Summary of Methods Used in the Preparation of The Magothy Watershed Restoration Strategy.

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The following summary comes from this document:

"The Magothy River Watershed Restoration Strategy." Prepared by the Anne Arundel County Office of Environmental & Cultural Resources in cooperation with the Magothy River Association and the Maryland Department of Natural Resources. July 2005. 146 pp, plus Appendixes. This excerpt is found on pp. 5 to 16 of this report. Also included is Appendix A that describes the approach used to score and rank the subwatersheds.

II. METHODS

Assessment of the nontidal tributaries to the Magothy River, and the Magothy River tidal shoreline, was accomplished using the Stream Corridor Assessment (SCA) and the Tidal Shoreline Survey (TSS) methodologies described below. These two assessment methods provide a rapid means of examining and cataloguing the observable environmental problems within a watershed so that better targeting of future monitoring, management, and/or protection efforts can be accomplished. These surveys are not detailed scientific surveys, nor will they replace chemical and biological surveys in determining overall stream and estuary conditions. However, these methods can be employed, at a watershed scale, on a rapid and relatively low cost basis.

In addition to the SCA and Tidal Shoreline Survey, synoptic stream chemistry and flow data were collected in each subwatershed with a perennial stream. The synoptic survey data supplemented the SCA information, providing a more holistic assessment of the Magothy River Watershed.

The data from the SCA survey, the synoptic survey results, flow data, and other landscape indicators were used to rank the subwatersheds using a scoring system based on the Basin Condition Score (Victoria, et al., 2003), a method developed for use during the execution of the County's Upper Patuxent River Watershed Restoration Action Strategy (Anne Arundel County, 2004). The purpose of this work effort was to identify and prioritize subwatersheds, and specific projects within those subwatersheds, for restoration.

Lastly, the County incorporated public participation into the process through work sessions with stakeholders to review and discuss the data collected.

STREAM CORRIDOR ASSESSMENT

The Stream Corridor Assessment (SCA) provides a rapid overview of the tributary stream network, provides basic information about those streams, and identifies where potential environmental problems occur. Through this effort, 49 miles of perennial stream in 24 subwatersheds were field assessed within the 35 square mile Magothy River Watershed between late spring and early summer 2004. Table 1 summarizes basic information about each subwatershed surveyed.

While almost any group of dedicated stakeholders can be trained to perform an SCA survey, the Maryland Conservation Corps (MCC) has proven to be an ideal group to do this work in Maryland. The MCC is part of the AmeriCorps Program, initiated to promote greater involvement of young people in their communities and the environment. MCC staff has participated in numerous SCA surveys for the Maryland Watershed Restoration Action Strategy program.

Table 1. Subwatersheds Assessed for the Magothy River Stream Corridor Assessment.

Subwatershed Name	Subwatershed ID	Drainage Area (Acres)	Stream Miles
Bailey's Branch	29	411	1.7
Muddy Run	30&39	656	1.4
Magothy Branch	31	1639	3.8
Brookfield Branch	32	442	1.6
Beachwood Branch	35	556	2.0
Cockey Creek	36	1846	4.4
Kinder Branch	41	620	1.0
Cornfield Creek	43	499	0.7
Rouses Branch	44	555	1.7
Nanny's Creek	45	289	0.8
Gibson Island	48, 61, 93	959	2.0
UNT Magothy River	49	220	1.1
Grays Creek	50	776	2.1
Old Man Creek	52	498	1.5
Blackhole Creek	53	700	2.2
UNT Magothy River	54	250	0.2
Cattail Creek	55	2084	2.9
Cypress Creek	88	976	1.2
Dividing Creek	103	862	2.9
Mill Creek	105	1082	3.8
Forked Creek	109	856	3.4
Deep Creek	120	1355	5.4
Little Magothy River	127	1382	4.0
Magothy River Direct Drainage	25, 26, 47, 60, 62, 64, 65, 66, 67, 75, 76, 82, 101, 102, 108, 110, 113, 116, 117, 118, 119, 122, 278	2821	3.0

The MCC program is managed by Maryland Department of Natural Resources (DNR) and was chosen to conduct the Magothy River SCA due to their extensive experience with this methodology.

Prior to the initiation of the Magothy River SCA, members of the MCC's Bay Crew completed an intensive training program designed and instructed by Maryland DNR Watershed Services staff. Through the intensive training, the MCC teams learned to assess the general condition of in-stream and riparian habitats, identify the locations of potential wetland creation sites, record problem locations using a Global Positioning System (GPS) unit, and to identify and assess severity and correctability for problems as categorized in Table 2.

Table 2. Categories of Projects Observed during the SCA and the TSS.

Project Type	Abbreviation[1]	Notes
Trash Dump	TD	Any type of large trash concentration.
Erosion Site	ES	Areas of stream bank or streambed erosion.
Shoreline Erosion*	SE	Areas of eroding tidal shoreline.
Fish Barrier	FB	Any natural or manmade blockage that impedes fish movement through tidal or nontidal areas.
Channel Alteration	CA	Any type of channel straightening or other type of traditional river management alteration.
Altered Shoreline*	AS	A non-natural tidal shoreline, usually changed to a bulkhead or riprap area.
Inadequate Buffer**	IB	Buffer considered impacted if <50 feet wide moving from edge of stream or landward from shore.
Pipe Outfall**	PO	A direct discharge from a pipe into the stream or tidal area.
Unusual Conditions	UC	Any out of the ordinary condition not described in the other categories. (e.g., odors, scum, excessive algae, water color/clarity, red flock, sewage discharge, oil)
Exposed Pipe	EP	An exposed length of pipe in the stream channel that could be damaged during high flows.
In/Near Stream Construction	IC	Any type of construction adjacent to or within the stream.

1) No asterick = SCA only, * = TSS category only, ** = used in SCA and TSS.

Prior to initiating the fieldwork, Anne Arundel County staff identified 1,789 properties adjacent to perennial streams or floodplains in the watershed. County staff sent information letters to those property owners. These letters also requested property owner permission to access the stream adjacent to the property, and provided a phone number and e-mail address to contact if the landowner did not want the crews to survey the stream on their property. Additionally, survey crews were instructed to not cross fence lines or enter any areas marked as “No Trespassing” unless specific permission to access the property had been granted by the landowner.

In preparation for the field component of the SCA, the MCC survey crew chief identified representative sites along each stream reach where survey crews were instructed to record specific information regarding in-stream habitat conditions, wetted width of the stream, thalweg depth, and bottom type. These reference sites were denoted on the field maps used by the survey crews.

The MCC field survey crews then walked each mile of identified stream (approximately 49 miles). At each site during the survey, field crews collected descriptive data, recorded the location, and took a photograph and recorded GPS site information to document each potential environmental problem observed. As an aid to prioritizing future restoration work, crews rated all problem sites on a scale of one to five in three categories: 1) how severe the problem is compared to others in its category; 2) how correctable the specific problem is using current restoration techniques; and 3) how accessible the site is for work crews and any machinery necessary to complete restoration work. A unique identification number was assigned to each problem observed and to each reference site identified along each surveyed stream reach. Each identifier was correlated to a location on the field map.

Photographs of, and GPS location information for, the problem areas and the reference sites were taken to document field conditions from both the upstream and downstream views. MCC crews completed field data sheets for each environmental problem observed, as well as for the reference sites along the stream reach. The results of the SCA survey efforts were submitted to Maryland DNR staff who compiled the information into a database format, labeled and organized all photographs by site, and incorporated all data and photographs into a readily usable GIS format.

Complete information on the SCA methodology, including descriptive information for each problem type, and definitions for levels of severity, correctability, and accessibility, can be found in "Stream Corridor Assessment Survey – Survey Protocols" (Yetman, 2001). A copy of the survey protocols can be found on the Maryland Department of Natural Resources web site at http://www.dnr.state.md.us/streams/pubs/other.html. Hard copies of the protocols also can be obtained by contacting the Watershed Services Unit of the Maryland Department of Natural Resources, Annapolis, MD.

SYNOPTIC STREAM SURVEY

The ability of a stream to support a diversity of aquatic life depends on the quality and availability of habitat as well as the chemical characteristics of its water quality. While the habitat features of a stream can be easily observed, measurements of water quality require field sampling and usually some laboratory analyses of the samples. To better understand the existing stream conditions, Anne Arundel County staff supplemented the SCA survey with a synoptic baseflow water quality survey.

Water Quality Sampling

Anne Arundel County staff conducted synoptic water quality sampling in early fall 2004. At least one non-tidal perennial stream was targeted for sampling in each identified subwatershed. Synoptic survey sampling locations are shown in Figure 3. A site description is found in Table 3. Sampling sites were located near road crossings within non-tidal reaches of perennial streams. Samples were collected upstream of the road crossing unless site conditions required downstream sampling.

Baseflow grab samples were collected at 24 sites within the watershed. Samples were collected mid-stream, just below the water surface, directly into a 250-ml plastic container. The water samples were immediately placed on ice and held at approximately 4°C. The samples were retrieved by the analytical laboratory within 24 hours of collection and analyzed for orthophosphate and nitrate-nitrogen in accordance with U.S. EPA protocols as described in Table 4.

Table 3. Description of Synoptic Survey Stations

Station ID	Anne Arundel County ADC Map Coordinate	Location Description
29-01	9-B10	Upstream of Milton Rd.
30-01	9-A11	Upstream of Old Mill Rd.
31-01	8-G10	Upstream of MD10, east of Elvaton Dr.
32-01	9-C10	Upstream of Rte 100, near Disney Ave.
35-01	9-D12	Upstream of Magothy Bridge Rd.
36-01[a]	9-F13	At the end of 12th Street
36-02	9-F12	Upstream of Woods Rd.
36-03	9-H12	~200 feet downstream of N. Beacrane Rd.
41-01	8-H11	At end of KenMar Ave.
43-01	10-F12	~325 ft. NE of Milburn Circle and Thorpe Rd.
44-01	8-J12	Upstream of Pasadena Rd.
45-01	9-A12	~275 ft. NW of Oak Hollow Drive
49-01	10-F3	Upstream of Circle Ave., near Wileys Lane
50-01[a]	16A2	Upstream of North Shore Rd.
50-02[b]	16-C1	End of South Rd., near Maryland Ave.
52-01	15-B1	~200 feet SSE of Malibu Ct.
53-01	15-H2	Upstream of Glencrest Terrace.
54-01[b]	16-E1	Upstream of Thies Dr.
55-01	15-A3	Downstream of MD Rte 2
55-02	14-K4	Downstream of B & A Trail
88-01	15-C5	~240 ft. north of Dunkeld Ct.
103-01	15-E9	Upstream of Jones Station Road
105-01	15-G9	Upstream of College Parkway
109-01	15-K9	Due east from Greenblades Ct. to stream, then downstream ~400 feet below confluence
120-01	16-C11	~200 feet NW of Seminole Dr., downstream of confluence
127-01 [a]	16-G13	Upstream of Cape St. Claire Rd.

[a] = water sample, no flow measurement; [b] = no water sample, no flow measurement

Table 4. Water Quality Analytical Parameters

Parameter	Analytical Method	Detection Limits (mg/L)
Nitrate (NO_3)	EPA 300.0	0.06
Orthophosphate (PO_4)	EPA 365.3	0.02

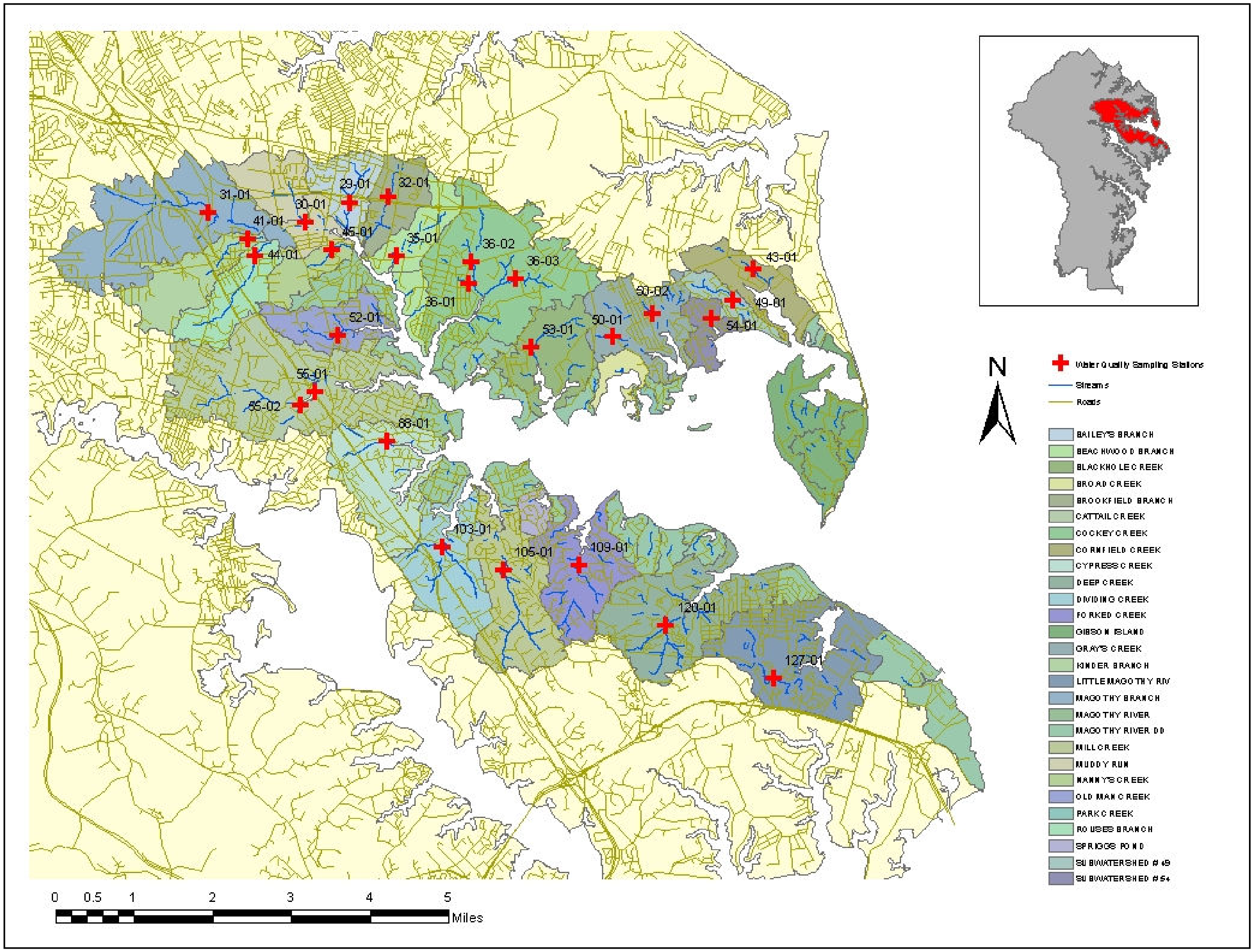

Figure 3. Synoptic Sampling Stations in the Magothy River Watershed

An upstream and downstream photo was taken at each site to document site conditions at the time of sampling. Additionally, the stream cross-sectional area was measured and an average velocity of flow was determined so that stream discharge could be calculated. For most stations, velocity was measured using standard techniques employed by the U.S. Geological Survey and equipment appropriate for the flow condition. At some stations, surface velocity measurements were necessary because of shallow water depths. Finally, some velocity measurements were taken directly in road culverts rather than in the natural channel up or down stream. When this occurred, an area of flow was calculated using techniques described in Evett and Liu (1987) and the average velocity was applied to that area for discharge calculations.

At three sampling stations (127-01, 36-01, 50-01), a water sample was obtained, but a flow measurement was not possible due to low velocity or instream site conditions. At one station (54-01), the stream was discovered to be dry on the day of the survey, so no data were obtained. At a second station (50-02), the stream map indicated a single thread channel available for sampling, but a forested wetland existed on the site instead, so no data were collected here. To estimate discharge and develop loading rates, a regression relationship between drainage area and discharge was developed using the flow data obtained at the other stations assessed during this work.

Water quality data, cross-sectional area, and stream velocity were entered into an Excel spreadsheet for processing and analysis. Nitrate and orthophosphate concentration data were used to score relevant metrics in the subwatershed condition evaluation described below. In addition, these data were also used in conjunction with the discharge data to estimate unit area loading rates for each subwatershed sampled. For samples where levels were reported as below the detection limit, a value of one half the detection limit was used in computing constituent loading rates.

EVALUATION OF SUBWATERSHED CONDITIONS

Restoration and protection decisions should be made using acceptable and sound scientific methodology. To that end, Anne Arundel County has developed a methodology to assist in the review and assimilation of the data collected, and to provide a means to prioritize Magothy River subwatersheds for restoration and/or protection actions.

The method used was derived from the Basin Condition Score (BCS) methodology developed in support of the Upper Patuxent River Watershed Restoration Action Strategy (Anne Arundel County, 2004). The subwatershed assessment methodology is comprised of a series of indicators that score various characteristics of each subwatershed. Individual indicators are organized into groups that include water quality and hydrologic conditions, living resources and habitat conditions, and landscape conditions. Table 5 lists the indicator groups and their associated indicators. Details about how each indicator is scored can be found in the complete method description, which is contained in Appendix A. The data used to score the indictors comes from the SCA (Pellicano et al., 2004), the synoptic stream survey data, and available Geographic Information Systems (GIS) spatial data developed by Anne Arundel County. Once each indicator is scored, watershed conditions are determined using the ranges described in Table 6.

Some indicators within indicator groups are believed to better characterize critical ecological processes. Consequently, selected indicators are weighted to emphasize their importance over others when evaluating subwatershed health. Each indicator within a group is either unweighted or given a weighting factor of two or three. The decision about which indicators to weight is based on scientific literature and the best professional judgment of the authors. An indicator is unweighted if it has a lesser influence on ecological processes in a subwatershed of interest, or if lesser quality data had to be used to derive its score. Data quality decisions were made in consultation with GIS professionals for spatial mapping data and through discussions with the data collection participants (e.g., SCA survey manager).

Table 5. Individual Indicators Used to Evaluate Subwatershed Conditions

Indicator Group	Individual Indicator
Water Quality and Hydrologic Conditions	Baseflow Nitrate/Nitrite Concentration Departure
	Baseflow Orthophosphate Concentration Departure
	Flooding Potential
	Stream Baseflow Conditions
Living Resource and Habitat Conditions	Anadromous Fish Utilization
	Presence/Absence of Sensitive Species Protection Areas
	Channel Erosion
	Pipe Outfalls
	Buffer Conditions
	Fish Barriers
	Overall Habitat Rating
	Channel Alterations
Landscape Conditions	Current % Imperviousness
	Road Crossings
	Forest polygon edge/area
	Full Build Out Increase in Impervious Cover
	% of Subwatershed in Proposed Greenway
	% of Subwatershed Land Area with Permanent Protection
	% of Subwatershed Land Area in Agricultural Land Use

Table 6. Scoring Ranges for Evaluation of Subwatershed Conditions Rating

Indicator Group	Subwatershed Quality Rating			
	Good	Fair	Poor	Very Poor
Water Quality and Hydrologic Conditions	<13	13-30	31-43	>43
Living Resource and Habitat Conditions	<41	41-88	89-140	>140
Landscape Conditions	<33	33-72	73-111	>111
Overall Condition Score	**<85**	**85-187**	**187-294**	**>294**

GIS DATA PROCESSING AND ANALYSIS

A variety of GIS operations were performed in the conduct of this study. All mapmaking (except as noted by citation) for this report was done using ArcGIS 9.0. Analysis and data manipulations were done in ArcGIS 9 and in ArcView 3.1 using the XTools extension. XTools is a collection of tools developed to give ArcView 3.X functionality found in ArcInfo and ArcGIS. Details about XTools can be found on-line at
http://www.odf.state.or.us/divisions/management/State_forests/XTools.asp

Most GIS work was done to score variables used in the subwatershed condition assessment described in Appendix A and descriptions of the methods used can be found there. Appendix B describes the data layers used for that purpose and for the development of subwatershed maps found in the Subwatershed Conditions section of this assessment. In scoring most of the subwatershed condition assessment variables, usually only a simple examination of various map data were needed. More complex operations are described with the relevant metric.

Summaries of subwatershed land use are provided in each individual subwatershed description found in Section III. These data were generated using land use information from 1998. Land use data were checked and adjusted using aerial photography from 2000 and 2002. Only minor adjustments in the coverage were necessary. Definitions of the various land use categories are listed in Appendix B.

It should be noted that the County's land use coverage describes associated general land uses of the County and is not a precise land cover data set. Therefore, the actual footprints of certain categories found in the coverage typically have inclusions of other cover types, making most categories a mosaic of related and associated land covers. For example, an area classified as Single Family Residential typically includes houses, streets, and yards along with small areas of associated forest commonly found in residential developments. Areas placed in the Industrial category might include factories, parking areas and surrounding landscaping green space and small, undeveloped forest buffer areas that are part of the parcel of interest. As a consequence of this situation, the land use information presented in this assessment should be regarded as a generalized, semi-qualitative description of land use conditions in the Magothy River watershed and not a quantitative summary of land cover distribution.

NONTIDAL STREAM AND SUBWATERSHED RESTORATION PROJECT RANKING

One of the products of the SCA methodology application is a list of potential restoration sites associated with the problem identification process. As described in Yetman (2001), each observed problem is scored for severity, correctability, and accessibility. Table 7 provides brief definitions of how each category is scored in the SCA.

The SCA project rating data were used to rank projects within each subwatershed in the following manner. First, only projects with a severity rating of moderate or higher were considered in the ranking process. Then, the scores for each category were summed and the projects with the lowest scores were judged the highest priority projects for implementation. The rational for this approach is that projects that were judged highly severe but were also judged relatively easy to access and easily correctable would be the easiest to implement and have the best return on investment for improving the subwatershed of interest. Projects that were somewhat more difficult to access and/or were judged more difficult to correct got lower scores using this approach. Prioritized project lists were generated for each subwatershed and are presented in the individual subwatershed narratives in Section III**.**

Table 7. Problem Evaluation Categories Scored during the SCA

Category	**Condition Rating Description (Assigned Point Value)**		
	Low	**Moderate**	**High**
Severity	Problems generally are low intensity or only occur over a short distance of stream channel. Problems judged not significant. **(5)**	Problem somewhat widespread, assessment crews have observed worse during assessment. **(3)**	Problems generally widespread with large impact on system health. Magnitude and/or extent of problem relatively great**.** **(1)**
Correctability	Easy to correct. Typically, low intensity problems that might be solved with volunteer labor or little engineering analysis. **(1)**	More difficult to correct. Might require significant volunteer labor, or a small piece of construction equipment to correct. **(3)**	Most difficult. Impacts extensive and likely require professional expertise to diagnose and determine corrective actions. Large, expensive, construction projects typical. **(5)**
Accessibility	Easy to access. Near road crossings or on public property. **(1)**	Project might be accessible by foot but not easily by vehicle. **(3)**	Project difficult to access by foot and by vehicle. **(5)**

Tidal Shoreline Survey

The tidal shoreline habitat is a transition zone between the terrestrial and aquatic ecosystems, known as the intertidal zone. Within the intertidal zone, land is alternately covered by water and exposed to the air as the tides rise and fall. In the Chesapeake Bay area, this zone is often characterized by tidal wetland or marsh and mudflats. Important in maintaining healthy habitat for aquatic and avian species, wetland vegetation also serves to improve water quality, prevent shoreline erosion, and decrease turbidity by absorbing excess nutrients, trapping and anchoring sediment, and buffering wave action. Equally important to the efficacy of the intertidal zone is the riparian buffer habitat located immediately landward. Forested riparian areas serve multiple purposes including filtering nonpoint source pollutants present in runoff and preventing shoreline erosion.

The tidal shoreline survey was developed by the Maryland DNR to assess environmental conditions of Maryland shorelines and identify the location of potential environmental problems. from the water using a shallow draft boat.

For the Magothy River, 76 miles of tidal shoreline were surveyed in July 2004. Volunteers from the Magothy River Association (MRA) teamed with experienced Maryland DNR Watershed Services Unit staff to complete this survey. The MRA volunteers provided boats and crew to assist in the survey. The boats cruised between 10 and 100 feet offshore at a speed of less than 5 miles per hour. Survey crews observed shoreline conditions, making note of potential environmental problems including altered shorelines, inadequate shoreline buffers, pipe outfalls, and areas of shoreline erosion (See Table 2 for category definitions). Survey crews also logged the location of each potential problem using GPS. Photos were taken every 30 feet to create a continuous photographic coverage of the shoreline. The digital photos were tied back into the GPS data and incorporated into a GIS product. This GIS product allows an observer to review what the shoreline looked like at any specific point during the survey.

Tidal Shoreline Restoration Ranking

Potential problem areas identified through the survey work were ranked with respect to their severity as per the criteria presented in Table 8. Correctability and accessibility ratings generally follow the same criteria as the SCA.

Table 8. Criteria Used to Rank Tidal Shoreline Problem Severity.

Problem	Very Severe = 1	Moderate = 3	Minor = 5
Altered shoreline	>1000 feet long Wall/Bulkhead	500 feet long Combination	<100 feet long Rip-Rap
Inadequate Buffer	>1000 fee long No trees or marsh Lawn	500 feet long 0 foot width Shrubs/Small trees	<100 feet long <50 feet forest buffer present
Pipe Outfall	Large amount of discharge Strong odor and color Significant impact downstream	Small discharge Little/no odor or color Local impact downstream	Stormwater outfalls No dry weather discharge Not causing erosion
Shoreline Erosion	>1000 feet long >10 feet high banks	500 feet long 5 feet high banks	<100 feet long 1-2 foot high banks

PUBLIC PARTICIPATION

Anne Arundel County desired to provide a mechanism for stakeholder involvement in the development of the Magothy River Watershed Restoration Strategy. The primary stakeholders were represented by the Magothy River Association (MRA), the County's partner in this project. The MRA, founded in 1946, is an all-volunteer, non-profit organization representing over 45 communities within the Magothy River Watershed. The MRA focuses primarily on projects associated with protection and restoration of the Magothy River, its tributaries, and surrounding lands.

Planned opportunities for stakeholder involvement were facilitated by the County and MRA through invitations to participate in the field activities, as well as participation in data review and development of restoration recommendations. The MRA provided the direct avenue to stakeholder contact, soliciting interest and participation in the project.

APPENDIX A

METHODS USED IN THE EVALUATION OF SUBWATERSHED CONDITION FOR THE MAGOTHY RIVER WATERSHED RESTORATION STRATEGY

INTRODUCTION

The purpose of this document is to describe the prioritization methodology used to evaluate and rank subwatersheds in the Magothy River Watershed for restoration activities.

METHODS

In this approach, indicators were developed to evaluate overall subwatershed conditions. These indicators are based upon data collected during the Stream Corridor Assessment (SCA) performed by DNR staff, water quality data collected during 2004 by OECR staff, and GIS data developed by Anne Arundel County. The methods used in the SCA are found in Yetman (2001). Water quality assessment methods are described in Section II of this report. In addition, GIS procedures are described in this document and in Section II of this report.

Some indicators are believed to better characterize critical ecological processes. Consequently, these indicators were weighted to emphasize the importance of some variables over others when evaluating subwatershed health. Each indicator was either unweighted or had a weighting factor of 2 or 3 applied. The decision about which indicator to weight was based upon scientific literature and the best professional judgment of the authors. Besides having a lesser impact on ecological processes in a subwatershed of interest, indicators were also left unweighted if it was judged that insufficient data had to be used to score the indicator. Data quality decisions were made in consultation with GIS professionals and through discussions with participants of the SCA.

The points for each indicator were summed to develop a score that can be used to compare conditions between assessed subwatersheds, leading to a condition classification as illustrated in Table 1. Along with the total condition score, each individual indicator was placed in an indicator group, which also received its own condition score. By lumping indicators into groups, one is able to interpret where general problems exist within a subwatershed even if an overall score indicates only moderate or low impairment. Using the ranges, subwatershed condition overall and by indicator group was classified as described in Table 1.

Table 1. Scoring ranges for the various indicator groups used in this methodology.

Indicator Group	Subwatershed Quality Rating			
	Good	Fair	Poor	Very Poor
Water Quality and Hydrologic Conditions	<13	13-30	31-43	>43
Habitat and Living Resource Conditions	<41	41-88	89-140	>140
Landscape Conditions	<33	33-72	73-111	>111
Overall Condition Score	<85	85-187	188-294	>294

A. WATER QUALITY AND HYDROLOGIC CONDITIONS.

Water quality data provide insight into the ability of organisms to survive in aquatic systems, and an indication of the impacts of development or other anthropogenic activities in a subwatershed. Water quality data were collected during a synoptic survey of the study area described in the body of the report.

WQH1—Baseflow Nitrate Concentration Departure

Justification: Nutrient concentrations associated with relatively unimpaired subwatersheds have been documented for Coastal Plain watersheds. In addition, excess nutrient loading has been shown to be a main impairment in Chesapeake Bay water quality.

Scoring Definition: This indicator is scored using nitrate concentrations determined from synoptic sampling. The level of departure from levels listed below, which is based upon guidance from USEPA (2000) and local unpublished data, is considered indicative of impairment. If more than one station exists in a subwatershed, an average is taken of all available concentration values within a subwatershed of interest and scored as described below:

Definition	Score (Unweighted)	Quality Rating
<0.1 mg/L	1	Good
0.1 to 0.3 mg/L	4	Fair
>0.30 to 0.50 mg/L	7	Poor
>0.5 mg/L	10	Very Poor

WQH2—Baseflow Orthophosphorous Concentration Departure

Justification: Nutrient concentrations associated with relatively unimpaired watersheds have been documented for Coastal Plain watersheds. In addition, excess nutrient loading has been shown to be a main impairment in Chesapeake Bay water quality.

Scoring Definition: This indicator is scored using orthophosphate concentrations determined from synoptic sampling. The level of departure from levels listed below is considered indicative of impairment. These categories are based upon levels described in DNR (2002). If more than one station exists in a subwatershed, an average is taken of all available concentration values within a subwatershed of interest and scored as described below:

Definition	Score (Unweighted)	Quality Rating
<0.005 mg/L	1	Good
0.005 to 0.010 mg/L	4	Fair
0.011 to 0.015 mg/L	7	Poor
>0.015 mg/L	10	Very Poor

WQH3—Flooding Potential

Justification: Flooding is a significant concern to some stakeholders in assessed subwatersheds. This indicator scores the potential of damage to developed areas and intrusion into the 100-yr floodplain by older structures.

Scoring Definition: An examination is made of developed land and its presence or absence in the 100-yr floodplain as defined by digital versions of FEMA maps.

Definition	Score (Weighting Factor 2)	Quality Rating
No developed land in 100-yr FP	2	Good
0 to 15% of 100-yr FP includes developed land	8	Fair
16 to 25% of 100-yr FP includes developed land	12	Poor
>25% of 100-yr FP includes developed land.	20	Very Poor

WQH4—Stream Baseflow Condition

Justification: A major impact associated with development concerns the loss of baseflow in stream channels. Because of the lack of recharge, baseflow in urban and suburban streams is typically depressed compared to undeveloped watersheds, with streams frequently dry even during light or moderate drought conditions. The maintenance of baseflow during dry months is a critical habitat feature for aquatic organisms.

Scoring Definition: This indicator is scored using the channel flow status parameter scored during the habitat assessment performed as part of the representative sites evaluated during the SCA stream walks. All indicators were scored using the qualitative categories that are part of the RBP habitat assessment (Optimal, Suboptimal, Marginal, Poor). These ratings were converted to values by selecting the median value within the category (18 for Optimal, 13 for Suboptimal, 8 for Marginal, and 3 for Poor). All scores within each subwatershed were then averaged and scored as described below:

Definition	Score (Unweighted)	Quality Rating
Rated optimal	1	Good
Rated suboptimal	4	Fair
Rated marginal	7	Poor
Rated poor	10	Very Poor

B. HABITAT AND LIVING RESOURCE CONDITIONS.

Habitat conditions and living resource conditions within each of the Magothy River subwatersheds were evaluated using GIS data from County sources and from the information collected as part of the Stream Corridor Assessment (SCA) performed by the Maryland Conservation Corps and Maryland Department of Natural Resources. In addition, GIS data from DNR on anadromous fish usage and on the presence or absence of threatened and endangered species was used in this metric group. With this information, a total of eight indicators were developed to evaluate overall habitat and living resource conditions in the study subwatersheds. An indicator group score is calculated by summing the scores of all eight indicators and scored using the ranges in Table 1. The indicators used are described below:

HLR1—Anadromous Fish Utilization

Justification: Because anadromous fishes return to the same streams each season, these species are an indicator of moderate to high quality habitat conditions. Like invertebrates, these species integrate water quality impacts over longer time frames due to the presence of multiple life history phases utilizing these areas.

Scoring Definition: The presence or absence from subwatersheds as detailed in Mowrer and McGinty (2002) forms the basis of the score. A total of five species are evaluated: yellow perch, white perch, American shad, blueback herring, and alewife. Because of the age of the data, this indicator is unweighted

.

Definition	Score (Unweighted)	Quality Rating
4 or 5 species use the subwatershed	1	Good
2 or 3 species use the subwatershed	4	Fair
1 or 2 species use the subwatershed	7	Poor
No species use the subwatershed.	10	Very Poor

HLR2—Presence/Absence of Sensitive Species Protection Areas

Justification: Loss of biodiversity is indicative of an impacted subwatershed. The presence of areas supporting rare or endangered species signify high quality habitat within that subwatershed.

Scoring Definition: Because of the nature of the GIS data associated with this indicator, exact locations, numbers, and extent of distribution are not know for the species in question. Consequently, the presence or absence of these species is used to score this indicator.

Definition	Score (Unweighted)	Quality Rating
1 or more SSPA present in subwatershed	1	Good
No SSPA present in subwatershed	10	Very Poor

HLR3—Channel Erosion

Justification: Channel erosion can be a serious habitat impairment. While streams naturally erode banks and rework floodplains over time, excess streambank erosion due to watershed development results in siltation of spawning areas, smothers bottom dwelling invertebrates, and can have adverse impacts on stream channel and floodplain form and function (Waters 1995).

Scoring Definition: Data on eroding banks were collected during the SCA. Each bank was rated during the field assessment. Using the severity rating given during that evaluation, only banks rated moderate in severity or greater were used in calculating this indicator. Channelization impacts were not included in this indicator. The total amount of both banks in this condition was divided by the total amount of stream bank in the subwatershed (double the total GIS-derived stream length) and scored as described below:

Definition	Score (Weighting Factor 3)	Quality Rating
Value <0.10	3	Good
Value between 0.10 and 0.20	12	Fair
Value between 0.21 and 0.30	21	Poor
Value >0.30	30	Very Poor

HLR4—Pipe Outfalls

Justification: As described in Yetman (2001), pipe outfalls represent potential non-point source pollution directly piped into the stream system. The number of outfalls is also an indirect indicator of development density with more outfalls equal to increased development.

Scoring Definition: The total number of outfalls per square mile of subwatershed was calculated and scored as described below:

Definition	Score (Unweighted)	Quality Rating
<2 per sq. mi.	1	Good
2 to 5 per sq. mi.	4	Fair
6 to 10 per sq. mi.	7	Poor
>10 per sq. mi.	10	Very Poor

HLR5—Buffer Conditions

Justification: Riparian buffers are necessary for stream stability and are a major component of stream habitat through the production of woody debris (Everett and Ruiz 1993, Benke et al 1985, Palmer et al 1996). Streams with more diverse and healthy biological communities tend to have more extensive streamside forested buffers.

Scoring Definition: Buffer impairment was evaluated during the SCA. Using the severity rating given during that evaluation, only buffer impairments rated moderate in severity or greater were used in calculating this indicator. Buffer conditions on both banks were evaluated, but impacts associated with channelization were not included in this indicator. Consequently, the total amount of buffer on both banks in the defined condition was divided by the total amount of potential stream buffer (double the GIS-derived stream length) and scored as described below:

Definition	Score (Weighting Factor 3)	Quality Rating
Value <0.10	3	Good
Value 0.10 to 0.20	12	Fair
Value 0.21 to 0.30	21	Poor
Value >0.30	30	Very Poor

HLR6—Fish Barriers

Justification: Free access to habitat is necessary to preserve ecological integrity of stream systems. Barriers to migration, particularly man-made ones, disturb the natural movement of individuals and their usage of available stream habitat.

Scoring Definition: Barriers associated with both natural and manmade structures are evaluated as part of the SCA. Since height of the barrier is provided, barriers greater than 12 inches are considered high enough to impede river herring, so those barriers greater that 12 inches are counted. The total percentage of stream mileage lost above all the blockages was divided by the total amount of habitat available and scored as described below:

Definition	Score (Weighting Factor 3)	Quality Rating
Value <0.10	3	Good
Value 0.10 to 0.20	12	Fair
Value 0.21 to 0.30	21	Poor
Value >0.30	30	Very Poor

HLR7—Overall Habitat Rating

Justification: Overall habitat ratings were developed for each subwatershed using data collected as part of the biological sampling work. Instream habitat and streamside condition are well correlated with biological health and ecological function.
Scoring Definition: This indicator is scored using the habitat assessment information collected as part of the representative sites evaluation performed during the SCA stream walks. Representative sites are distributed throughout the all the major branches of each subwatershed. The MCC crews scored all the indicators using the following qualitative categories: Optimal, Suboptimal, Marginal, and Poor. These ratings were converted to values using a 20-point scale like that used in the US EPA's RBP habitat assessment. A median value was established within each category (18 for Optimal, 13 for Suboptimal, 8 for Marginal, and 3 for Poor). Each qualitative metric was converted to a numeric score and summed to give a total habitat score. Total habitat scores were assigned a qualitative rating using the total possible number of points broken into quartiles. If applicable, multiple scores within subwatersheds were averaged.

Definition	Score (Weighting Factor 3)	Quality Rating
Rating of Optimal	3	Good
Rating of Suboptimal	12	Fair
Rating of Marginal	21	Poor
Rating of Poor	30	Very Poor

HLR8—Channel Alterations

Justification: Channelization and other alterations of stream systems typically have adverse impacts on water quality (Maxted et al, 1995), stream geomorphology (Hupp 1992, Waters 1995), and biological communities (Waters 1995).

Scoring Definition: Channel alterations are evaluated as part of the SCA. Using the severity rating given during that evaluation, only channel alterations rated moderate in severity or greater were used in calculating this indicator. The total length of channel altered is divided by the total amount of stream length to obtain the following:

Definition	Score (Weighting Factor 2)	Quality Rating
Value <0.10	2	Good
Value 0.10 to 0.20	8	Fair
Value 0.21 to 0.30	14	Poor
Value >0.30	20	Very Poor

C. LANDSCAPE CONDITIONS.

Any given subwatershed is a mosaic of different land use and land cover conditions, all influencing each other and the ecological health of the receiving stream. Understanding surrounding conditions helps determine the restorability of a particular watershed once it's disturbed. To ascertain the potential resilience of a watershed, various subwatershed-wide landscape conditions were evaluated using GIS data. The following seven indicators were developed and are described below:

LC1—Current Percent Imperviousness

Justification: There is evidence to suggest that total levels of impervious surface in a watershed are directly related to a watershed's overall condition (Schueler and Holland 2000).

Scoring Definition: As described in Schueler and Holland (2000), streams with less than 10% total impervious surface are considered relatively unimpaired, those between 10 and 25% are stressed, while those with greater than 25% are considered impaired. Imperviousness can be estimated using impervious coefficients derived from local land use conditions in the geographic area where the watershed of interest in located. Imperviousness was estimated using land use data from 1998 with impervious coefficients derived from AA County (2002b) applied to the total area of each land use polygon. These coefficients are listed in Appendix B of this report.

Definition	Score (Weighting Factor 3)	Quality Rating
≤10%	3	Good
11-18%	12	Fair
19-25%	21	Poor
>25%	30	Very Poor

LC2--Road Crossings

Justification: The number of road crossings on streams has been shown to relate to sediment delivery to developing watersheds (Haskins and Mayhood 1997). Increased numbers of road crossings are also associated with increased watershed development as roadways are constructed to support development needs.

Scoring Definition: The higher the number of crossings, the more potential for adverse impacts on stream channel conditions. Dividing the total number of road crossings by subwatershed area in square miles provides the indicator score, as described in Haskins and Mayhood (1997).

Definition	Score (Unweighted)	Quality Rating
<1.5	1	Good
1.5 to 2.0	4	Fair
>2.0 to 3.0	7	Poor
>3.0	10	Very Poor

LC3—Forest polygon edge/area

Justification: The presence of large forest blocks has been shown to have a positive impact on aquatic and terrestrial species (Rich et al 1994) while forest fragmentation has been demonstrated to have adverse impacts on species that depend upon intact forest areas (Gates and Evans 1996).

Scoring Definition: The more intact the forest area within a subwatershed, the greater the continuity of forest area within the subwatershed. This indicator is calculated by dividing the total perimeter (feet) of all large forested polygons by the area (square feet) of all the forest polygons within the Magothy River as captured by our GIS land use data and verified with recent aerial photography. Then, an area weighting for each polygon's ratio by subwatershed is calculated. The weighted ratios are summed to get an overall ratio for all the forested areas within a subwatershed of interest. Street trees, small wooded yards and other patchy forest habitat are ignored in this metric. Because of the uncertainty associated with the GIS characterization of the necessary data layers, this indicator is unweighted.

Definition	Score (Unweighted)	Quality Rating
< 0.006	1	Good
0.006 to 0.008	4	Fair
0.009 to 0.010	7	Poor
>0.010	10	Very Poor

LC4—Full Build Out Increase in Impervious Cover

Justification: Numerous studies have shown that increased impervious cover (IC) in a watershed leads to degradation of stream ecological conditions. Estimating future build out provides an indication of susceptibility to ecological degradation compared with current conditions.

Scoring Definition: Scored as LC1 using the relationship between current imperviousness and future impervious surface by comparing recent land use/land cover information with predicted build out as described in County zoning maps. The change in impervious area associated with individual land use polygons being brought to full build out conditions from their current land use condition is determined by multiplying the area of a polygon with a particular zoning by its assigned impervious surface coefficient. These coefficients are listed in Appendix B of this report. Next, current imperviousness is subtracted from this estimate of future imperviousness. Then, the differences in impervious area are summed, compared to current imperviousness, and reported as total change for the subwatershed.

Definition	Score (Weighting Factor 2)	Quality Rating
<10% IC at full build out	2	Good
11-18% IC at full build out	8	Fair
19-25% IC at full build out	14	Poor
>25% IC at full build out	20	Very Poor

LC5—Percent of Subwatershed in Proposed Greenway

Justification: Anne Arundel County has identified land area in the County for inclusion in a series of corridors connecting natural areas collectively known as Greenways (Anne Arundel County 2002a). Subwatersheds located in the proposed greenway are likely to have higher levels of protection and preservation than those outside this area because greenway areas were identified as lands having significant ecological value compared to other lands in the County.

Scoring Definition: This indicator is scored using the percentage of total subwatershed area proposed for inclusion in the County Greenway.

Definition	Score (Weighting Factor 2)	Quality Rating
>30% of subwatershed in proposed Greenway	2	Good
20 to 30% of subwatershed in proposed Greenway	8	Fair
10 to 19% of subwatershed in proposed Greenway	14	Poor
<10% of subwatershed in proposed Greenway	20	Very Poor

LC6—Percent of Subwatershed Land Area with Permanent Protection

Justification: Protected land usually means that little future development will occur within an subwatershed of interest. Other condition factors being equal, subwatersheds with large amounts of protected land are of higher quality because of the likelihood of being habitat islands in future developed areas surrounding them.

Scoring Definition: Land considered permanently protected includes County, State or Federal parkland or wildlife conservation areas, lands with conservation easements, or any lands with other types of protection that prevents its conversion from open space to developed area. The total amount of this land will be computed as a percentage of total subwatershed area. There is some overlap with LC5.

Definition	Score (Weighting Factor 2)	Quality Rating
>80% land area in permanent protection	2	Good
50 to 80% of sub in perm. protection	8	Fair
30 to 49 % of sub in perm. protection	12	Poor
<30% of sub permanently protected.	20	Very Poor

LC7—Percent of Subwatershed Land Area in Agricultural Land Use

Justification: Conversion of forest areas to agricultural land use can have adverse, long-term impacts on stream systems (Harding et al 1998). Subwatersheds with large amounts of cropland are likely to be more impacted than those with lesser amounts of these land uses (Richards et al 1996).

Scoring Definition: Land cover classified as agriculture is used to score this indicator, with the category breaks loosely inspired by Harding et al (1998). The total amount of land in this category is divided by the subwatershed area and scored as described below:

Definition	Score (Weighting Factor 2)	Quality Rating
<10% of subwatershed in Ag	2	Good
10 to 25% of subwatershed in Ag	8	Fair
26 to 35% of subwatershed in Ag	12	Poor
>35% of subwatershed in Ag	20	Very Poor

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