organisms living in the stream. Water quality programs have traditionally relied on chemical and bacterial indicators to assess quality because government programs have historically focused on controlling point discharges of pollutants from industrial sources and community sewage treatment plants. These physical, chemical, and bacteriological parameters can also be used to reveal degradation from nonpoint pollution sources, but more sampling is required. Most data collected by DEQ in Loudoun Country are physical, chemical, and bacteriological data.

Sampling the aquatic organisms in Crooked Run

Biosurvey Parameters -- Biosurvey parameters are used to monitor pollutants that affect aquatic organisms, and to evaluate the relative seriousness of the impacts. Aquatic organisms (also called benthic macroinvertebrates) include the aquatic insects, crayfish and other crustaceans, clams and mussels, snails, aquatic worms, and other similar organisms. These organisms are excellent indicators for assessing the health of streams because they cannot escape changes in water quality. Each insect has requirements that the stream must provide for the insect to live in the stream. By determining the number and type of insects in a stream, the quality of the water and the health of the stream environment can be assessed.

Stonefly nymph indicates good quality

Mayfly nymph indicates moderate quality

A list of stream monitoring stations and the type of monitoring data available for each station is provided in **ATTACHMENT A**.

Organizations That Collect Stream Monitoring Data

To meet the requirements of the Clean Water Act and to keep citizens informed, stream monitoring is being conducted in Loudoun County at many locations by federal, state, and local authorities, and by watershed organizations and citizen groups.

Federal and Regional Government –

- **US Geological Survey (USGS)**– USGS collects chemical, sediment, and stream flow data at stations in Goose and Catoctin Creeks. Eight additional stations in other streams were added in 2002.

- **Metropolitan Washington Council of Governments (COG)** – COG has conducted baseline biological monitoring surveys in several Loudoun County streams under contract with the county. The surveys focus on non-point pollution problems using assessments of stream habitat and benthic macroinvertebrates, and include prioritized recommendations regarding preservation and restoration needs. They have completed studies of Sugarland Run, Talbot Farm Tributary, and Catoctin Creek. They are currently completing studies of the Goose Creek, Catoctin Creek, Broad Run, Limestone Branch, Dutchman Creek and Piney Run mainstem conditions.

DEQ – The Virginia Department of Environmental Quality (DEQ) collects stream monitoring data to evaluate the compliance of state waters with water quality standards and support of beneficial uses. These data are used to identify waters that fully meet and waters that do not meet the state water quality standards. Waters that do not meet the water quality standards for their designated uses are identified as impaired and are listed in DEQ's biennial 305(b) report to the public, the U.S. Environmental Protection Agency (EPA), and the Congress. DEQ collects stream quality data at 16 to 18 stations in Loudoun as part of Virginia's ambient water quality monitoring network. DEQ also collects stream habitat and macroinvertebrate data at 3 stations. The number of sampling stations and sampling frequency was reduced in 2001.

DEQ's sampling strategy for Loudoun County provides monitoring that is rotated between different subwatersheds every two years in a six-year cycle. The number of stations is selected on the basis of watershed size, stream order, and nonpoint pollution potential rating done by the Department of Conservation and Recreation. Twelve samples are taken at each site over the 6-year period. In addition, a number of trend stations located near stream flow gauges are sampled routinely. DEQ is also sampling streams on a random basis statewide, and one station was selected in Loudoun County on Wancopin Creek.

- **Physical, Chemical, and Bacteriological Monitoring –** Most DEQ sampling assesses physical, chemical, and bacteriological parameters to determine whether the stream water meets state water quality standards.
- **Biosurvey Monitoring –** DEQ does some aquatic insect and stream habitat monitoring to determine whether streams meet aquatic life criteria – currently at three stations in Catoctin Creek, Little River, and Goose Creek.
- **Reference Stream Sampling –** DEQ is also doing biosurvey monitoring to identify better reference streams to use to assess the health of the streams they are monitoring.

Loudoun County and County Agencies – There are several county authorities and agencies that monitor Loudoun streams. Monitoring includes assessing physical, chemical, and bacteriological water quality parameters

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- **Loudoun County Sanitation Authority (LCSA)** – LCSA monitors point wastewater and drinking water treatment discharges throughout the county. It does not routinely monitor streams, but does special studies at sites of proposed discharges. One such special study is being done on Broad Run. LCSA also conducts drinking water source protection studies that include limited assessments of riparian buffers and stream erosion. A study was completed in 2003 on the Beaverdam Reservoir in the Goose Creek watershed.
- **Loudoun County Soil and Water Conservation District (LCSWCD)** – LCSWCD monitors selected streams, assists volunteer citizen groups, and works with landowners to install agricultural best management practices.
- **Loudoun County Building and Development (LCB&D)** – LCB&D has received over $1 million over five years in grant funds for water resource monitoring.

Citizen and Environmental Groups – Loudoun County citizens have formed local watershed committees or have joined countywide and regional groups with water monitoring programs. These groups monitor basic physical and chemical parameters, and benthic macroinvertebrates.
Volunteer citizen groups active in Loudoun include:

- Loudoun Wildlife Conservancy
- North Fork Goose Creek Watershed Committee
- Wancopin Creek Watershed Neighbors

Monitoring data collected by citizen groups have historically been compiled by LSWCD and entered into a database. These data have been shared with county authorities, town managers, and others interested in streams. Citizen data also have been sent to DEQ. In 2000 Loudoun Wildlife Conservancy began compiling data on a countywide basis. These data were used to prepare a report titled, "State of Loudoun Streams: 2002," by Loudoun Watershed Watch.

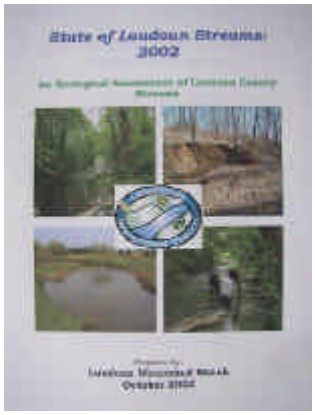
Piedmont Environmental Council (PEC) and Goose Creek Association (GCA) – PEC and GCA contracted with the Center for Watershed Protection (CWP) in 2001 to conduct a "Rapid Watershed Assessment of the Goose Creek Watershed." This assessment included baseline stream habitat data in three subwatersheds, and recommendations regarding preservation and restoration needs.

CURRENT GAPS IN STREAM MONITORING ACTIVITIES

Water monitoring has historically tended to focus on the collection of water quality data -- the more data collected, the better the monitoring program. In many instances it was not clear how this data would be used, and often it was not. In large part this is because there were no clearly defined goals for the use of the data, nor were the data translated into information that provided value and relevance to the water management community and the public.[9] What existed was uncontrolled and unorganized information.

Between 2000 and 2003 a concerted effort began in Loudoun County to develop water resource information systems that organized water quality data and provided an analysis of the data that gives it value and relevance. DEQ's TMDL studies, the Loudoun Environmental Indicators Project, the COG water quality assessments, LWW's **The State of Loudoun Streams: 2002** report, and Loudoun County Sanitation Authority's (LCSA) source water protection (SWP) program for Loudoun County are examples of these efforts.

State of Loudoun Streams



In 2002 Loudoun Watershed Watch published **The State of Loudoun Streams: 2002** report that provided an assessment of watershed conditions based on analyses of stream habitat, aquatic insect communities, and physical and chemical data collected by government and citizen groups at trend stations. This was the first time that monitoring data from state, regional, local, and volunteer groups was integrated into a comprehensive report on Loudoun streams. The findings of the report were:

- **Nonpoint sources of pollution (NPS)** affect all Loudoun streams. The state rates the impact as high for 67% of the streams. The main sources include urban storm water runoff, agricultural and grazing activities, failing septic tank systems, and wildlife. Failure to maintain riparian buffers and install adequate storm water, agricultural, and grazing best management practices (BMPs) are the principal reasons bacteriological quality and aquatic life in streams are degraded.
- **Increases in the amount of impervious surfaces** in watersheds that aggravate the effect of storm water runoff affect stream health. Assessments show that 22% of Loudoun streams are highly to moderately impacted. It is doubtful that streams highly impacted can be restored to health conditions. The high rate of development is causing more streams to be affected.
- The **bacteriological quality** of Loudoun stream water is generally marginal to poor. The poor quality is attributed to fecal contamination from nonpoint pollution sources. These high levels of contamination have existed for several years, although a couple of streams have shown improvement. Half of Loudoun streams exceed the fecal coliform water quality standard 30% or more of the time.
- The health of **stream habitats** varies considerably between streams. Monitoring sites on approximately 25% of the streams show marginal habitat conditions due to poor riparian buffers in agriculture areas, unstable banks due to high runoff episodes, and filling-in of stream bottoms with eroded sediments. These conditions have remained fairly consistent over the last several years.
- Conditions for **aquatic life** remain good at monitoring sites in almost 70% of the streams. There is good diversity of aquatic insects, and pollution intolerant species, such as mayflies, predominate. Monitoring sites in 30% of the streams show poor diversity and many more pollution tolerant species of insect such as midge larva. Biological conditions fluctuate considerably from year to year.

Recommendations – The report concluded that Loudoun County needs to develop watershed management plans to implement the policies of Loudoun's Green Infrastructure and Stream Corridor Overlay District in the Comprehensive Plan, and to implement best management practices to support state efforts to

[9] Peters, Charles, Robert Ward. "A Framework for 'Constructing' Water Quality Monitoring Programs." Water Resources IMPACT, Sept. 2003, Vol.5, No.5, p.3.

meet the requirements of the Federal Clean Water Act, the Chesapeake Bay Act, and the Virginia Water Quality Standards. In order to accomplish this, the following were recommended.

- Loudoun County should create a **water management authority** to develop watershed management plans and oversee the implementation of TMDL plans for Loudoun streams. A system of small subwatersheds should be identified that provide homogeneous management areas. Additional information regarding impervious cover and loss of forest lots will aid management planning. The authority needs to work with the Loudoun Watershed Watch to bring together stakeholders to support this process.
- Agricultural sources of nonpoint pollution are degrading Loudoun streams. Loudoun needs additional cost sharing and tax-incentive programs to encourage landowners to install **agriculture best management practices** to protect streams including fencing to protect streams from livestock.
- Loudoun County needs to support a **countywide stream monitoring program** to assess changes in stream health and progress in restoring water quality to supplement state efforts. The program should utilize low cost methods to assess bacteriologic quality, habitat conditions, and biological conditions.
- An updated **stream monitoring program and strategy** is needed for Loudoun County if the county is to play a leadership role in water resource protection. The updated strategy should focus on providing more representative data on watersheds, and on measuring the effectiveness of stewardship initiatives to restore water quality. This can be best accomplished by randomly selecting additional monitoring sites in each watershed to provide a **probabilistic sampling program**. A better balance between assessments of chemical, bacteriological, habitat, and biological parameters is needed to provide an accurate picture of stream health conditions. Increased monitoring by county and citizen groups should be encouraged to offset reductions in monitoring by the state.

Goose Creek Source Water Protection

In September 2003 the Loudoun County Sanitation Authority (LCSA) issued the findings and draft recommendations regarding the development of a source water protection (SWP) program for Loudoun County. This program is needed to protect drinking water sources within the Goose Creek watershed. The plan adopts a multi-barrier approach that will protect against: (1) detrimental increases in nutrients and sediments; (2) impacts of urbanization and agriculture; and (3) public health risks. Protections will include: (1) pre- and post-development best management practices (BMPs) regarding enhanced erosion and sediment controls; (2) riparian buffers and corridors within the watershed including riparian buffer restoration; and (3) enhanced floodplains and wetlands.

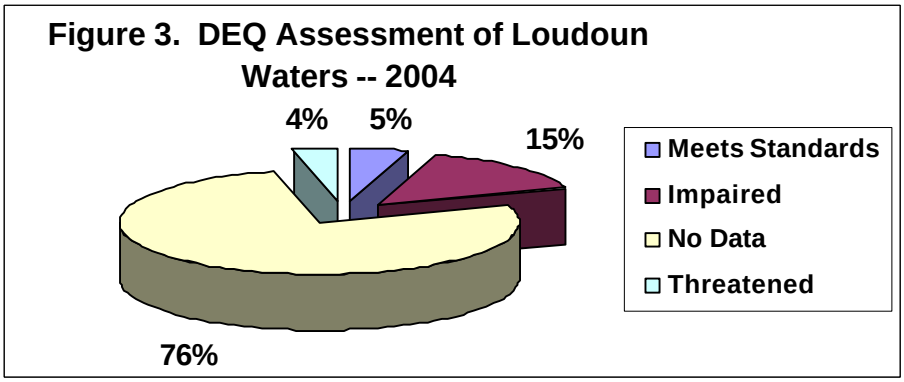
The SWP program includes a "risk monitoring & compliance" component that relies upon stream monitoring. Enhanced stream monitoring is needed to assess: (1) water quality and quantity; (2) stream habitats; (3) aquatic life (benthic macroinvertebrate) populations; and (4) stream cross-sections to assess erosion levels. To accomplish this needed stream monitoring, the report recommends:

- The development of partnerships to consolidate stream monitoring efforts;
- The provision of reliable funding for monitoring activities;
- Tracking implementation progress and prioritizing activities; and
- Public involvement and outreach.

DEQ's 2004 Water Quality Assessment Report

In 2004 DEQ issued their (305(b)/303(d) Integrated Report that is required under the Federal Clean Water Act. This report provides the Environmental Protection Agency and the public an update on the status of water quality in Virginia waters. The important findings of this assessment pertaining to Loudoun County are as follows:

- **New Impaired Waters --** There are new impairments in the following watersheds:
  - North Fork Catoctin – Fecal Coliform
  - South Fork Catoctin – Benthic
  - Middle Goose Creek – Fecal Coliform
  - Sycolin Creek – Fecal Coliform
  - Tuscarora Creek – Fecal Coliform
  - Broad Run – Fecal Coliform
- **Unassessed Waters –** Approximately 75% of the waters in Loudoun County have not been assessed by DEQ because of the scarcity of monitoring stations and resources to generate monitoring data. The percentage distribution of unsampled, impaired, threatened, and waters that meet standards is shown in **Figure 3**. It is know from the TMDL reports on Catoctin Creek and Goose Creek that most of the waters in these watersheds do not meet fecal coliform standards.
  - This highlights the need for a coordinated effort to provide **comprehensive stream monitoring in the county**.
  - These data are needed to develop watershed management plans, to protect clean waters, to set priorities to restore unhealthy waters, and monitor progress in meeting TMDL Implementation Plan goals.



- **Threatened Waters --** Many waters in Loudoun County are impacted by pollution because of land uses around them. Impaired waters are those documented by DEQ as being unsuited for their intended use for aquatic life and recreation. A list was previously provided in **Table 1**. Threatened waters are those that DEQ is still monitoring to document the impairment. A list of these waters is provided in **Table 2**.

Table 2. Comprehensive List of Threatened Waters in Loudoun County – 2003.

Name of Waters	Data Base Used	Description
THREATENED WATERS LISTED BY DEQ		
Piney Run (Unnamed Tributary	**LWC Site 15 -- benthic**	**Aquatic Life Use - Threatened** – 3.6 stream miles segment begins at confluence with Piney Run upstream to headwaters
Catoctin Creek	**LWC Site 3 -- benthic**	**Aquatic Life Use - Threatened** – stream segment below Taylorstown Bridge
North Fork Catoctin Creek	**LWC Site 1 -- benthic**	**Aquatic Life Use - Threatened** – stream segment from mouth upstream
Milltown Creek	**LWC Site 11 – benthic**	**Aquatic Life Use – Threatened** – 2 mile stream segment downstream from headwaters
Limestone Branch (Unnamed Tributary)	**LWC Site 5 – benthic**	**Aquatic Life Use – Threatened** 1.9 miles from headwaters to confluence with Limestone

Name of Waters	Data Base Used	Description
		Branch
Limestone Branch (Unnamed Tributary)	**LWC Site 16 – benthic**	**Aquatic Life Use – Threatened** 5 miles from headwaters to confluence with Limestone Branch
Panther Skin Creek	**LWC Site 12 – benthic**	**Aquatic Life Use - Threatened** – 3.7 miles from the headwaters to the mouth
North Fork Goose Creek	**LWC Site 7 -- benthic**	**Aquatic Life Use - Threatened** – 2.6 mile stream segment begins at the outlet from Sleeter Lake and continues downstream
North Fork Goose Creek	**NFGCWA Site 4 -- benthic**	**Aquatic Life Use - Threatened** – 2.5 mile stream segment upstream from confluence with Beaverdam Creek
North Fork Goose Creek	**NFGCWA Site 5 -- benthic**	**Aquatic Life Use - Threatened** - 2.5 mile stream segment upstream from confluence with Beaverdam Creek
North Fork Goose Creek	**DEQ – 1ANOG005.69 sufficient exceedances of the phosphorous screening value of 200 ug/L were recorded**	**Aquatic Life Use - Threatened** – 4.3 miles segment begins at the confluence of an unnamed tributary to North Fork Goose Creek, approximately 0.25 river miles upstream from the Route 725 bridge, and continues downstream to its confluence with Crooked Run, approximately 0.35 river miles upstream from Route 729 bridge.
Crooked Run	**LWC Site 6 – benthic**	**Aquatic Life Use - Threatened** – 2.1 miles upstream from mouth at NF Goose Creek
North Fork Beaverdam Creek	**DEQ ANOB007.97 – benthic**	**Aquatic Life Use - Threatened** – 2.1 miles downstream from headwaters
North Fork Beaverdam Creek	**LWC Site 10 – benthic**	**Aquatic Life Use - Threatened** – 1.1 mile segment
North Fork Beaverdam Creek	**LWC Site 9 -- benthic**	**Aquatic Life Use - Threatened** - 2.9 mile segment upstream from the confluence with Beaverdam Creek.
Tuscarora Creek	**LWC Site 2 - benthic**	**Aquatic Life Use - Threatened** - 3.6 miles segment upstream from the confluence with Goose Creek.
Broad Run/ Beaverdam Run	**LWC Site 13 – benthic**	**Aquatic Life Use - Threatened** - 0.5miles segment upstream of Ashburn pond.
Sugarland Run	**LWC Site 14 -- benthic**	Aquatic Life Use - Threatened - 5.8 miles segment begins at the confluence of Folly Lick Branch to confluence with the Potomac River.
OTHER WATERS THAT ARE THREATENED (Based on County Data)		
Piney Run	**LCSWCD Site 13 at Rt. 685**	**Fecal Coliform – Threatened** -- The portion of Piney Run extending from the unnamed lake at stream mile 3.5 upstream to its headwaters should be considered threatened for fecal coliform.
North Fork Goose Creek	**LCSWCD Site 3 at Rt. 733, site 7 at Rt. 729, and site 8 at Rt.782**	**Fecal Coliform – Threatened** – North Fork Goose Creek from its mouth at Goose Creek upstream to the confluence of Crooked Run and the current impairment
North Fork Goose Creek	**LCSWCD site 3 at Rt. 733, site 7 at Rt. 729, and site 8 at Rt. 782**	**Aquatic Life – Threatened** - North Fork Goose Creek from its mouth at Goose Creek upstream to the confluence of Crooked Run
Crooked Run	**LCSWCD site 6 at Rt. 725**	**Fecal Coliform – Threatened** - Crooked Run

Name of Waters	Data Base Used	Description
		from its mouth to its headwaters
Beaverdam Creek	**LCSWCD site 4 at Rt. 731**	**Aquatic Life – Threatened** - Beaverdam Creek segment from its confluence with the North Fork Goose Creek upstream to the confluence with North Fork Beaverdam Creek
Little River	**LCSWCD site 1 at Rt. 629**	**Fecal Coliform – Threatened** - Little River from the confluence with Hungry Run upstream to the Loudoun County line

Stream Monitoring Gaps

The gaps in the current stream monitoring activities that are identified in the State of Loudoun Streams: 2002 report, the SWP Program, and other reports[10] that have been prepared in recent years regarding Loudoun water resources are outlined in the following.

- **Integrated Monitoring Plans and Guidelines** – There is little joint planning or collaboration between state, regional, and county authorities, and citizen groups involved in stream monitoring in Loudoun County. Each entity has unique goals, protocols, sampling stations, and schedules.

- **Local Monitoring Relies on and is Constrained by State Resources** – Virginia currently ranks 50th among states in percentage of the state budget dedicated to funding natural resource programs (0.6 %). DEQ cannot meet stream monitoring needs on its own. Instead, DEQ relies on regional, county and citizen groups to collect data to help identify water quality problems. In addition, the Virginia Department of Conservation and Recreation (DCR) relies largely on county and stakeholder groups to develop TMDL Implementation Plans and watershed management plans. Currently, Loudoun County does not fund stream monitoring activities.

- **Gaps and Overlaps in Monitoring Coverage** – Most stream monitoring is conducted by DEQ, and they can only sample a limited number of stations. Seventy-six percent of the Loudoun waters including entire subwatersheds are not sampled. For example, there is only one DEQ sampling station in the Loudoun portion of Broad Run, which is Loudoun County's third largest watershed. The opposite may be true in other watersheds. For example, the North Fork Goose Creek watershed is one of the most monitored of all Loudoun watersheds. DEQ, LSWCD, LWC, and NFGC all have monitoring stations, sometimes at the same location.

- **Threatened Waters** – Stream segments classified by DEQ as impaired for their intended uses are largely based upon sample results from one monitoring station. County and citizen data, as well as TMDL water quality modeling, indicate that water quality standards are not being met in large portions of watersheds, but there is no field data to substantiate this. Additional baseline data is needed to document the scope of water quality degradation and to assess the effectiveness of TMDL implementation.

- **Different Protocols Utilized** – Monitoring authorities and citizen groups use different protocols that often make data incompatible. DEQ has a unique protocol based upon EPA's Rapid Bioassessment Protocol (RBP). LWC's protocol is also based upon EPA's RBP but with some modifications to accommodate citizen monitors. LCSWCD and North Fork Goose Creek Association use the Save Our

[10] Reports have been prepared by the Loudoun Environmental Indicators Project; the Center for Watershed Protection incorporation with the Piedmont Environmental Council and the Goose Creek Association; and the Council of Governments.

Streams (SOS) protocol developed by the Izaak Walton League. Council of Governments (COG) uses a Rapid Stream Assessment Technique (RSAT) that they developed. The Center for Watershed Protection (CWP) uses a Riparian Improvement Tracking (RIT) protocol they developed. Loudoun County authorities contract out stream assessments to environmental engineering firms that use their own protocols.

- **Watershed Focus Lacking** – In the past stream monitoring has not been designed to support watershed management planning at the subwatershed level. Instead, monitoring stations have been selected to assess compliance with state water quality standards, or to assess a particular stream or stream segment of interest to a local citizens group. This has created the overlaps and gaps in data discussed above.

- **Random Data from Probabilistic Stations** – There is no unbiased stream monitoring data available for Loudoun County collected from randomly selected stations that can be extrapolated to assess stream health over an entire stream length with known statistical confidence. Stream monitoring data, collected to date, have been used to track trends in water quality at specific targeted locations. Sampling stations have been selected based upon professional judgment in the case of DEQ, and lay judgment for citizen monitoring stations. Sites are normally located near a bridge and have public assess. Data collected at these targeted stations are biased, not random, and results are only applicable to the particular site being sampled.[11] Assessment results cannot be extrapolated to assess overall water quality and stream health conditions in a subwatershed. These assessments are needed to establish watershed protection strategies and stream restoration priorities.

[11] U.S. Fish & Wildlife Service. "Freshwater Biomonitoring Using Benthic Macroinvertebrates." National Conservation Training Center. May, 2003

STREAM MONITORING PROGRAM STRATEGY

Protecting Loudoun's water resources require the participation of all stakeholders in applying a comprehensive strategy that recognizes diverse interests. The strategy must be based on sound science, and should integrate the social, economic, and cultural factors important to the stakeholders. Successful monitoring programs are those that organize a series of activities to produce and convey information that can be used by these stakeholders.[12]

This comprehensive stream monitoring plan for Loudoun County is a sequential step toward a goal to provide information systems that will produce and convey water quality information in a manner relevant to water resource decision makers. Its design is the product of stakeholder participation and it represents a collaborative initiative that seeks to addresses the shared goals of its participants. It demonstrates what stakeholders can do working together that they cannot do working alone.

Program Visions

Watershed management planning requires prioritized goals that address needs that incorporate a wide range of social, economic, and environmental factors.[13] The key components of watershed plans are considerations about water quality, stream management, habitat restoration, and the relationship between land use planning and healthy watersheds. The development of watershed management plans that incorporate national, regional, and state legislative commitments as well as community priorities needs to be a function of local governments and watershed organizations.

- **Virginia –** It is the vision of Virginia State government agencies[14] that local government and watershed groups will become the principal authorities that prepare watershed management plans. Under the Chesapeake 2000 Agreement, Virginia agreed to "work with local governments, community groups, and watershed organizations to develop and implement locally supported watershed management plans." These plans are to address the protection, conservation, and restoration of stream corridors, riparian buffers, and wetlands for the purpose of improving habitat and water quality. The development of effective watershed management plans will enable Virginia to meet the Total Maximum Daily Load (TMDL) and storm water provisions of the federal Clean Water Act.

- **Loudoun County –** It is Loudoun Watershed Watch's (LWW) vision[15] that Loudoun County government and County Agencies will become the principal authorities that collect water resource data, and prepare and implement watershed management plans with the support of citizen watershed organizations. In the short term, Loudoun government and agencies lack adequate resources to accomplish these tasks. As a result, the proposed stream monitoring program strategy relies heavily upon citizen volunteers as a key component to maintain data collection in the interim. As county government and agency water quality protection and restoration programs grow, the citizen's role in data collection should diminish proportionately. The long-term citizen role is envisioned to focus on watershed plan implementation, environmental stewardship, and community education.

Monitoring Framework

A monitoring framework facilitates communication among government and citizen volunteers working on different components of the monitoring program, and guides the design of the monitoring program to insure that all

[12] Markowitz, A., L.T. Green, J. Laine. 2003. "The 3C's: Communicate, Coordinate, Collaborate – Doing Together What We Can't Do Alone." Water Resources IMPACT, American Water Resources Association, Vol. 5, No. 5, p. 8-10.
[13] Firehock, Karen. "A Watershed Planning Primer for Virginia," University of Virginia, 2003.
[14] Firehock, Karen. "A Watershed Planning Primer for Virginia," University of Virginia, 2003.
[15] Loudoun Watershed Watch. "State of Loudoun Streams: 2002." 2002.

components are included, balanced, connected, and focused on producing relevant information. The key focus of a monitoring framework is the flow of information from one activity and component to another. [16]

The information flow starts with identifying the information users, articulating the monitoring goals that identify the type of information that the users desire, and developing a monitoring strategy designed to meet the goals. The second component of the framework is providing a monitoring design that will guide operations in obtaining the desired information. Several designs may be needed to provide different types of information. The third component is conducting environmental sampling where measurements are made that can convert the water's and aquatic life's properties into numbers. The forth component is storing data in an information system that organizes the data for easy retrieval and for analyses and interpretation. Data storage needs to include sufficient descriptive information about the data (i.e., "meta data").

Information flow continues with data analysis and interpretation by applying statistics and graphical presentations to the data. The data analysis methods should be determined prior to sampling so the data collected will adequately support the desired data analysis methodologies. The sixth component is the dissemination of the data that has been analyzed and interpreted to government decision makers and the public in the form of presentations and reports. The final component is periodic evaluations of the monitoring program to assess whether goals are being accomplished and resources are being efficiently utilized.

Watershed Level Monitoring

Stream monitoring at the watershed level provides data for achieving broader environmental protection objectives. It provides an integrated, inclusive strategy for more effectively protecting and managing surface waters and ground water resources using naturally defined hydrological units (the watershed) as the integrating management unit. The watershed approach to monitoring allows an emphasis to be placed all aspects of water resource quality – physical, chemical, and biological. This approach also offers a means of conducting comprehensive evaluations of ecological status and improvements from restoration activities. Biological assessment integrates the condition of the watershed from tributaries to mainstem through the exposure/ response of indigenous aquatic communities.[17] The steps involved in protecting water quality are outlined in **Table 3**.

Table 3. Steps in Water Resource Protection[18]

STEPS	STRATEGIES / PROJECTS
1. Detect water quality and aquatic life impairments	• Baseline data collection • 305(b) assessment
2. Assess the relative severity of the impairments	• Reference condition documentation • Compare baseline data with WQ standards or reference conditions • 303(d) assessment
3. Identify the specific stress agents causing impairments	• TMDL study • Stream walks/assessments • Special studies
4. Identify and limit the specific sources of these stress agents	• TMDL Implementation Plan
5. Design appropriate best management practices/treatment to meet the prescribed limits	• TMDL Implementation Plan
6. Evaluate effectiveness and compliance	• Trend data collection

[16] Peters, Charles, Robert Ward. "A Framework for 'Constructing' Water Quality Monitoring Programs." Water Resources IMPACT, Sept. 2003, Vol.5, No.5, p.3.
[17] EPA. *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers.* EPA 841-B-99-002. July 1999
[18] EPA. *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers.* EPA 841-B-99-002. July 1999.

Judgment and Probabilistic Sampling Design[19]

A well-planned stream sampling design will ensure that resulting data are adequately representative of the target stream and defensible for their intended use. The sample design process will also consider the efficient us of time, money, and human resources. A good design will meet the study needs with a minimum expenditure of resources.

There are two main categories of sampling design: judgment designs and probability-based designs. **Judgment sampling** involves selection of monitoring sites on the basis of expert knowledge or professional judgment. Such stations can be used to track trends in the water quality in a watershed. **Probability-based designs** involve random selection of monitoring sites. This allows statistical inferences to be made about the sampled population from the data obtained. These data allow baseline assessments to be made with an efficient use of resources. **Table 4** provides a summary of the main features of each type of sampling design. The monitoring program proposed for Loudoun County combines the use of both designs.

TABLE 4. Judgment Versus Probability-based Sampling Designs.

	Judgment	Probability-based
Advantages	• Can more efficient with knowledge of site and use of historical data • Easier to implement • Preferred for educational purposes and citizen participation	• Provides ability to calculate uncertainty associated with estimates • Provides reproducible results within uncertainty limits • Provides ability to make statistical inferences • Can handle decision error criteria
Disadvantages	• Depends upon expert knowledge • Cannot reliably evaluate precision of estimates • Depends on personal judgment to interpret data relative to study objectives • Cannot make statistically valid statements • Constrained by historical site locations	• Random locations may be difficult to access • An optimal design depends on an accurate conceptual model

Program Collaboration

In Loudoun County stream monitoring can best be achieved through the collaboration of federal, state, regional, and local authorities; and citizen watershed organizations. A monitoring strategy and plan that: (1) identifies the common ground among all parties, (2) provides a common language, (3) articulates benefits for each party, and (4) identifies the added benefits from working together will provide the most effective use of limited state, county, and volunteer resources. The contributions envisioned that each party can bring to a joint strategy are as follows.

- **EPA –** The Federal Environmental Protection Agency (EPA) administers the Federal Clean Water Act and oversees implementation of the Act by the Virginia Department of Environmental Quality (DEQ). EPA sets standards and provides guidelines for water quality monitoring, stream protection, and water quality restoration. Loudoun County receives grant funds and technical guidance from EPA.

- **USGS –** The US Geological Survey (USGS) records stream flows at ten locations in Loudoun County, and provides real-time flow data. USGS also provides grant funds and technical guidance on water quality, and stream protection and restoration.

[19] EPA. *Guidance on Choosing a Sampling Design for Environmental Data Collection.* EPA/240/R-02/005. 2002.

- **DEQ and DCR –** State agencies have the legal mandate and professional staff to monitor streams and ensure that state water quality standards are met. They have a large amount of trend monitoring data at selected stations throughout the county. They provide grant funds and technical support to local governments and citizen groups as resources permit regarding monitoring, watershed management planning, and pollution control. DEQ uses county and citizen data to help identify threatened waters that need state study.

- **County Government and Agencies –** Loudoun County ordinances provide for the protection of stream corridors. Loudoun County and County Agencies have professional staff to provide safe drinking water, monitor and control point discharges of pollution, protect citizens from water related health hazards, and monitor and manage stormwater facilities as resources permit. The County and County Agencies also have grant funds to conduct drinking water source protection studies, to monitor surface and groundwater resources, and to begin developing watershed management plans.

- **Citizen Groups –** There are a large number of citizen groups and environmental organizations active in Loudoun County whose goals include environmental stewardship and stream habitat protection. These groups provide a voice for stakeholders and support for use of state and county resources to protect water resources. Citizen groups also have trained volunteers who can collect water samples for physical and chemical analyses, monitor benthic macroinvertebrates, and assess stream habitats. Environmental organizations have trained staff to provide environmental education.

STREAM MONITORING GOALS

On March 6, 2003 state, regional, and local stakeholders participated in the "Comprehensive County Stream Monitoring Plan Design Development Conference" sponsored by Loudoun Watershed Watch at Rust Sanctuary, Leesburg, VA. Attendee met to identify the stream monitoring goals needed for a comprehensive stream monitoring program for Loudoun County. Participants understood that healthy streams must have a diversity of aquatic life, stable stream banks and substrates, vibrant native vegetation, and healthy floodplain and buffer areas. It was agreed that stream monitoring should be directed at helping to achieve the goals needed to realize this vision. The stream monitoring goals formulated at this conference and upon which this comprehensive monitoring plan is based are listed in **Table 5**.

Table 5. Stream Monitoring Goals for Loudoun County.

Reasons for Monitoring	Who Will Use This Data	How Will the Data Be Used?
Goal #1: Characterize the Current Status of Water Quality and Stream Health:		
• To develop baseline data using probability sampling to characterize the health of Loudoun streams	Loudoun County & Agencies, Loudoun Watershed Watch*	Development plan reviews, erosion controls, and baseline stream assessment reports
• To determine whether water quality standards are being met	DEQ	305(b) and 303(d) reports on water quality
• To provide data to help develop watershed management plans	Loudoun County & Agencies	Watershed management plans
• To establish stream preservation and restoration priorities	Loudoun County & Agencies, Loudoun Watershed Watch	Stream protection and restoration action plans
• To identify problem streams and stream segments	DEQ, Loudoun County & Agencies, Loudoun Watershed Watch	Targeted, special water quality and stream health studies
Goal #2: Provide Trend Assessments and Forecasts:		
• To document water quality trends over time	DEQ, Loudoun County & Agencies, Loudoun Watershed Watch	Status reports on the health of streams, watershed management plans
• To provide data to help develop watershed management plans	Loudoun County & Agencies	Watershed management plans
Goal #3: Evaluate TMDL Implementation and Watershed Management Plans:		
• To determine whether TMDL implementation is working	EPA, DCR, DEQ	TMDL status reports
• To determine if watershed management plans are effective	Loudoun County & Agencies, Loudoun Watershed Watch	Watershed management plan status reports and assessments
Goal #4: Provide Environmental Stewardship and Education:		
• To provide documentation for educate materials regarding pollution prevention and environmental stewardship	Loudoun County & Agencies, Loudoun Watershed Watch	Educational materials
• To provide avenues for citizens to demonstrate concern regarding stream health	Loudoun Watershed Watch	Educational materials
Goal #5: Coordinate State, County, and Citizen Resources:		
• To divide monitoring needs rationally between state, county, and citizen groups	NA	NA

* Loudoun Watershed Watch is used to indicate member groups including Loudoun Wildlife Conservancy, North Fork Goose Creek Committee, and Piedmont Environmental Council.

How Monitoring Data Will Be Used by DEQ

Guidance developed by DEQ[20] provides that stream monitoring data from local government and citizen groups that are "approved" will be used by DEQ in their 305(b) stream quality assessment report to EPA. To be "approved," all citizen water quality data is to be sent to DEQ's Citizen Monitoring Coordinator (CMC) who is responsible for evaluating and approving SOPs, QA/QC plans, training manuals, and current monitoring procedures for citizen monitoring groups. The guidelines for DEQ's use of approved data are as follows:

- Biological monitoring sites characterized as either "excellent" or "good" will be designated as "Areas of low probability for adverse conditions." Biological sites periodically characterized as 'fair" or "poor" will be designated as "Areas of medium probability for adverse conditions" and listed as areas with insufficient data but threatened[21]. Follow-up monitoring will be scheduled as soon as possible. Biological sites that are consistently poor will be characterized as "Areas of high probability for adverse conditions" and listed as areas with insufficient data but threatened. Follow-up monitoring by DEQ will be prioritized.
- The summaries of local government and citizen data will be placed under a separate Citizen Monitoring section of the 305(b) report.
- Stream segment lengths represented by a local government or citizen monitoring site will be determined by the CMC in conjunction with the local groups using mileage delineation section of DEQ's 305(b) and 303(d) assessment guidance manual.
- Local government and citizen monitoring data from stations that complement or are comparable to DEQ stations will be used as background data.
- The CMC will provide all "approved" local government and citizen data in the appendices of the 305(b) report.
- Regional DEQ planning and monitoring staff will be given a list of all stations classified as "Area of medium probability for adverse conditions: and "Area of high probability for adverse conditions." The regional monitoring staff will review the list and consider including appropriate sites in their regional monitoring plan for future monitoring activities.

How Monitoring Data Will Be Used by Loudoun County

Loudoun County government has adopted land-use planning, development, and quality of life policies that protect major rivers, stream corridors, floodplains and wetlands, lakes, reservoirs, and impoundments[22]. The county recognizes that these natural resources are fragile and irreplaceable, and, therefore, need protection and preservation. The County's watersheds are the key natural resource element in the Green Infrastructure, and will be used as its primary organizing unit.

Loudoun County government will use stream monitoring data to help implement a variety of county programs including the following:

- **Loudoun County General Services, Stormwater Management Program (LCGS) --** LCGS will use stream monitoring data to assess the impacts of stormwater discharges into Loudoun streams and evaluate the effectiveness of stormwater rehabilitation programs.

[20] VA DEQ. "Water Quality Assessment Guidance Manual for Y2004."
[21] In 2004 DEQ will substitute the term "observed effects" for "threatened." However, since the new term has no inherent meaning and provides an obtuse characterization of data, LWW will continue to use "threatened."
[22] Loudoun Comprehensive Plan, Chapter Five, The Green Infrastructure: Environmental, Natural, and Heritage Resources, 2002.

- **Loudoun County Building and Development (LCB&D) –** LCB&D will use stream monitoring data to identify threatened stream corridors that need to be protected with best management practices for stormwater and other non-point pollution from developments.

- **Loudoun County Health Department, Division of Environmental Health (LCHD) –** LCHD will use stream monitoring data to identify failing septic disposal systems, and to evaluate the effectiveness of septic system restoration programs.

- **Loudoun County Sanitation Authority (LCSA) –** LCSA uses stream monitoring data for drinking water source protection studies that include limited assessments of riparian buffers and stream erosion.

- **Loudoun County Soil and Water Conservation District (LCSWCD) –** LCSWCD uses stream monitoring data to help evaluate the effectiveness of cost-sharing programs for landowners who install agricultural best management practices.

The County will be developing comprehensive watershed management plans to help identify best management practices that are needed for individual watersheds. Water quality data will be a critical component of these watershed plans, and new water quality data will be needed for many stream segments impacted by stormwater and agricultural practices, and segments that will be subject to future development.

How Monitoring Data Will Be Used by Citizen Groups

Citizen monitoring groups in Loudoun County are dedicated to maintaining clean and healthy streams in Loudoun County, and educating citizens about the importance of our streams and stream corridors to people and wildlife. These groups use stream monitoring data to:

- Identify trends in water quality and stream health in Loudoun watersheds over time;
- Develop baseline water quality and stream health data to supplement state and local data;
- Identify potential water quality and stream health problems;
- Assess the impacts of land use activities (urban, industrial, and agricultural) on water quality and stream health;
- Provide educational materials to the local community and stream users about pollution prevention and environmental stewardship; and
- Show public officials that citizens care about the health of streams and the wise management of water resources.

Many of the activities of these groups are supported by grant funds from DEQ and other organizations such as the Audubon Naturalist Society, Izaak Walton League, Canaan Valley Institute, Chesapeake Bay Restoration Fund, and National Fish and Wildlife Foundation.

STREAM MONITORING DESIGN

In May 2003 Loudoun Watershed Watch sponsored a second workshop to help develop a "Loudoun County Stream Monitoring Strategy." At this two-day workshop, state, regional, and local stakeholders outlined a structure for a comprehensive, countywide stream monitoring program that will provide statistically valid data on stream health.[23] Sampling designs were agreed upon to achieve the different monitoring goals. A list of the stream monitoring designs from the workshop, and included in this document, is provided in **Table 6.**

Table 6. Summary of Monitoring Designs To Be Applied in Loudoun County.

Monitoring Goal	Monitoring Design	Implementing Group/Authority
#1 & #4	Watershed Survey	Loudoun County & Agencies, Citizen Groups
#2	Trend Monitoring	DEQ, Citizen Groups
#1	Probabilistic Monitoring	Loudoun County & Agencies, Citizen Groups
#3	TMDL Validation	DEQ, Citizen Groups

The workshop participants recognized that the proposed monitoring design is ambitious, and is beyond the individual capabilities of DEQ, Loudoun County government and Agencies, and citizen volunteers to fully implement at this time. Nevertheless, workshop participants are confident that increased funding will be available in the future as TMDL implementation and watershed planning becomes more important.

What Will Be Monitored?

Aquatic resources are complex systems that can be assessed using many different parameters. However, many types of analyses require expensive monitoring instruments or costly analytical protocols. Existing stream monitoring data suggest that the principal contamination problems affecting Loudoun watershed are (1) fecal bacteria from agricultural and human activities, and (2) sediments from erosion and stormwater flows. The bacteria affect water use involving direct body contact, and sediments impact aquatic life in the streams. Erosion is aggravated by changes in land use from forest lots to residential and commercial lots, and other degradation of forested and wetland riparian buffers. No widespread nutrient problems have been identified to date.

The proposed monitoring designs focus on six types of data: (1) basic water chemistry parameters, (2) fecal bacteria contamination, (3) macroinvertebrate community, (4) instream physical habitat and riparian habitat, (5) nutrients, and (6) sediment contamination. Sampling and analytical protocols for these parameters need not be expensive, and volunteers can be adequately trained to collect the required samples. Special studies can be done to assess other water quality and stream health parameters on an as-needed basis.

I. Watershed Survey Design

Summary

A watershed survey is the collection of new and existing information on conditions and processes at the watershed level.[24] This information can be used to identify the type of additional monitoring that may be needed and problem areas for corrective action, and to bolster watershed awareness and education at all levels, including the individual landowner, community groups, and county authorities.

[23] Recommended in the Loudoun Watershed Watch, "State of Loudoun Streams: 2002," report.
[24] Pennsylvania Citizen's Volunteer Monitoring Program and River Network. "Designing Your Monitoring Program." 2001. p. 5-6.

A watershed survey is an important step in developing watershed management plans. It has two parts:

- **Information Research Survey** – Existing information from reports, interviews, and public meetings regarding stream and watershed conditions and characteristics is compiled; and
- **Field Surveys** – Field data and visual observations on various watershed conditions and characteristics are collected.

A Watershed Survey is also an important component of a TMDL Implementation Plan. It can identify specific stream segments where controls can be applied to reduce NPS pollution loads, or erosion and sediment problems that impact aquatic life.

Purpose

A Watershed Survey is a starting point in the development of watershed management plans and TMDL Implementation Plans because it provides basic information on the watershed that can be used to determine which areas or issues need to receive attention. The information can be used to establish monitoring priorities that most efficiently use monitoring resources, and to identify best management practices that will address the most critical needs. The results can also be used to develop community education and awareness programs and materials.

Siting Criteria and Priorities

The goal is to conduct an Information Research Survey on the entire length of a stream, and a Field Survey on as much of a stream as possible. Considerations for determining which stream segments should receive the highest priority for Field Surveys includes:

- Stream segments that contain problem areas that might be a high priority for some corrective action;
- Stream segments that contain special resource areas such as parks and public access; and
- Stream segments that contain threats to human and aquatic life uses of the water.

Priority should also be given to streams on which TMDL Implementation Plans are being developed. Further, priority should be given to headwater streams that are in subwatersheds that show good stream health and should be protected against degradation.

Survey Parameters

Data collected from an Information Research Survey can be used to narrow the geographic and topical scope of a watershed monitoring plan. It can help direct monitoring to specific reaches or areas of the watershed where current uses and human impacts threaten the health of the stream and need to be assessed with a Field Surveys. The activities associated with each type of survey are summarized in **Table 7.**

Table 7. Summary of Activities Conducted During a Watershed Survey.

Survey Activities	Parameters and Methods Applied
Research Watershed Information – Literature search for reports, plans and other known documents pertaining to the watershed to identify uses, values, threats, and conditions.	Possible sources of information: • EPA Surf Your Watershed • DEQ Regional Offices • Soil and Water Conservation District • Loudoun County LCSA • Loudoun County Mapping
Research Citizen Concerns – Survey citizen uses, values, and perceived threats to the watershed.	Hold a public meeting for watershed residents to identify local uses, values, and threats
Field Survey – Survey the stream, riparian, and watershed characteristics and conditions including: • Habitat assessment	Preferred protocols include: • Visual assessment based upon EPA RBP • Watershed Field Inventory (Adopt-A-Stream)

• Macroinvertebrate assessment • NPS and erosion assessment • Stream channel cross section	• EPA BioRecon • COG RSAT* • CWP Riparian Improvement Tracking (RIP)**

*Galli, J. 1996. Final Technical Memorandum: Rapid Stream Assessment Technique (RSAT) Field Methods. Washington Metropolitan Council of Governments (COG).
**Center for Watershed Protection (CWP). 1998. "Rapid Watershed Planning Handbook." Ellicott City: Center for Watershed Protection.

Schedule of Field Surveys

It is recommended that Field Surveys be conducted on a one-time basis for the purpose of helping to develop monitoring plans for a particular watershed and TMDL Implementation Plans. Follow-up Special Surveys can be conducted if there are seasonal or event-oriented problems that need further investigation (e.g., storm event pollution runoff).

Field Survey should be scheduled for the summer months when college interns may be available to assist, and for the fall when stream access is easier. A recommended schedule for Field Surveys that gives priority to TMDL streams is provided in **Table 8**.

Table 8. Proposed Five-Year Schedule for Watershed Surveys.

Watershed	Purpose	Date for Field Survey
Limestone Branch	TMDL Implementation	Summer 2004
Piney Run	TMDL Implementation	Fall 2004
Sycolin Run	TMDL Implementation	Summer 2005
SF Catoctin Creek	TMDL Implementation	Fall 2005
NF Catoctin Creek	TMDL Implementation	Summer 2006
Little River	TMDL Implementation	Fall 2006
NF Goose Creek	TMDL Implementation	Summer & Fall 2007
Beaverdam Creek	TMDL Implementation	Summer & Fall 2008

Data Analysis

The results of the watershed survey are a set of quantitative measures and qualitative observations. These data and observations can be recorded in a spreadsheet or database, analyzed using EPA RBP methods, and summarized on tables and graphs on maps in order to reveal and present problems areas for action. The maps can include:

- Areas where data to make management decisions are lacking;
- Areas of different land uses;
- Problems and conflicts that need to be resolved by management decisions;
- Special areas in need of protection; and
- Special projects to address problems found in the assessment.

Quality Assurance/Quality Control (QA/QC)

Recommended Quality Assurance/Quality Control measures that should be applied to Field Surveys include the following:

- Written, detailed protocol comparable with DEQ, CWP, and COG guidelines;
- Training/Certification for surveyors;
- Data quality objectives as provided in **Table 9;**
- Equipment inspection and maintenance;
- 10% level of field observation by project coordinator; and
- 10% level of lab analysis of preserved field benthic macroinvertebrate samples.

Table 9. Quality Objectives for Watershed Surveys.

Monitoring Parameter	Quality Objectives
Benthic Macroinvertebrate Sample	80% accuracy in ID 90% accurate of count 90% completeness on data sheet
Habitat Assessment	90% completeness on data sheet
Pollution Source Assessment	90% completeness on data sheet
Stream Cross Section	90% completeness on data sheet
Other parameters and meta data	90% completeness on data sheet

State/County/Citizen Role

Countywide Watershed Surveys have not been attempted previously in Loudoun County, although they have been applied in specific areas by COG and CWP with success. Expanding monitoring to include this design will require additional resources from each of the parties committed to a collaborative monitoring program. It is envisioned that each party will contribute the following to implement the comprehensive strategy:

- **State –**
  - DEQ to provide technical support in reviewing Information Research Survey and Field Survey protocols, and in selecting stream segments for Field Surveys; and
  - DCR to provide technical support in incorporating Watershed Survey data into TMDL Implementation Plans.

- **County –** Loudoun County and County Agencies should provide:
  - Information Research Survey support for each watershed to be surveyed;
  - Mapping and data analysis support; and
  - GPS units for Field Surveys.

- **Citizen –** LWW should provide:
  - Citizen Stream Monitoring Coordinator to lead the project;
  - Citizen volunteer survey members to work with interns;
  - Trainers for conducting Field Surveys;
  - Field Survey equipment and materials;
  - Data recording, analysis, and report preparation; and
  - QA/QC implementation.

Funding Requirements – Watershed surveys will be very labor intensive and will require much planning and coordination. Possible funding sources include DCR for surveys of TMDL watersheds, county grants from their water resource monitoring funds, and grants from other sources. Funding requirements will include:

- Funding for a citizen Watershed Survey Project Coordinator (20 hr/wk for 8 months);
- Funding for two summer interns (40 hrs/wk for 2 months) to conduct Field Surveys; and
- Funding for two fall interns (20 hrs/wk for 4 months) to conduct Field Surveys.

Training Requirements – LWW member organizations have a core cadre of trained volunteers who can conduct Field Surveys. The Watershed Survey Project Coordinator should be trained by the organization that developed the assessment protocol being used. The Project Coordinator or another experienced surveyor can then train survey team members. Following the training, surveyors can be observed in the field gathering data to assure that training is effective. Follow up field audits can also be used to assess the adequacy of training.

II. Trend Monitoring Design

Summary

Representative water quality data from any permanent monitoring station can be used to evaluate trends in water quality at the station. Documentation of short-term, mid-term, and long-term trends can be used to assess water quality and the effectiveness of best management practices implemented to restore water quality. Trend sampling stations must be carefully selected based upon professional judgment to provide data to answer specific questions about water quality and stream health.

Trend data from one monitoring site can be combined with other trend data to produce trend analyses for larger drainage areas. The sampling methods and laboratory analytical methods must be standardized to combine data from various stations or to compare trends in different streams. Further, the timing of sample collection must be kept relatively constant from month to month and year to year in order not to introduce additional variables.

Purpose

Trend stations are established to provide data for detecting and evaluating tendencies in long-term water quality changes. They provide a balance between limited time and resources and sampling as many parameters as possible using relatively simple methods. The data can also be used to identify problems areas for further monitoring, and for educational and awareness purposes at the community and watershed levels.

Siting

To date, the stream monitoring data collected in Loudoun County by DEQ, LWC, LSWCD, and NFGC have been trend data from monitoring stations selected on the basis of professional judgment. These monitoring stations have been used to assess approximately 25% of the stream miles in Loudoun County and are listed by watershed in **Appendix A**. To the extent possible these stations should be maintained, although some modifications are needed where existing stations of different groups are clustered.

Additional trend monitoring sites should be established to:

- Provide monitoring data in subwatersheds not currently sampled, and
- Provide additional trend data in subwatersheds subject to TMDL management in order to help assess the effectiveness of TMDL implementation.

Selecting additional trend stations to meet these needs should be based on considerations used by DEQ to site their trend stations[25].

- Sites should be located where benthic macroinvertebrate samples can be taken.
- Sites should be located near the mouth of the drainage area to evaluate the loadings being discharged to the subsequent downstream watershed; either upstream or downstream of the confluence.
- On mainstem streams containing water from multiple upstream tributaries, sites should be located near the discharge into the Potomac River.
- Sites should represent different stream orders (sizes).
- New sites should be located to the extent possible near flow gauging stations or near locations where flow can be accurately interpolated from gauging station in the same or in adjacent drainages. The volume of water passing the sampling site (flow or discharge rate) is an important water quality parameter and is required to calculate "pollution loadings."

[25] DEQ. 1999. "Virginia's Water Quality Monitoring Strategy."

Based on these considerations, a recommended list of trend stations is provided in **Appendix B.** Adjustments made to the existing monitoring station locations are indicated.

Parameters and Protocols

Trend stations should be monitored for all parameters that are subject to water quality standards and are included in the Chesapeake Bay Tributary Strategy requirements. Additional parameters can be monitored, especially by DEQ, as resources permit. The basic parameters are listed in **Table 10.**

Table 10. Minimum Sampling Parameters for Trend Sampling Stations in Free Flowing Streams.

Parameter	Sampling Protocol	Analytical Protocol	Frequency
Water Temperature	Thermometer		Bimonthly
pH	LaMotte Kit		Bimonthly
DO	LaMotte Kit		Bimonthly
Turbidity			Bimonthly
Water Flow			Bimonthly
Nitrates	LaMotte Kit		Bimonthly
Phosphates	LaMotte Kit		Bimonthly
Benthic Macroinvertebrates	LWC/SOS		Spring & Fall
Stream Habitat	LWC		Yearly
E. coli Bacteria			Bimonthly

Sampling Protocols – The sampling protocols and analytical methods used may need to vary between government and citizen organizations.

- DEQ will use methods and protocols required under state water quality standards.
- Data collected by County authorities and County Agencies for physical, chemical, and bacteriological parameters should be uniform with DEQ methods and protocols, if funds are available for analyses at contract labs. If not, the county should use protocols consistent with those used by citizen groups.
- Physical, chemical, and bacteriological data collected by citizen groups will likely **not** be used to enforce state and Federal laws, and protocols can be selected that are less costly and do not require a contract lab for analysis.
- County monitoring for benthic macroinvertebrates should follow the DEQ/LWC protocol guidelines. Citizen monitoring groups will follow either the DEQ/LWC or the 2002 SOS protocol at their choosing.
- A **Loudoun Stream Monitoring Protocol Committee** of state, county, and volunteer group representatives will be formed by LWW to help establish uniform parameters between the county and citizen groups that are consistent with DEQ guidelines, to the extent possible.

Frequency

Trend assessments require as many samples collected under as many different conditions as resources will allow. An important consideration is providing enough samples to produce a statistically reliable trend analysis particularly with respect to understanding variability. In order to produce the needed information, trend stations should be sampled for a minimum of five years.

It is recommended that Loudoun adopt DEQ's frequency of sampling trend stations which is:

- bimonthly (6 times per year) for chemical and bacteriological parameters,
- yearly for stream habitat, and
- twice yearly for benthic macroinvertebrates.

If resources do not permit this level of sampling for at least five consecutive years, trend stations should be sampled for least two years out of every six-year period following the model established by DEQ in 2002.

Collecting benthic macroinvertebrate samples at an increased number of trend stations twice yearly will only be feasible if funding for a biology technician who can do the ID work in-house. If funds are not available, benthic macroinvertebrate monitoring will likely be limited to those sites currently being monitored by citizen groups.

Supplementing DEQ Sampling – Most trend stations monitored by DEQ will be monitored two years out of every six years. It is recommended that Loudoun County and citizen groups continue to monitor some of these sites during the off-four year period if any of the sites meets the following criteria:

- The site is in a watershed with a TMDL Implementation Plan, or
- The site is in a watershed that is considered "threatened" due to identified NPS, nutrient, sediment, or aquatic life problems.

Data Analysis

Basic statistical summaries should be used to summarize the data and to reveal patterns over time at a site as follows:

- Seasonal and/or annual averages to show values typical of the data set;
- Seasonal and/or annual medians to show values typical of the data set;
- Maximums and minimums to show extreme conditions; and
- Range to show variability.

Results will be compared with reference conditions during the sampling year, and over time from year to year. Reference conditions include water quality standards, informal guidelines established by federal or state authorities, actual results from county or regional reference sites, and any index of biological integrity (IBI) adopted by DEQ.

Quality Assurance/Quality Control (QA/QC)

The quality assurance and quality control measures that should be applied include the following:

- Written, detailed protocols comparable with DEQ guidelines;
- Training/Certification for stream monitors/sample collectors;
- Data quality objectives as provided in **Table 11;**
- Equipment inspection and maintenance;
- 10% level of field observation by project coordinator; and
- 10% level of lab analysis of preserved field benthic macroinvertebrate samples.

Table 11. Quality Objectives for Trend Sampling.

Monitoring Parameter	Quality Objectives
Benthic Macroinvertebrate Sample	80% precision in collecting representative sample 90% accuracy in ID 90% accurate of count 90% completeness on data sheet
Habitat Assessment	80% precision in scoring 90% completeness on data sheet
Pollution Source Assessment	80% precision in scoring 90% completeness on data sheet
Other parameters and meta data	90% completeness on data sheet

State/County/Citizen Role

DEQ has been monitoring in Loudoun County for over 20 years, and Loudoun Soil and Water Conservation Service and citizen groups have been monitoring since 1997. The citizen monitoring has been supported with grant funds from DEQ and other sources. Expanding monitoring to include additional trend stations and parameters will require additional resources from each of the parties committed to a comprehensive monitoring program in Loudoun County. It is envisioned that each party will contribute the following to enhance trend monitoring:

- **State –** DEQ should provide:
  - Continued monitoring at designated ambient water quality stations;
  - Technical assistance in selecting additional trend stations for county and re-siting stations for citizen groups as necessary;
  - Training and QA oversight of county operations; and
  - Technical guidance on monitoring protocols to the Loudoun Stream Monitoring Protocol Committee.

- **County –** Loudoun County and County Agencies should provide:
  - Funding for a County Water Resources Program Coordinator position to provide training, data entry, data analysis, report preparation, protocol updates, and QA oversight of county and citizen water monitoring activities;
  - Funding for the analysis of bacteriological samples at a professional laboratory;
  - Chemical field test kits, sample collection materials, and suspended solids testing equipment to loan to citizen groups as necessary;
  - Funding for two part-time intern positions as stream monitors to collect samples at new sites and unsampled DEQ sites;
  - Funding of a part-time biology technician to do benthic macroinvertebrate sample ID; and
  - Participation in a Loudoun Stream Monitoring Protocol Committee to provide uniform protocols for monitoring.

- **Citizen –** LWW organizations should provide:
  - Continued monitoring at existing trend sites with expanded parameters as necessary;
  - Participation in a Loudoun Stream Monitoring Protocol Committee to provide uniform protocols for monitoring;
  - Training and QA oversight of citizen volunteers program; and
  - Equipment for benthic macroinvertebrate sampling.

Funding Required – Growth and development in Loudoun County has created an urgent need for the county to play a leadership role in watershed management planning, TMDL implementation, stream resource surveys, and water resource monitoring. A variety of county authorities and programs currently need more comprehensive water resource data to perform their required functions including the Health Department, Sanitation Authority, Stormwater Management, Building and Development, and Planning. The county should provide funding for the required positions and resources.

Training Required – Loudoun Soil and Water Conservation District and LWW member organizations have a core cadre of trained individuals who can monitor streams and collect chemical samples. The Loudoun Stream Monitoring Coordinator should be trained by DEQ in the assessment protocols being used. The Coordinator or another experienced monitor can then train stream monitor team members. Following the training, monitors can be observed in the field gathering data to assure that training is effective. Follow up field audits can also be used to assess the adequacy of training.

III. Probabilistic Monitoring Design

Summary

The probabilistic (or random) monitoring design is used to characterize the impact of nonpoint pollutants and other human caused stress factors on the health of benthic communities and stream habitats in wadeable streams. A probabilistic monitoring design provides comprehensive information about large geographic areas, while keeping costs reasonable. It also allows the impacts from individual stress factors that degrade stream health to be measured.

- The probabilistic design will encompass the major subwatersheds in the county. Stream segments will be stratified by stream order to assure approximately equal representation among 1st and 2nd order, and 3rd and 4th order wadeable streams. Higher order, non-wadeable streams will be excluded from the design.
- Loudoun County should follow the sample design recommended by DEQ and collect samples once at each probabilistic site. Sampling should occur during mid-March to mid-May to compensate for seasonal variations and different phases of benthic organism life cycles.
- The parameters sampled will include benthic macroinvertebrates, stream habitat, nutrients, and physical parameters.

Purpose

The purpose of using a random sampling design is to assess "stream health" over a large number of streams and watersheds. Stream health is a measurement of the degree to which human caused stressors have impacted water quality, aquatic life, and stream habitat. Probabilistic sampling design provides randomly selected, unbiased data that can be used to statistically characterize stream health within the basin being sampled.

Selecting a Probabilistic Design

Simple Random Design – Simple random sampling is appropriate when the population being sampled is relatively uniform or homogeneous. For some parameters such as nutrient and bacterial levels, there may be relative uniformity when nonpoint pollution inputs are dispersed throughout the watershed. However, other parameters such as aquatic live and habitat may not be relatively uniform. Another factor to consider is that data on stream segments may not be equally important throughout a watershed. For example, conditions in headwater streams may be more important that conditions in mainstem segments with respect to restoring and maintaining water quality and stream health.

Stratified Random Design -- Stratified random sampling is commonly used to incorporate prior information to develop a probability-based sampling design that is more efficient than simple random sampling. In Loudoun County it is likely more efficient to stratify stream segments in a watershed according to stream order and then randomly select sampling sites separately for each strata type.

Siting

Streams within Loudoun County need to be divided into 100 meter segments that can be used for monitoring. The county's GIS mapping system and software designed to segment streams can be used for this purpose. The criteria for including a stream segment in the population to be sampled include the following:

- Stream segments with intermittent flows will be excluded;
- Down stream segments that are not wadeable will be excluded; and

- Small streams with drainage areas of less than 500 acres that flow directly into the Potomac River will be excluded.

Each 100 yard stream segments that is to be included will be given a unique identifier, and a label as to its stream order.

Number of Sampling Sites -- It is recommended that Loudoun County monitor 50 sites per year for five years for a total of 250 samples. The random selection of probabilistic sampling sites within each stratum should be based upon a proportional allocation so the number of monitoring sites selected in each stratum is the same as the proportion of the total stream segments in the stratum to the total number of stream segments in the county.

Parameters

Probabilistic stations should be sampled for the parameters listed in **Table 12**. It is recommended that benthic macroinvertebrates and stream habitat are the primary indicators to be used to characterize stream health.

Table 12. Minimum Sampling Parameters for Probabilistic Sampling Stations in Free Flowing Streams.

Parameter	Sampling Protocol	Analytical Protocol
Rainfall	Weather station	
Water Temperature	Thermometer	
pH	LaMotte Kit	Field Kit Instructions
DO	LaMotte Kit	Field Kit Instructions
Turbidity	Visual assessment	
Stream Flow	Visual assessment	
Nitrates	LaMotte Kit	Field Kit Instructions
Phosphates	LaMotte Kit	Field Kit Instructions
Benthic Macroinvertebrates	RBP II using 20-1 sq.ft. jabs with D-net in representative habitat along 100 meter stream segment – preserve sample for lab ID*	Contract lab/DEQ lab ID**
Stream Habitat	RBP II – visual assessment	
Pollution Sources Inventory	ANS – visual assessment	
Stream Cross Section	ANS	

* DEQ's sample collection protocol using LWC D-nets will be followed.
** Funds are need for services at contract labs.

Frequency

Probabilistic sites should be sampled once during the springtime (March - May) of the year to control for seasonal variations. Sampling each station once will provide the maximum number of samples with the available resources.

5-Year Sampling Plan and Schedule – The 250 sample sites in the four strata will be randomly selected, along with an additional 250 sites to be used as substitute sites if the original site cannot be accessed or is not wadeable. Monitoring sites will then be clustered geographically in the county and different clusters will be sampled in each of the five years to the extent possible. This approach will allow volunteers to work in more limited geographic areas and have less travel time between sampling sites.

Data Analysis

Statistical analysis of the physical, chemical, and bacteriological data is relatively straightforward because most common statistical analysis procedures assume that the data were collected randomly. Basic statistical summaries can be used to summarize the data including estimates of mean, proportions, and variability.

Biological conditions can be analyzed using a multimetrics approach and either a reference stream or streams or the new Virginia Biological Index (VBI) being developed by DEQ in 2003.

Quality Assurance/Quality Control (QA/QC)

Quality assurance measures need to be compatible with the capabilities of county authorities and citizen watershed organizations. QA/QC parameters should include the following:

- Written, detailed protocol comparable with DEQ guidelines;
- Training/Certification for monitors;
- Data quality objectives as provided in **Table 13;**
- Equipment inspection and maintenance;
- 10% level of repeat field collection and assessment by separate monitoring team; and
- Mixing of field monitoring team members between different monitoring sites.

Table 13. Quality Objectives for Probabilistic Sampling.

Monitoring Parameter	Quality Objectives
Benthic Macroinvertebrate Sample	80% precision in collecting representative sample 90% accuracy in ID 90% accurate of count 90% completeness on data sheet
Habitat Assessment	80% precision in scoring 90% completeness on data sheet
Pollution Source Assessment	80% precision in scoring 90% completeness on data sheet
Stream Cross Section	80% precision in measurements 90% completeness on data sheet
Other parameters and meta data	90% completeness on data sheet

State/County/Citizen Role

Countywide probabilistic sampling has not been attempted previously in Loudoun County. Expanding monitoring to include this new design will require additional resources from each of the parties committed to a collaborative monitoring program. It is envisioned that each party will contribute the following to implement the comprehensive strategy:

- **DEQ –** DEQ should provide:
  - Technical guidance on probabilistic design and monitoring site selection;
  - Training of citizen and County trainers;
  - Sharing DEQ stream monitoring data; and
  - Transferring state, local government, and citizen data to EPA's STORET.

- **County –** Loudoun County and County Agencies should provide:
  - Funding for a County Water Resources Program Coordinator position to provide training, data entry, data analysis, report preparation, protocol updates, and QA oversight of county and citizen water monitoring activities;

- Maps of sampling sites;
- Letters to property owners on whose property monitoring will need to occur;
- A county website on which monitoring data will be provided;
- Funding for benthic macroinvertebrate sample ID at a contract lab;
- Funding for field test kits for physical and chemical parameters; and
- Hand-held GPS units to locate and record sampling sites.

- **Citizen –** LWW should provide**:**
  - A Citizen Stream Monitoring Coordinator supported by grant funds;
  - Volunteer stream monitors;
  - Training for field stream monitor teams;
  - Benthic macroinvertebrate sample collection equipment;
  - Field collection of samples and assessment of habitat parameters; and
  - Field QA assessments.

Funding Required – The same county resources needed for trend monitoring could be used to implement a probabilistic monitoring program as well. The principal additional cost is for the laboratory analyses of benthic macroinvertebrate samples at a professional laboratory.

Training Required -- Loudoun County has a core cadre of trained stream monitors currently volunteering with citizen watershed organizations. The County Water Resource Program Coordinator, the Citizen Stream Monitoring Coordinator, and selected county and citizen team leaders will need additional training in proper water and benthic macroinvertebrate sample collection and analyses, in habitat survey techniques, in assessment of pollution impacts, and in diagramming stream cross-sections using the designated protocols. Experienced trainers from federal, state or national organizations should provide this training. This cadre of trained team leaders can then train other county and citizen monitors.

IV. TMDL Implementation Assessment Monitoring Design

Summary

The same representative water quality data collected at monitoring station under the **trend monitoring design** can be used to assess TMDL Implementation Plans. Documentation of short-term, mid-term, and long-term trends can be used to assess water quality and the effectiveness of best management practices implemented to restore water quality. Some additional trend sampling stations may be needed for TMDL assessment on a case-by-case basis to ensure adequate assessment of the entire watershed.

Purpose

EPA provides grant funds to states under Section 319 of the Clean Water Act to control nonpoint pollution sources. EPA guidelines[26] to award these grants require that TMDL Implementation Plans include a monitoring component to validate the effectiveness of the implementation efforts. An implementation assessment is designed to document the effectiveness of the best management practices (BMPs) that have been installed to control nonpoint pollution and improve water quality. DEQ has responsibility to assess TMDL implementation, and they have advised they will do this when remedial controls have been installed. DEQ's responsibility is only to assess stream segments with a known impairment.

Three types of data should be provided in an implementation assessment monitoring plan.

[26] EPA, "Supplemental Guidelines for the Award of Section 319 Nonpoint Source Grants to States and Territories in FY 2003."

- **Baseline Data** – The purpose of TMDL implementation assessment is to document whether the water quality has change from impaired to supporting. To accomplish this, baseline water quality data are needed in watersheds with impaired streams before control measures are installed. DEQ did not conduct comprehensive studies of the water quality throughout the watersheds to determine which sections are impaired and which meet water quality standards. For example, in the Catoctin watershed, 75% of the stream miles were not assessed by DEQ. DEQ's data also do not include stream survey, habitat, or aquatic life data that characterize conditions in the watersheds. Therefore, existing DEQ data cannot be relied upon to provide an adequately baseline to validate the effectiveness of pollution controls to be provided by TMDL Implementation Plans for the watershed. Additional baseline data can be obtained from supplemental monitoring stations. Baseline data against which progress to restore water quality can be assessed does not need to meet DEQ requirements regarding collection, analytical, and QA/QC protocols since it will not be used to establish or delist an impairment.

- **Trend Data** – DEQ has one trend station in the Catoctin watershed that will be sampled on a regular basis. Five additional stations will be sampled at six-year intervals with twelve samples collected over a two-year period. This level of monitoring will not be sufficient to track progress in restoring water quality throughout the watershed. Supplemental trend data will be needed at these sites during the off-four year period. These data also do not need to meet DEQ requirements regarding collection, analytical, and QA/QC protocols since it will be used to track progress and not to establish or delist an impairment.
- **Validation Data** – DEQ guidelines[27] provide that an impairment can be remove when one or two years of data from the same monitoring station that caused the original impairment show that water quality standards are being met. The impairments in the Catoctin watershed listed in 2002, for example, were based upon data from five monitoring stations – one in Catoctin Creek, two in North Fork Catoctin Creek, and two in South Fork Catoctin Creek. A benthic impairment was added in the Catoctin watershed in 2004. Data for delisting an impaired stream involves legal requirements, and will need to be collected by DEQ and meet their collection, analytical, and QA/QC protocols.

Loudoun County Agencies and citizen environmental groups should provide supplemental assessment monitoring that targets stream segments not monitored by DEQ for two reasons.

- **Monitor Adequacy of Water Pollution Load Model** – Controls on nonpoint pollution loads into impaired watershed are based upon models and not comprehensive field studies. Baseline and tracking stream monitoring data can be used to assess the adequacy of the model assumptions and parameters. If field data show the implemented management controls based on the model are not effective, recommendations on redesigning the management controls will be considered by DEQ.

- **Track Improvements in Water Quality Throughout Watershed --** A TMDL validation to delist an impaired stream should only be undertaken by DEQ if trend data throughout the watershed show that significant progress has been made in meeting water quality standards. Relying upon data at one or two stations in an entire watershed over a one or two year period is inappropriate.

Siting

It is recommended that the same monitoring stations established under the trend monitoring designs be used to develop the baseline, trend, and validation data needed to asses the effectiveness of TMDL implementation. Additional trend stations will be located in each TMDL watershed as the need arises. For example, the recommended stations to use to assess progress and validate the current TMDL in Catoctin Creek are listed in **Table 14.**

[27] DEQ, "Water Quality Assessment Guidance Manual for Y2004 305(b)/303(d) Integrated Water Quality Report," November 3, 2003.

Table 14. List of TMDL Implementation Plan Monitoring Stations for the Catoctin Watershed -- 2004. (Pink highlighted=impaired segment; green highlight=meets standards segment)

Stream Name	Cause[1]	Boundaries of Impaired Segment	Monitoring Station[2]
Catoctin Creek Mainstem	FC	7.2 mile segment from its mouth at the Potomac River upstream to the confluence with Milltown Creek	1. **DEQ** – Maintain **bacteria and benthic** trend site 1ACAX004.57 at Rt. 668
Milltown Creek	Meets Standard	NA	2. **Local/NFGC** - Establish a **bacteria and benthic** trend site at Compher Rd/Rt 682 & Rt 681. 3. **LWC** – Maintain **benthic** monitoring at Site #11 off of Rt. 691
Unnamed Tributary	Meets Standard	NA	4. **Local/DEQ** – Provide continuous **bacteria** sampling at DEQ AW station 1AXJT002.22 off Rt. 681. **5. Local/NFGC** - Establish **bacteria and benthic** trend near mouth at Cottagegrove Ln & Rt. 681 site.
North Fork Catoctin Creek	FC	4.1 mile segment from the confluence with Catoctin Creek upstream to a point 0.2 miles downstream of the Rt. 287 bridge	6. **Local/DEQ** - Provide continuous **bacteria** sampling at DEQ's AW 1ANCO00.42 site at Rt. 681. 7. **LWC** - Maintain **benthic** site #1 at mouth of stream
North Fork Catoctin Creek	FC	North Fork Catoctin Creek from the impaired segment starting at stream mile 4.1 to its headwaters	8. **Local/DEQ –** Provide continuous **bacteria** sampling at AW site 1ANOC009.37 at Rt. 718.
South Fork Catoctin	FC	17.3 miles from the mouth at Catoctin Creek upstream to the headwaters	9. **Local/DEQ** - Provide continuous **bacteria** sampling at DEQ's AW 1ASOC001.66 at Rt. 698 . 10. **Local/DEQ** – Provide continuous **bacteria and benthic** sampling at DEQ's AW site 1ASOC007.06 at Rt. 738. 11. **Local** – Establish **bacteria** trend station at Rt. 611
South Fork Catoctin Creek	Benthic	3.4 miles of South Fork Catoctin Cr from Rt. 287 upstream to Purcellville town line near Rt. 690.	12. **LWC** – Maintain **benthic** site #4 at Rt. 611 – Purcellville Nature Park

[1] Causes of Impairments: FC = Fecal Coliform Bacteria; Benthic – Aquatic Life; NA – Does not apply
[2] AW = Ambient Watershed station; Local = to be sampled by local agency or citizen group

Parameters

TMDL Implementation will require improved Best Management Practices (BMPs) in riparian buffers in order to decrease runoff and protect stream banks from erosion caused by livestock and residential stormwater runoff. Improved BMP should show improvements in benthic macroinvertebrate and stream habitat conditions and in decreased bacteriological levels making these good parameters to validate TMDL implementation. The same

parameters used in the trend monitoring designs can be used in the TMDL implementation assessment design for monitoring to be done by county agencies and citizen monitoring groups to supplement DEQ monitoring. These parameters are listed in **Table 15**.

Table 15. Minimum Sampling Parameters for Trend Sampling Stations in Free Flowing Streams.

Parameter	Sampling Protocol	Analytical Protocol	Frequency
Water Temperature	Thermometer		Bimonthly
pH	LaMotte Kit		Bimonthly
DO	LaMotte Kit		Bimonthly
Turbidity	LaMotte Kit		Bimonthly
Water Flow			Bimonthly
Nitrates	LaMotte Kit		Bimonthly
Phosphates	LaMotte Kit		Bimonthly
Benthic Macroinvertebrates	LWC/SOS		Spring & Fall
Stream Habitat	LWC		Yearly
E. coli Bacteria			Bimonthly

Frequency

Trend assessments require samples collected under as many different conditions as resources will allow. An important consideration is providing enough samples to understanding variability. In order to produce the needed information, trend stations should be sampled for a minimum of five years.

It is recommended that Loudoun adopt DEQ's frequency of sampling trend stations which is:

- bimonthly (6 times per year) for chemical and bacteriological parameters;
- yearly for stream habitat; and
- twice-yearly for biological parameters.

If resources do not permit this level of sampling for at least five consecutive years, trend stations should be sampled for least two years out of every six-year period following the model established by DEQ in 2002.

Data Analysis

Trend data used to validate TMDL Implementation will allow a broad range of statistical analyses.

- Trend data can be analyzed using basic statistical summaries including:
    - Averages to show values typical of the data set;
    - Correlations to show the degree of differences between data sets; and
    - Comparisons with various reference conditions including water quality standards, informal guidelines established by federal or state authorities, and actual results from county or regional reference sites.
- Habitat and biological conditions can be analyzed using a multimetrics approach and either a reference stream or streams or the new Virginia Biological Index (VBI) being developed by DEQ in 2003.

State/County/Citizen Role

Expanding monitoring to assess TMDL implementation will require only modest additional resources from each of the parties committed to a comprehensive monitoring program in Loudoun County. It is recommended that each party contribute the following to assess TMDL implementation:

- **State –**
  - DEQ and DCR establish TMDL Implementation plans that include a DEQ, local agency, and citizen implementation assessment monitoring component; and
  - DEQ/DCR use county and citizen assessment data in their tracking of TMDL implementation progress and their assessment of the adequacy of TMDL models.

- **County –**
  - Loudoun County play the lead role in TMDL implementation assessment monitoring to provide supplemental validation data; and
  - Loudoun County provides trend monitoring data and support to citizen monitoring programs to help assess TMDL implementation.

- **Citizen –**
  - Loudoun Wildlife Conservancy and North Fork Goose Creek Watershed Association provide stream monitoring data to help assess TMDL implementation;
  - Loudoun Watershed Watch provide data compilation and data analysis; and
  - Loudoun Watershed Watch provides outreach to Loudoun communities to develop additional citizen, stream stewardship groups, and to recruit citizen stream monitors.

Funding Requirements -- The same county resources needed to support trend and probabilistic monitoring can be used to support a TMDL implementation assessment monitoring program as well.

RECOMMENDATIONS

Loudoun County's Green Infrastructure Strategy provides a guide for the development of environmental policies. The county recognizes that its water resources are fragile and irreplaceable, and, therefore, need protection and preservation. The County's watersheds are the key natural resource element in the Green Infrastructure, and are being used as its primary organizing unit.

The policies and ordinances adopted to implement the Green Infrastructure Strategy come at a critically important time because, concurrently, the Virginia Department of Environmental Quality (DEQ) published findings that most streams in Loudoun County have impairments and do not meet the Virginia Water Quality Standards. Virginia is required under the Federal Clean Water Act to identify impaired waters and work with local governments and communities to restore the water resources to meet standards.

To help address these problems, the Loudoun County Water Resources Technical Advisory Committee has been tasked with the development of a Water Resources Protection Plan. The plan is to have three components: (1) water quality protection, (2) water quantity protection, and (3) watershed management. Stream monitoring is a part of the water quality and watershed management components of the Water Resources Protection Plan.

It is Loudoun Watershed Watch's (LWW) vision[28] that Loudoun County government and County Agencies will become the principal authorities that collect water resource data, and prepare and implement watershed management plans with the support of citizen watershed organizations. Stream monitoring can best be achieved through the collaboration of federal, state, regional, and local authorities; and citizen watershed organizations. A countywide monitoring plan that incorporates the contributions of each party will provide comprehensive coverage and effective use of limited state, county, and volunteer resources.

Stream Monitoring Program Structure

In 2002 Loudoun Watershed Watch published The State of Loudoun Streams: 2002 report that provided recommendations regarding needs for watershed management planning and stream monitoring. These recommendations provide an outline for a County administrative structure that can accomplish these important goals.

- Loudoun County should create a **Water Resource Management Administrator** to oversee the development of watershed management plans and the implementation of TMDL plans for Loudoun streams. A system of small subwatersheds should be identified that provide homogeneous management areas. Additional information regarding impervious cover and loss of forest lots will aid management planning. The authority needs to work with the Loudoun Watershed Watch to bring together stakeholders to support this process.
- Loudoun County should support a **countywide stream monitoring program** so the county can play a leadership role in assessing changes in stream health and progress in restoring water quality. This program would supplement state program activities. The program can utilize low cost methods to assess bacteriologic quality, habitat conditions, and biological conditions.
- Loudoun County should adopt an updated **stream monitoring strategy** to providing more representative data on watersheds and to measure the effectiveness of land stewardship initiatives to restore water quality. This can be best accomplished by randomly selecting additional monitoring sites in each watershed to provide a **probabilistic sampling program**. A better balance between assessments of chemical, bacteriological, habitat, and biological parameters is needed to provide an accurate picture of stream health conditions. Increased monitoring by county and citizen groups should be encouraged to offset reductions in monitoring by the state.

[28] Loudoun Watershed Watch. "State of Loudoun Streams: 2002." 2002.

Collaborative Approach to Stream Monitoring

Water quality data will be critically important as Loudoun County begins developing comprehensive watershed management plans. New water quality data will be needed for many stream segments impacted by stormwater and agricultural practices, and segments that will be subject to future development.

Collecting the needed stream monitoring data can best be achieved through the collaborative efforts of federal, state, regional, and local authorities; and citizen watershed organizations. A countywide monitoring plan that incorporates the contributions of each party will provide comprehensive coverage and effective use of limited state, county, and volunteer resources.

Federal – The U.S. Environmental Protection Agency (EPA) administers the Federal Clean Water Act and oversees implementation of the Act by the Virginia Department of Environmental Quality (DEQ). EPA sets standards and provides guidelines for water quality monitoring, stream protection, and water quality restoration. Loudoun County receives grant funds and technical guidance from EPA. The U.S. Geological Survey (USGS) records stream flows at ten locations in Loudoun County, and provides real-time flow data. USGS also provides grant funds and technical guidance on water quality, and stream protection and restoration.

State – State agencies have the legal mandate and professional staff to monitor streams and ensure that state water quality standards are met. They have a large amount of historical trend monitoring data at stations throughout the county. They provide grant funds and technical support to local governments and citizen groups as resources permit regarding monitoring, watershed management planning, and pollution control. DEQ uses county and citizen data to help identify threatened waters that need state study.

- **DEQ –** DEQ should provide the following support:
  - Technical guidance on probabilistic design and monitoring site selection;
  - Technical support in establishing Information Research Survey and Field Survey protocols, and in selecting stream segments for Field Surveys;
  - Technical assistance in selecting additional trend stations for county and re-siting stations for citizen groups as necessary;
  - Technical guidance on monitoring protocols to the Loudoun Stream Monitoring Protocol Committee;
  - Training of citizen and County trainers and QA oversight of county operations; and
  - Transferring state, local government, and citizen data to EPA's STORET.

- **DCR –** DCR should provide the following support:
  - Funding to citizen organizations to provide supplemental TMDL implementation assessment monitoring data; and
  - Technical support in incorporating Watershed Survey data into TMDL Implementation Plans.

- **DEQ/DCR –** DEQ and DCR should cooperate to provide the following support:
  - Technical support in establishing TMDL implementation assessment monitoring plans that will complement DEQ monitoring plans; and
  - Use of county and citizen monitoring data in their validation of TMDL models, assessment of TMDL implementation, and assessment of water quality conditions.

County Government and Agencies – Loudoun County and County Agencies have laws and ordinances that protect stream corridors. They have professional staff to provide safe drinking water, monitor and control point discharges of pollution, protect citizens from water related health hazards, and monitor and manage stormwater facilities, as resources permit. The County and County Agencies also have contract funds to conduct drinking water source protection studies, to survey and monitor surface and groundwater resources, and to begin developing watershed management plans.

Loudoun County and County Agencies should provide the following support:

- Funding for full and part-time County or County Agency positions as follows:
  - a County Water Resources Program Coordinator;
  - two summer interns (40 hrs/wk for 2 months) to conduct Field Surveys;
  - two fall interns (20 hrs/wk for 4 months) to conduct Field Surveys;
  - two part-time intern positions as stream monitors to collect samples at new sites and unsampled DEQ sites; and
  - a part-time biology technician to do benthic macroinvertebrate sample ID, or funding for benthic macroinvertebrate sample ID at a professional laboratory;
- Leadership in collecting and analyzing stream monitoring data to provide supplemental TMDL implementation validation data;
- Training and QA oversight for county operations;
- A Loudoun Stream Monitoring Protocol Committee to provide uniform protocols for monitoring;
- Chemical field test kits, sample collection materials, and suspended solids testing equipment to loan to citizen groups as necessary;
- Information Research Survey support for each watershed to be surveyed;
- Mapping, data recording, data management, and data reporting support;
- Notification to affected property owners regarding probabilistic monitoring;
- A county website on which monitoring data will be provided; and
- Hand-held GPS units to locate and record sampling sites.

Citizen Groups – Citizen groups and environmental organizations help lead efforts in Loudoun County to promote environmental stewardship and stream habitat protection. These groups provide a voice for stakeholders and support for use of state and county resources to protect water resources. Citizen groups also train volunteers who collect water samples for physical and chemical analyses, monitor benthic macroinvertebrates, and assess stream habitats. Environmental organizations have trained staff to provide environmental education.

LWW organizations should provide the following support**:**

- A Citizen Stream Monitoring Coordinator supported by grant funds;
- A Loudoun Stream Monitoring Protocol Committee to provide uniform protocols for monitoring;
- Citizen volunteers to work with interns on watershed surveys;
- Citizen volunteer stream monitors to collect field data and conduct field assessments;
- Continued monitoring at existing trend sites with expanded parameters as necessary;
- Field Survey equipment and materials including benthic macroinvertebrate sample collection equipment;
- Data recording, analysis, and report preparation;
- Training for field stream monitor teams; and
- Field QA/QC implementation.

ATTACHMENT A
HISTORICAL TREND STATIONS IN LOUDOUN COUNTY

Monitoring Site	Chemical	Bacterial	Habitat	Benthics
Broad Run - Mainstem • Rt. 7	**DEQ** 1973-2001	**DEQ** 1973-2001	None	None
Broad Run – Mainstem • LCSA Property	**LCSA** 1990-2000	**LCSA** 1990-2000	None	None (begin in 2002)
Beaverdam Run – Rt. 641	None	None	**LWC** 2000-2001	**LWC** 2000-2001
Catoctin Creek - Mainstem • Rt 663	**DEQ** 1978-2001 **LSWCD** 1999-2001 **LWC** 2001	**DEQ** 1978-2001 **LSWCD** 1999-2001	**DEQ** 1997-2001 **LSWCD** 1999-2001 **LWC** 1997-2001	**DEQ** 1997-2001 **LSWCD** 1999-2001 **LWC** 1997-2001
North Fork Catoctin Creek -- • Rt 681	**DEQ** 1973-2001 **LWC** 2001	**DEQ** 1973-2001	**LWC** 1997-2001	**LWC** 1997-2001
• Rt 287	**DEQ** 1973-2001	**DEQ** 1973-2001		
• Rt 690	**DEQ** 1973-2001	**DEQ** 1973-2001		
• Rt 719	**LSWCD** 1999-200	**LSWCD** 1999-2001	**LSWCD** 1999-2001	**LSWCD** 1999-2001
South Fork Catoctin Creek - • Rt 698	**DEQ** 1973-2001	**DEQ** 1973-2001		
• Rt 738	**DEQ** 1973-2001	**DEQ** 1973-2001		
• Rt 611	**LWC** 2001		**LWC** 1997-2001	**LWC** 1997-2001
• Rt 711	**LSWCD** 1999-2001	**LSWCD** 1999-2001	**LSWCD** 1999-2001	**LSWCD** 1999-2001
Beaverdam Creek • Rt. 734	**DEQ** 1976-2001 **LSWCD** 1999-2001	**DEQ** 1976-2001 **LSWCD** 1999-2001	None	**LSWCD** 1999-2001
• Rt. 731				
• Rt. 626, Foxcroft Rd	**DEQ** (new site)	**DEQ** (new site)	None	
North Fork Beaverdam Creek • Rt. 719, Airmont Rd	**DEQ** (new site)	**DEQ** (new site)	None	
Butchers Branch • Rt. 831			**LWC** 1997-2001	**LWC** 1997-2001
Goose Creek -- Mainstem – • Rt. 7	**DEQ** 1973-2001	**DEQ** 1973-2001	**DEQ** 1996 - 2001	**DEQ** 1996-2001
Little River – • Rt. 50	**DEQ** 1973-2001	**DEQ** 1973-2001	**DEQ** 1997-2000	**DEQ** 1997-2000

Monitoring Site	Chemical	Bacterial	Habitat	Benthics
• Rt. 629	**LSWCD** 1999-2001	**LSWCD** 1999-2001	None	**LSWCD** 1999-2001
• Rt. 632	**LSWCD** 1999-2001	**LSWCD** 1999-2001	None	**LSWCD** 1999-2001
Sycolin Creek – • Rt. 15	**DEQ** 1973-2001	**DEQ** 1973-2001	None	None
• Rt. 653	**DEQ** 1973-2001	**DEQ** 1973-2001	None	None
• Rt. 621	**DEQ** 1973-2001	**DEQ** 1973-2001	None	None
• Rt. 797	**DEQ** 1973-2001	**DEQ** 1973-2001	None	None
Tuscarora Creek • Rt. 632	**DEQ** 1973-2001	**DEQ** 1973-2001	**LWC** 1997-2001	**LWC** 1997-2001
S. Fork Goose Cr. • Rt. 734	**DEQ** 1973-2001	**DEQ** 1973-2001	None	None
Panther Skin Creek	None		**LWC** 2000-2001	**LWC** 2000-2001
North Fork Goose Creek • Rt. 733	**LSWCD** 1999-2001	**LSWCD** 1999-2001		**LSWCD** 1999-2001
• RT. 722	**NFGC** 1996-2001	**DEQ** 1970-2001		**NFGC** 2000-2001
• Rt. 794, Rt 611	**LSWCD** 1999-2001	**LSWCD** 1999-2001		**LSWCD** 1999-2001
• Rt. 782	**NFGC** 1996-2001 **LSWCD** 1999-2001	**LSWCD** 1999-2001	**LWC** 1997-2001	**LWC** 1997-2001 **NFGC** 2000-2001 **LSWCD** 1999-2001
• Rt. 630			**LWC** 1997-1998	**LWC** 1997-1998
• Rt. 729	**NFGC** 1998-2001 **LSWCD** 1999-2001	**LSWCD** 1999-2001		**NFGC** 2000-2001 **LSWCD** 1999-2001
• Villages at Round Hill	**NFGC** 1996-2001			**NFGC** 2000-2001
Crooked Run				
• Rt. 727	**NFGC** 1996-2001		**LWC** 1997-2001	**LWC** 1997-2001 **NFGC** 2000-2001
• Rt. 725	**LSWCD** 1999-2001	**LSWCD** 1999-2001		**LSWCD** 1999-2001
Limestone Branch • Rt. 15	**DEQ** 1974-2001	**DEQ** 1974-2001	None	None
• RT. 661	None	None	**LWC** 1997-2001	**LWC** 1997-2001
• Rt. 740	None	None	**LWC** 2001	**LWC** 2001
Piney Run - Main Stem • Rt. 671	**DEQ** 1990-2001	**DEQ** 1990-2001	None	None
• Rt. 683	**LSWCD** 1999-2001	**LSWCD** 1999-2001	None	**LSWCD** 1999-2001
• Rt. 685	**LSWCD** 1999-2001	**LSWCD** 1999-2001	None	**LSWCD** 1999-2001
Piney Run • Sweet Run Tributary	**None**	**None**	**LWC** -- 2001	**LWC** -- 2001

ATTACHMENT B
PROPOSED COUNTYWIDE TREND MONITORING STATIONS

Table 1. Proposed Trend Monitoring Stations for Piney Run and Dutchman's Creek.[29]

Stream	Station ID	Rationale
Piney Run (A01)		
Station #1: Maintain DEQ Trend site 1APIA001.80 at Rt. 671 - bacteria[30]	1APIA001.80[31]	Maintain DEQ trend station 1APIA001.80 at stream mouth and **USGS gauge station**.
Station #2: Maintain LCSWCD #12 biomonitoring sampling at Rt. 683	Piney #2	Provides biomonitoring data in impaired segment. *Continued bacteria monitoring is optional.*
Station #3: Maintain sampling LWC #15 – biomonitoring off Rt. 685	Piney #3	Monitors major tributary to Piney Run and possible reference station for 1st/2nd order streams
Station #4: • Maintain LCSWCD #13 at Rt. 685	Piney #4	Monitors non-impaired upper segment of Piney Run. *Continuing biomonitoring is optional.*
Dutchman's Creek (A01)		
Station #1: • Add biomonitoring at Rt. 674 • Add bacteriological sampling at Rt. 674	1ADUT000.62	Establish a trend station with bio and bacteria sampling at mouth of Dutchman's Creek at DEQ AW station 1ADUT000.62
Station #2: • *Add bacteriological sampling at Rt. 673*	*1ADUT002.72*	*Optional - Monitor bacteria contribution of upper portion of Dutchman's Creek*
Station #3: • *Add bacteriological sampling at Rt. 674*	*1AXCO000.39*	*Optional - Monitor bacteria contribution via major tributary from Lovettsville area*

Table 2. Proposed Trend Monitoring Stations for Catoctin Creek.

Stream	Station ID	Rationale
Catoctin Creek – Main Stem (A02)		
Station #1: **Maintain LCSWCD site #14 (bacteria) at Rt. 672 at mouth**	**Catoc #1**	*Optional- Maintain bacteria (and biomonitoring?) station at mouth of stream in impaired area.*
Station #2: Maintain LWC #3 downstream of Rt. 668	Catoc #2	LWC #3 at same location will provide reference sampling station for LWC data
Station #3: Maintain DEQ Trend site 1ACAX004.57 at Rt. 668 – bio and bacteria	1ACAX004.57	Maintain DEQ trend station near stream mouth and **USGS gauge station** that includes both bacteria and bio
Station #4: *Maintain LCSWCD site #15 upstream of Rt. 668*	*Catoc #3*	*Optional - Maintain station upstream of DEQ's trend monitoring site at Rt. 668 to provide reference station for LCSWCD data*[32]
Milltown Creek (A02)		
Station #1: Establish trend site at DEQ's AW site at Rt. 673 • Add bacteria • Add bio	1AMIH001.98	Establish a trend site near the mouth of Milltown Creek at DEQ ambient station 1AMIH001.98
Station #2: *Maintain LWC #11 site near headwaters of*	Millt #2	*Optional – Move station to the downstream site at Rt. 673*

[29] Stations designated in highlighted cells are first level priority, and stations in unhighlighted cells are second level priority.
[30] Bacti = *E. coli* sampling
[31] Recommend using DEQ site designations whenever possible.
[32] If LCSWCD identifies aquatic insects to family level, metrics can be calculated and a reference station for higher order streams will be needed.

Milltown Cr.		
Unnamed Tributary to Catoctin Creek (A02)		
Station #1: Establish trend site at DEQ's AW site off Rt. 681 • Add bacteria • Add biomonitoring	1AXJT002.22	This major tributary that flows into the non-impaired portion of Catoctin Creek should be monitored
North Fork Catoctin Creek (A02)		
Station #1: Maintain LWC #1 biomonitoring at mouth of stream	NFCat #1	Or move LWC #1 to Rt. 681 site to provide biomonitoring and bacteria data at same site, if feasible.
Station #2: **Establish trend site at DEQ's AW 1ANCO00.42 site at Rt. 681** • Add bacteria	1ANCO00.42	Establish a trend site at mouth and **USGS gauge station** to help monitor health of lower portion of stream. Biomonitoring provided at nearby LWC #1.
Station #3: Maintain LCSWCD #10 at Rt. 287 (Wheatland Farm) – bacteria and biomonitoring	NFCat #1	Maintain site upstream of impaired portion to monitor stream quality and health.
Station #4: Maintain LCSWCD #11 station at Rt. 719 – bacteria and biomonitoring	NFCat #2	Maintain trend site upstream of Hillsboro to help monitor health of upstream portion of NF Catoctin Creek. DEQ has ambient site at Rt. 718 downstream of town.
South Fork Catoctin Creek (A02)		
Station #1: Establish trend station at DQ AW 1ASOC001.66 at Rt. 698 • Add bacteria monitoring • Add biomonitoring	1ASOC001.66	Establish a trend site at mouth and **USGS gauge station** to help monitor health of lower portion of stream.
Station #2: Maintain LCSWCD #9 at Rt. 711 – bacteria and biomonitoring	SFCat #1	Maintain trend site in middle portion of impairment to monitor stream health below new benthic impairment in Purcellville.
Station #3: Establish trend station at Rt. 611 at the Purcellville Nature Park • Maintain LWC #4 – biomonitoring • Add bacteria monitoring	SFCat #2	Establish a trend site to help monitor health of upper portion of stream. Two possible sites: • Downstream of Valley Industrial Park at Rt. 611 which will be in a new benthic impairment section, or • Upstream of town at DEQ (AW) 1ASOC012.38 at Rt. 690.

Table 3. Proposed Trend Monitoring Stations for Limestone Branch.

Stream	Station ID	Rationale
Limestone Branch (A03)		
Station #1: Maintain DEQ Trend site 1ALIM001.16 at Rt. 15	1ALIM001.16	Maintain trend site that monitors main stem and unnamed south fork tributaries at **USGS gauge station**. Rt. 15 site not suitable for citizen biomonitoring.
Station #2: Establish trend station on unnamed south fork tributary. • Add bacteria at Plains of Raspberry Rd. crossing • Maintain LWC #16 - bio site off Rt. 740	Limst #2	Establish a trend site on south unnamed tributary with bacteria station at easily accessible bridge site, and biomonitoring at establish upstream LWC site on private property.
Station #3: Establish trend station on unnamed north fork tributary at DEQ (AW) 1AXAQ00.95 at Rt. 661. • Maintain LWC #5 – biomonitoring upstream of bridge • Add bacteria downstream of bridge	1AXAQ00.95	Establish a trend site on north unnamed tributary with biomonitoring site at established upstream LWC site at regional park, and bacteria station at easily accessible downstream bridge site below cows access to water.

Table 4. Proposed Trend Monitoring Stations for North Fork Goose Creek and Crooked Run.

Stream	Station ID	Rationale
North Fork Goose Creek (A06)		
Station #1: Maintain LCSWCD # 3 station at Rt. 733 – bacteria and biomonitoring	NFGos #1	Monitor unimpaired segment at mouth below confluence with Beaverdam Creek
Station #2: Maintain LCSWCD #7 at Rt. 729 (Iron Brdg) – bacteria Maintain NFGCWA #5 at Rt. 729 - Chemistry	NFGos #2	Maintain established trend site for bacteria and biomonitoring in unimpaired segment below confluence with Crooked Run and USGS gauge station.
Station #3: Maintain DEQ (Trend) 1ANOGO05.69 at Rt. 722 Maintain NFGCWA #4 – bio at Rt. 722	1ANOGO05.69	Maintain established trend monitoring for bacteria and bio parameters in impaired segment of stream.
Station #4: Maintain LCSWCD #5 at Rt. 611 – bacteria and biomonitoring	NFGos #4	This provides second station in impaired segment and biomonitoring below threatened segment..
Station #5: Maintain LCSWCD #8 station at Rt. 782 (Tranquility Brdg) – bacteria and biomonitoring Maintain NFGCWA #1 at Rt. 782 – chemistry Discontinue LWC #7 – biomonitoring at Rt. 782	NFGos #5	**Maintain established trend station for bacteria and bio parameters below Sleeter Lake in upstream segment of NF Goose Cr.** Suggest LWC discontinue biomonitoring at same location as LCSWCD.
Station #6: • Maintain NGGCA #8 at Simpson Creek at Rt. 719.	NFGos #6	Maintain established Biomonitoring station at mouth of Simpson Creek. Move station upstream of bridge.
Station #7: • Maintain NFGCWA #7b at Bus. Rt. 7 interchange	NFGos #7	Maintain established Biomonitoring station upstream of Round Hill to monitor upper portions of stream. Move station upstream of old RR bridge.
Station #8: • Maintain NFGCWA #2 at Jack's Run at Rt. 690.	NFGos #8	Maintain established biomonitoring station of major tributary of NF Goose Creek
Crooked Run (A06)		
Station #1: *Maintain LWC #6 upstream of Rt. 727*	*Crook #1*	*Optional – Maintain biomonitoring station as a reference site for 3rd order streams.*
Station #2: Maintain LCSWCD #6 at Rt. 725 – bacteria Discontinue LCSWCD #6 at Rt. 725 – biomonitoring Maintain NFGCWA #3 at Rt. 727 – biomonitoring	*Crook #2*	Maintain establish trend station with biomonitoring and bacteria sampling in Crooked Run. Optional – move down to Rt. 727 to be closer to mouth of creek. **Suggest either LCSWCD or NFGCWA discontinue biomonitoring at nearby stations.**

Table 5. Proposed Trend Monitoring Stations for Beaverdam Creek.

Stream	Station ID	Rationale
Beaverdam Creek (A07)		
Station #1: • Maintain DEQ trend station 1ABEC004.76 at Rt. 734. • Maintain LCSWCD #4 - biomonitoring	1ABEC004.76	Maintain DEQ trend station 1ABEC004.76 near mouth of Beaverdam Creek and **USGS gauge station**, and maintain LCSWCD biomonitoring at site. *Optional – discontinue LCSWCD bacteria sampling.*
Station #2: Add bacteria and biomonitoring at DEQ (AW) 1ABEC011.19 station at Rt. 626	Beavdm #2	Establish trend station with biomonitoring and bacteria sampling in unimpaired segment upstream of Dog Branch at DEQ (AW) 1ABEC011.19 station at Rt. 626 to monitor the upper portion of watershed.
North Fork Beaverdam Creek (A07)		
Station #1: Add bacteria and biomonitoring at Rt. 630.	NFBvdm #1	Establish trend station with biomonitoring and bacteria sampling near mouth of NF Beaverdam Creek (old LWC #9 site).

Table 6. Proposed Trend Monitoring Stations for Middle Goose Creek.

Stream	Station ID	Rationale
Middle Goose Creek (A08)		
Station #1: Add bacteria and biomonitoring at DEQ (AW) 1AGOO022.44 at Rt. 734.	1AGOO022.44	Establish trend station at DEQ (AW) 1AGOO022.44 near mid-portion of stream with bio and bacteria monitoring.
Station #2: Maintain DEQ Trend 1AGOO030.75 at Rt. 611. • Add biomonitoring at Rt. 611.	1AGOO030.75	Maintain established DEQ trend station in mid section of stream at **USGS gauge station** and supplement with biomonitoring.
Panther Skin Creek (A08)		
Station #1: Maintain LWC #12 biomonitoring at Rt. 623 • Add bacteria sampling at Rt. 623	PanthS #1	Establish trend station near mouth of Panther Skin Creek at existing LWC Biomonitoring site, and add bacteria sampling.
Little River (A08)		
Station #1: Maintain LCSWCD #2 station at Rt. 632- bacteria and biomonitoring.	Little #1	Maintain established trend station in impaired portion of stream.
Station #2: Maintain LCSWCD #1 at DEQ (AW) 1ALIV006.92 at Rt. 629 – bacteria and biomonitoring.	1ALIV006.92	Maintain establish trend station in mid-portion of stream in unimpaired area.

Table 7. Proposed Trend Monitoring Stations for Lower Goose Creek.

Stream	Station ID	Rationale
Lower Goose Creek (A08)		
Station #1: Maintain existing DEQ Trend 1AGOO002.38 site at Rt. 7 that includes bacteria and biomonitoring	1AGOO002.38	Maintain existing DEQ trend site near mouth of Goose Creek and downstream of Sycolin Creek and Tuscarora Creek confluences.
Station #2: Maintain existing DEQ Trend 1AGOO011.23 site at Rt. 621 that includes bacteria.	1AGOO011.23	Maintain existing DEQ trend site in unimpaired portion of stream and **USGS gauge station**. Not a safe site for citizen biomonitoring.
Tuscarora Creek (A08)		
Station #1: • Add bacteria and biomonitoring at DEQ (AW) 1ATUS000.04 at Goose Creek CC bridge.	1ATUS000.04	Establish trend station at DEQ 1ATUS000.04 site (moved downstream from original Rt. 653 site) that includes bio and bacteria monitoring.
Station #2: Maintain LWC #12 biomonitoring at Lawson Rd.	***Tuscar #2***	Maintain sampling above Lawson Rd bridge, or discontinue and move to trend location near mouth of stream.
Sycolin Creek (A08)		
Station #1: • Add bacteria and biomonitoring at DEQ (AW) 1ASYC002.03 site at Gant Lane off Rt. 653.	1ASYC002.03	Establish trend station at DEQ (AW) 1ASYC002.03 site in unimpaired portion of stream near mouth that includes bio and bacteria monitoring.
Station #2: • Add bacteria and biomonitoring at Rt. 650	***Sycoln #2***	Establish trend station at Rt. 650 in impaired portion of stream downstream of confluence of South Fork of Sycolin Cr.

Table 8. Proposed Trend Monitoring Stations for Broad Run.

Stream	Station ID	Rationale
Broad Run (A09)		
Station #1: • Maintain DEQ Trend 1ABRB002.15 at Rt. 7 • Add biomonitoring at Rt. 7	1ABRB002.15	Maintain existing DEQ trend station 1ABRB002.15 near stream mouth and **USGS gauge station**, and supplement with biomonitoring when water levels permit.
Station #2: • Maintain existing LCSA bacteria trend	*BrdRun #2*	Maintain existing LCSA bacti trend station at site of proposed STP.

site at STP property off Rt. 607.		
Station #3: • *Add bacti monitoring at Rt. 625.*	*BrdRun #3*	*Optional - Establish a bacti trend station at Rt. 625.* • *Upstream of Rt. 7 Broad Run is mostly a muddy-bottom stream requiring a different biomonitoring protocol*
Beaverdam Run (A09)		
Station #1: • Add bacti monitoring at LCSA STP site off of Rt. 607 at mouth of Beaverdam Run	BvdmRn #1	Establish a bacti trend station at mouth of Beaverdam Run. Alternative is for LCSA to sample this site under existing sampling program at nearby Broad Run site.
Station #2: • Add LWC 13B Biomonitoring at end of Gloucester Prkwy.	BvdmRn #2	Establish a biomonitoring trend station near mouth of Beaverdam Run. Stream becomes muddy-bottom below this point.
Station #3: • LWC #13 at Rt. 641.	BvdmRn #3	Maintain existing upstream site to better assess health of stream above pond at Ashburn Village.

Table 9. Proposed Trend Monitoring Stations for Sugarland Run.

Stream	Station ID	Rationale
Sugarland Run (A10)		
Station #1: • Maintain DEQ Trend 1ASUR004.42 at Rt. 7	1ASUR004.42	Maintain an existing DEQ trend station for bacti monitoring.
Station #2: • Maintain LWC #14 below Dominion HS site.	Suglnd #2	Maintain existing LWC biomonitoring site in middle of impaired area.

ATTACHMENT C
LOUDOUN'S STREAM RESOURCES

Identifying Stream Resources – Loudoun streams have a name of their own, which partially identifies them. Identifying a specific location along a stream, such as a stream monitoring station, is most commonly done using its geographic coordinates of latitude and longitude. Computer generated Geographic Information Systems (GIS) allows geographic coordinates to be represented by decimal degrees.

DEQ uses an additional identifier to describe a specific point on the reference line formed by the water body that is being adopted by Loudoun County to facilitate data sharing. This consists of a water body identification code followed by the number of "river miles above the mouth of the stream on which the point is located. The coding identifiers consist of the following:

- The principal rivers and the tributaries that feed them are first identified by a numerical code for each major drainage basin. Larger stream systems may be divided into major segments or sub-basins that are identified by letter.
- Tributaries and smaller streams with each major basin or sub-basin are then identified by a three-letter code based on the stream name.
- This is followed by a five-digit numerical value that identifies the specific point on the stream as the number of "river miles" upstream from the stream's mouth.
- The identification codes for the streams in Loudoun County are listed in **Table __**.

Table __. Subwatersheds in Loudoun County with Areas >440 Acres with DEQ/DCR Identification Nomenclature[33].

Major Watershed	Subwatershed	Stream Name	Tributary Name	Area in Acres*
Lower Potomac River – Sub Basin 1A				
Broad Run (A09)	Broad Run-Mainstem (BRB)/Cabin Br No.2			10,535
Broad Run (A09)	Broad Run (BRB)	Upper Broad Run (___)		14,251
Broad Run (A09)	Broad Run (BRB)	Beaverdam Run (___)		8,264
Broad Run (A09)	Broad Run (BRB)	Horsepen Run (HPR)		8,594
Bull Run (A21)	Cub Run (A22) (___)/Elklick Run (___)			9,436
Bull Run (A21)	Upper Bull Run (___)			9,309
Catoctin Creek (A02)	Catoctin Creek-Mainstem (CAX)			10,527
Catoctin Creek (A02)	Catoctin Creek	Brens Creek (___)		7,089
Catoctin Creek (A02)	Catoctin Creek	Milltown Creek (MIH)		5,528
Catoctin Creek (A02)	Catoctin Creek	NF Catoctin Creek (NOC)		14,911
Catoctin Creek (A02)	Catoctin Creek	SF Catoctin Creek (SOC)		20,171
Clarks Run (___)				4,449
Direct to Potomac				6,441
Dutchman Creek (___)	Dutchman Creek-Mainstem (___)			8,257
Goose Creek	Lower Goose Creek-Mainstem (A08)(GOO)			21,082
Goose Creek	Lower Goose Creek (A08)	Little River (LIV)		15,745
Goose Creek	Lower Goose Creek (A08) (GOO)	Sycolin Creek (SYC)		10,960
Goose Creek	Lower Goose Creek (A08) (GOO)	Tuscarora Creek (TUS)		9,226
Goose Creek	Middle Goose Creek-Mainstem (A05)(GOO)			12,557
Goose Creek	NF Goose Creek-Mainstem (A06) (NOG)			20,304
Goose Creek	NF Goose Creek (A06)	Crooked Run (___)		8,104
Goose Creek	NF Goose Creek	Upper Beaverdam Cr-Mainstem (A07) (BEC)		13,607
Goose Creek	NF Goose Creek	Upper Beaverdam Cr (A07)	Dog Branch	4,623

[33] Virginia Department of Environmental Quality. "Virginia's Water Quality Monitoring Strategy." December, 1999. Page 140.

Goose Creek	NF Goose Creek	NF Beaverdam Creek (A07)(NOB)		12,045
Goose Creek	Upper Goose Creek-Mainstem (A04)(GOO)			18,312
Goose Creek	Upper Goose Creek (A04)	Lower Panther Skin Cr (___)		7,009
Goose Creek	Upper Goose Creek (A04)	Lower Panther Skin Cr (___)	Jeffries Branch	5,883
Limestone Br. (A03)	Limestone Branch (LIM)			10,342
Piney Run (A01)	Piney Run (PIA)			9.543

***** Acres are taken from Loudoun County GIS Data as provided by David Ward

Subdividing Watersheds – Watersheds in Loudoun County will be divided into smaller drainage basins in a manner that allows the development of a watershed management plan for each. DEQ considers the minimum size of a watershed to be 3000 acres, although smaller watersheds are listed[34]. A criterion has been adopted by DEQ in determining the minimum size of a watershed that can be used for the application and evaluation of best management practices to maintain or improve water quality. The criterion is whether land use practices are reasonably uniform. Uniformity is measured in terms of whether the dominant land uses normally generate similar types of NPS, and normally require similar types of BMP's to control the NPS. If the heterogeneity within a watershed may inhibit the application of uniform management plans, and representative monitoring of water quality would also be needed on a more local scale, smaller drainage basins are designated. This criterion has been adopted by Loudoun County.

Stream Order – The stream order classification system best suited for probabilistic sampling is the Shreve or "link" order.[35] This system is also useful for relating environmental variables to stream size. Order number is determined by adding the orders of the joining streams (e.g. the union of a 4th and a 5tyh order stream results in a stream of the 9th order). The Shreve order, consequently, is identical to the number of the 1st order sources that drain through a specific stream segment. The basins draining through any two-stream segments of Shreve order "n" contain exactly the same number of primary sources (n), of stream junctions or "forks" (n-1) and of stream segments (2n-1) or "links" between successive forks or between forks and primary sources. Streams of a specific Shreve order are therefore more uniform in size and the order number is independent of basin complexity. In addition, the order of the downstream "link" below any fork is a more informative measure of the change in stream size when two tributaries join, and the potential reservoir of aquatic species that are available to colonize upstream habitats.

Stream Size Parameters – Within free flowing streams, width, depth, water velocity and total discharge rate (volume per unit time) are extremely important size parameters. They have crucial effects upon the physical and chemical characteristics of the water, which in turn have ecological implications, and are necessary for calculating estimates of total material flow and the Maximum Total Daily Loadings (TMDLs) necessary for management planning and the permitting of point-source discharges. Ecologically and biologically, these stream size parameters are important because they influence the water temperature, oxygen content, the quantity of suspended material that a stream can carry and the size of substrate particles deposited within the streambed.[36]

Natural, Unimpaired Conditions – Comparison of the observed structure and function of aquatic communities with those expected under "natural," unimpaired conditions is the first phase of biological assessment of water quality. The biological communities expected under natural conditions vary with (a) the size and form of the stream; and (2) the geographic "ecoregion." Loudoun County has several options available.

- **Reference Stream** –The reference streams used by DEQ are the lower Rapidan River for muddy bottom streams and Catoctin Creek at Taylorstown for rocky bottom streams. Most streams in Loudoun County are rocky bottom streams. DEQ calculates the percent similarity between the monitored and reference

[34] Virginia Department of Environmental Quality. "Virginia's Water Quality Monitoring Strategy." December, 1999. Page 24.
[35] Virginia Department of Environmental Quality. "Virginia's Water Quality Monitoring Strategy." December, 1999. Page 28.
[36] Virginia Department of Environmental Quality. "Virginia's Water Quality Monitoring Strategy." December, 1999. Page 27.

streams for both the habitat and aquatic organisms. Unfortunately, Catoctin Creek at Taylorstown is a 3rd or 4th order stream, and may not a good reference for 1st and 2nd order streams.

- **Reference Conditions** -- EPA[37] recommend using "reference conditions" rather than reference streams to measure stream health since there are few sites left that reflects the best conditions. The reference condition is a composite of scores from sites that reflect the best physical, chemical, and biological conditions existing in the ecological region. Loudoun County will develop a reference condition index after sufficient probabilistic data is collected.
- **Fairfax County Reference Sites --** Loudoun County will also consider using reference site data from Prince William Forest. These data are currently being used by Fairfax County, and may be the best data available to Loudoun County from the local ecoregion.
- **Virginia Index of Biological Integrity (IBI) –** DEQ has developed an IBI (index of biological integrity) from an analysis of historical data collected in Virginia. The IBI provides a reference condition based upon statewide averages. Loudoun will use this index when it is adopted by DEQ until sufficient probabilistic data is available to do comparison analyses.

[37] U.S. Environmental Protection Agency (EPA). 1997. Volunteer Stream Monitoring: A Methods Manual. EPA 841-B-97-003.